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Post mortem study of otters in England and Wales 1992-2003

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Author:
E.A. Chadwick

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Research Contractor:
Dr. E.A. Chadwick
School of Biological Sciences,
Main Building
Museum Avenue
Cardiff

Tel: 029 2087 4000
Web: www.cardiff.ac.uk

Environment Agency's Project Manager:
Mike Jenkins, Swansea Office

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Steve Killeen   Head of Science

Executive summary

Post mortem examinations were carried out on 609 otters found dead in England and Wales between 1992 and 2003. Liver tissue was removed from a subsample of 350 animals and analysed for pollutants including organochlorine pesticides (OCs) and polychlorinated biphenyls (PCBs).

This report summarises data from otters collected between 1992 and 2003. It follows Bradshaw and Slater (2002), which summarised data collected between 1992 and 2000.

Road traffic accidents were the main cause of death and showed a seasonal trend, with more deaths occurring in the winter months. Total numbers of otter carcasses and their distribution have both increased over the study period, reflecting expanding otter populations.

There is some evidence for changes in the population structure towards a younger average age (smaller size, lower incidence of renal calculi), but further data are needed to confirm this. The animals were predominantly healthy, with little evidence of disease.

The most commonly occurring organochlorine pesticides measured in otter carcasses were the para para isomers of DDE and TDE (both derivatives of DDT – dichlorodiphenyltrichloroethane), and dieldrin. Dieldrin and pp'DDE were detected in 99 and 100 per cent of samples respectively in the latter three years of the study. Tissue concentrations of organochlorines were generally low, compared to data gathered in the 1960s and 70s. The dominant organochlorine in terms of concentration was pp'DDE, with a median concentration of 181 μg/kg wet weight.

Nine polychlorinated biphenyl compounds were found in more than 95 per cent of samples since 2001. The dominant PCB was congener 153, with a median concentration of 72 μg/kg wet weight. Another pollutant, hexachlorobenzene (HCB), was found in 99.5 per cent of samples in the latter three years of the study.

Levels of chemical pollutants showed some regional trends, with higher levels of PCBs in northern regions and higher levels of OCs in the Midlands. There was no clear trend over time, but the evidence may have been compromised by changes in analytical methodology in 2001.

Levels of OCs, PCBs and HCB were higher in males than in females and highest in juveniles of both sexes. Also, levels of PCBs increased with increasing body size in males but not in females. These patterns probably reflect excretion of the pollutant burden in colostrum and milk by reproductive females. No correlation between otter body condition and concentration of OCs or PCBs was found.

A number of further studies are planned or underway, to accompany the ongoing analysis of otter carcasses. These will make use of archived samples and iron out inconsistencies in the data, for example by assessing age more accurately from teeth and measuring baculum length from cleaned bones. A genetic study of the

expanding otter population is also beginning. For future years, several improvements have been made to post mortem and analytical procedures. Chemical analyses will be more comparable, decomposed samples will not be used and more measurements will be taken. This means the Environment Agency will have an even higher quality of data on otter health, with which to assess current and future changes to the population.

Acknowledgements

Thanks are due to the many people who have collected and submitted carcasses, particularly the Environment Agency, Countryside Council for Wales and the UK Wildlife Trusts. Thanks also go to the Environment Agency and to Cardiff University for funding and supporting the work. Data for all otters examined between 1992 and 2003 were provided by Dr Adeline Bradshaw and assistance with post mortem examinations has been gratefully received from many students at Cardiff University. Finally, thanks must go to Vic Simpson for his help and guidance.

Contents

Summary of main findings

Summary statements refer to the entire 1992-2003 dataset, except where otherwise specified.

Numbers received

1. The number of otters submitted has increased, reflecting both increasing populations and increased collection effort (Section 3.1).
2. Otter road deaths are markedly seasonal, with more in winter than in summer (Section 3.2), probably due to poor winter driving conditions.
3. The distribution of otter casualties has expanded, probably due to expanding population distribution (Section 3.3).

Post mortem findings

4. The sex ratio of the casualties is approximately 3 males: 2 females, and has not changed over time (Section 4.1).
5. On the basis of broad categorisation (adult, sub-adult, juvenile) there appears to have been no change over time in the age structure of the population (Section 4.1). However see points 7 & 9.
6. The median size for adult males is 112 cm in length (nose to tail tip), and 8.4 kg in weight. Females are smaller, at 103 cm and 6.1 kg (Section 4.2).
7. Trends are apparent towards decreasing length and weight over time, for some groups of the population (Section 4.2). These may be indicative of a decline in the average age.
8. On the basis of the number of females found pregnant or lactating during each month, there is no evidence for reproductive seasonality (Section 4.3). However, see point 15.
9. There has been a sharp decrease in the number of animals found with renal calculi, which may reflect decreasing average age of the population (Section 4.4).
10. The spatial distribution of animals found with staghorn renal calculi suggests higher incidence in two main areas; E Anglia and W Wales (Section 4.4). However this is based on small sample size and is not conclusive without further evidence.
11. Fighting injuries appear to be less common in animals in this study area (EA Wales, Midlands, N East and N West, Anglian & Thames) than in a comparative study of animals from Southern and S West Regions (Section 4.5). However, due to differences in methodology the number of fighting injuries in this study area may be underestimated.

12. The primary cause of mortality of animals examined in this study was road death (92%). The second most common cause of death was starvation of juveniles following abandonment (2-3%). Other causes included drowning, septicaemia, starvation and shooting (Section 4.6).

13. Median condition (according to Kruuk et al's 1987 index) was 1.08 for adult males, and 1.14 for adult females. Condition was affected by sex, age and reproductive status, being higher in females than males, increasing with age, and highest among reproductively active (pregnant and lactating) females (Section 4.7).

14. Condition of adult males and sub-adult females has declined, particularly since the 1995-1997 sampling period (Section 4.7).

15. Condition among males is particularly low in May, followed by a gradual increase over the course of the summer and autumn. This may reflect an influx of poor condition, young sub-adults into the road-kill sample group in May, thereby lowering the mean condition factor. If this interpretation is correct, it suggests that seasonal reproduction may be occurring (Section 4.7).

Chemical analysis

16. A significant change in analytical procedure in 2001 means that, for some determinands, comparison of data before and after this time is unrealistic (Section 5.1).

17. Outlying values among results of chemical analysis were predominantly from decomposed samples or from animals that were in poor condition prior to death (Section 5.2).

18. The most commonly occurring organochlorine pesticides (OCs) measured during this study were dieldrin, and the para-para isomers of DDE and TDE (both derivatives of DDT). Both dieldrin and ppDDE were found in 100% of samples, while ppTDE was found in 66% of samples analysed since 2001 (Table 5.1, Sections 6.4, 6.6, 6.14).

19. Isodrin and the beta isomer of hexachlorocyclohexane (beta-HCH) were found in 55% and 44% of samples analysed since 2001, respectively, but at very low levels. These levels were below detection limits during the earlier years of the study (Table 5.1, Sections 6.8, 6.16).

20. The most commonly occurring polychlorinated biphenyls (PCBs) were congeners 105, 118, 128, 138, 153, 156, 170, 180 and 187, these being found in > 95% of samples since 2001 (Table 5.1, Section 7.1).

21. The only other pollutant to be found in a high percentage of samples was hexachlorobenzene (HCB), which was found in 98% of samples, after exclusion of a single anomalous batch of data (Table 5.1, Section 8.1).

22. Males show significantly higher levels than females of OCs, PCBs and HCB, possibly reflecting the excretion by reproductive females of their pollutant burden in colostrum and milk (Sections 6-8)

23. Juveniles showed the highest levels of OCs, PCBs and HCB. This may reflect both the pollutant burden derived from their mother, as well as the low condition of juveniles found (Sections 6-8).

24. In males, PCB loading increased with increasing body size. This trend differed in extent between PCB congeners. Such increases with body size were not apparent for most of the OCs, with the exception of dieldrin in which the trend was less marked than for PCBs. HCB also showed higher levels in larger males (Sections 6-8).

25. For females, PCB loading was highest in animals of intermediate size. This may reflect bioaccumulation while not reproductively active, followed by excretion to cubs when reproduction occurs. No such trend was apparent among OCs, and a similar but weaker trend was apparent for HCB (Sections 6-8).

26. For OCs (including DDE, TDE, beta-HCH and Dieldrin), levels were highest in Midlands Region. Rankings varied between EA Regions for other determinands (Section 6).

27. Levels of PCBs and Hexachlorobenzene were higher in N East and N West than in other EA Regions (Sections 7-8).

28. Prior to 2001, no consistent trends over time were detectable in levels of OCs, PCBs or hexachlorobenzene. However, OCs, PCBs and hexachlorobenzene all show declines since 2001 (following improvements in analytical methods). (Sections 6-8).

29. No correlation was found between otter condition (k) and concentrations of the common OCs (pp-DDE, pp-TDE or dieldrin) or selected PCBs (congeners 118, 153, 180). (Section 6-7).

1 Introduction

1.1 Population decline and recovery

Although once widespread throughout Europe, the European otter *Lutra lutra* underwent a dramatic decline during the twentieth century, to the point where they became rare or extinct across much of their range (Chanin 2003). In the UK it is thought that this decline began in the mid 1950s and continued until at least the mid 1970s (Chanin and Jefferies 1978, Jefferies 1996, Macdonald and Mason 1988). The otter population was eliminated from most of England, with remaining populations restricted to parts of Northern Ireland, Wales, south west England and the Scottish coastline (Jones and Jones 2004).

A range of evidence suggests that these declines were related to the use of endocrine disrupting chemicals (EDCs) including organochlorine pesticides (OCs) and polychlorinated biphenyls (PCBs) (e.g. Chanin and Jefferies 1978, Engelhart et al. 2001, Gutleb and Kranz 1998, Leonards et al. 1997, Mason and Madsen 1993, Roos et al. 2001, Simpson et al. 2000, Sjoasen et al. 1997, Tans et al. 1996). Many EDCs biomagnify and bioaccumulate in the aquatic food chain. Fish-eating aquatic mammals such as otters may be particularly vulnerable to the impact of EDCs, because they are at the top of the food chain, they depend on an aquatic food web and their habitat is in areas influenced by industry and agriculture (Fossi and Marsili 2003). EDCs have been shown to impair reproductive function in mustelids (animals of the carnivore family Mustelidae, which includes otters), and this has been suggested as the major reason behind the European otter’s decline (Fossi and Marsili 2003).

Although otter populations are still recognised by the World Conservation Union (IUCN) as ‘near-threatened’, a combination of protective legislation and improvements in water quality has led to a gradual recovery, through both range expansion and increased abundance (Crawford 2003, Jones and Jones 2004). Otter populations are now expanding over much of Europe, including the UK. Distribution in England and Wales has increased and it has been suggested that the decline in levels of OCs and PCBs since legislation restricting or banning their use may have contributed to population recovery (Roos *et al*. 2001). In some parts of Europe, populations have now increased to the point where otters are viewed as a pest (Kranz 2000).

1.2 Background to this study

In northern Europe, the otter is the dominant predator of riverine food chains (Jacobsen 2005). As such, the health of otter populations can be used as an indicator of the overall health of river systems. Data and samples collected during post mortem analysis of otters found dead can be used to assess levels of pollution and relate this to health impacts.

Since 1992, otters found dead throughout England and Wales have been collected and used for post mortem study of a number of factors. Otters from Wales, the Midlands, North East, North West, Anglian and Thames Regions have been sent to Cardiff University for post mortem analysis. Otters from South West and Southern Regions have been sent to the Veterinary Investigation Centre in Cornwall.

The data and tissues collected now form a valuable archive that is being used for a number of research objectives.

1.3 Objectives of this report

The objectives of this report were:

- To assess the health and structure of the sampled population.
- To assess levels of chemical pollutants measured in otter tissues.
- To compare levels of chemical pollutants with health indicators.

This report summarises data collected from otters submitted to Cardiff University for post mortem analysis between 1992 and 2003. It follows Bradshaw and Slater (2002),which summarised data collected between 1992 and 2000. Where appropriate, data from 1992-2003 are pooled for statistical analysis. In some cases data are examined separately according to the year of collection.

2 Methods

2.1 Necropsy procedure

Carcasses were submitted frozen and stored at -20 ºC prior to examination. Dr Adeline Bradshaw carried out all examinations. The procedures followed were documented previously (Bradshaw and Slater 2002) and are summarised below.

2.1.1 Basic information retrieval

Data were recorded as outlined in Appendix 1, including sex, weight and length and an estimate of age (see below). In addition, nutritional state, reproductive status, lesions, growths and concretions were noted.

Age was estimated using weight and signs of sexual maturity. Females weighing less than 2.1 kg and males weighing less than 3 kg were recorded as juvenile. Females above this weight but with no sign of reproductive activity (nipples not showing, immature uterus) and males with a baculum less than 60 mm in length were recorded as sub-adult. Females above this weight and with signs of having reproduced at least once and males above this weight and with a baculum length greater than or equal to 60 mm were recorded as adult.

2.1.2 Health indicating factors

Body condition was calculated using the equation: $K = W / aL^n$

Where W = total body weight in kg, L = total length (nose to tail tip in metres). For males, a = 5.87 and n = 2.39. For females a = 5.02 and n = 2.33 (Kruuk *et al*. 1987).

2.2 Laboratory analysis

Liver samples were retrieved from carcasses where possible and retained for further analysis. All livers were wrapped in aluminium foil and stored at -20ºC until analysed at the Environment Agency laboratory in Exeter.

Chemical analyses were carried out according to procedures defined in Simpson *et al*. (2000).

350 liver samples have been analysed between 1992 and 2003. Samples were tested for organochlorine pesticides (OCs), polychlorinated biphenyls (PCBs), heavy metals and a range of other pollutants. Data for each sample and determinand are presented in full in Appendices 2 (OCs), 3 (PCBs) and 4 (other determinands).

Data from chemical analyses were pooled across 1992-2003, so that trends over time could be assessed and regional patterns examined. No heavy metal data have been recorded since the previous report (Bradshaw and Slater 2002) and so heavy metals are not analysed here.

2.2.1 Detection limits

Data from batches E523 to E698 were obtained from Dr A Bradshaw already edited, with samples showing levels less than the detection limit replaced by zero. Detection limits were not provided. Data from batch EX0042 were available in full, with detection limits. From this it was apparent that detection limits varied widely between samples for many determinands. For example, for pp'DDT detection limits varied from 12.5 to 45.2 µg/kg. The only sample from this batch that measured above the detection limit had a value of 31.1 µg/kg, which was below the detection limit for many other samples within the same batch. Similar concentrations may therefore not have been detected.

Preliminary screening of the data revealed some major differences in concentrations and percentage occurrence of determinands between analytical batches. On further investigation it was found that methodologies changed in 2001, when the laboratory moved and upgraded its equipment. This occurred between batch EX0042 and EX0450.

Prior to this, detection limits varied with sample size and the detection limit was higher for smaller samples. After this date, all determinands were reported to a consistent detection limit of 1 µg/kg (S. Padley, Starcross Laboratory, personal communication). Given the variability in detection limits and the approach previously taken by Dr Bradshaw, it was decided to treat all values below detection limits as zero, rather than the standard approach for chemical data, which is to use a value of half the detection limit.

2.2.2 Change in determinands

As well as detection limits being standardised in 2001, the list of determinands that were tested was changed. Table 2.1 lists the determinands that were tested, and how many animals from each batch were tested. Table 2.2 shows how the batches of animals were made up from different years. The number of data points for each determinand, and the number of determinands, vary considerably between batches and years.

2.2.3 Lipid or wet weight concentrations

Tissue concentrations may be reported on a wet weight, dry weight or lipid weight basis. Many studies report organic contaminant concentrations on a lipid weight basis. However, although lipid weights were recorded, the accuracy of some of these data was highly questionable. The median lipid content of all samples analysed was three per cent, which is similar to previous studies. For example, values of between 2.21 and 4.39 per cent were presented by Simpson (1998). While most values presented here were between two and four per cent (Figure 2.1), some were considerably higher, to a maximum of 42 per cent - a value that is clearly inaccurate.

Mean lipid content varied between analytical batches used in this study. For example, in batch EX0042, the mean lipid weight was 3.6 per cent ± 2.01 (n = 55), while in batch EX0450, the mean was 5.65 per cent ± 7.13 (n = 127). For a small number of animals, replicate samples were taken and analysed in more than one batch for comparison. Of these, many values varied markedly between samples taken from the same liver. For example, otter 230 was recorded in separate analyses as having a lipid content of 3.63 or 11.92 per cent, otter 241 with 2.31 or 6.02 per cent, otter 305 with 3.56 or 28.03 per cent. Clearly such differences between batches in lipid determination would have a marked effect on calculated contaminant values. We therefore expressed contaminant values in wet weight of tissues, on the assumption that the actual lipid content of liver varied less than the measured values. This approach is supported by Jefferies and Hanson (2000), who assert that wet weight concentrations give a better comparative result than lipid concentrations for studies of this kind. In order to calculate an approximate concentration in lipid for comparison with other studies, a conversion factor of x 33.33 can be used, based on the median 3% lipid content.

2.3 Statistical analysis

Various statistical tests were used to compare and describe datasets. These included chi-squared analysis, correlation (Pearson's correlation for normally distributed data, and Spearman's rank correlation for non-normally distributed data), and the Kruskal Wallis test. For the tests used, statistical significance is indicated where the given 'p value' is less than 0.05. Further information on these tests can be found in standard statistical texts, e.g. Sokal & Rohlf (1994).

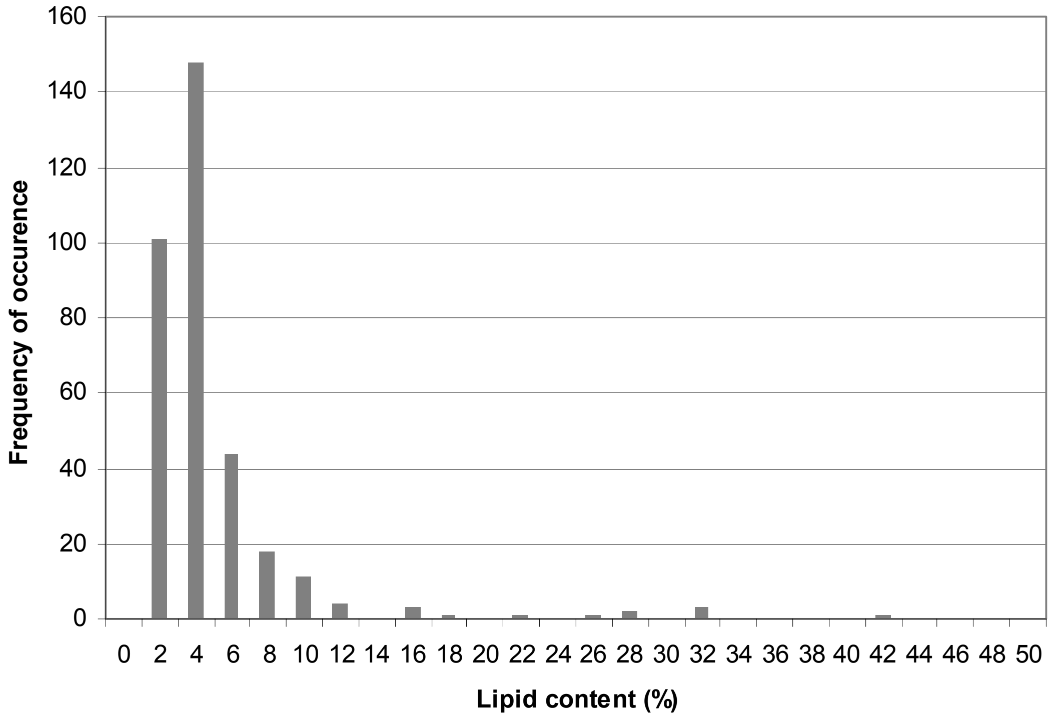

Figure 2.1 Percentage frequency distribution of liver lipid content.
All samples, 1992-2003.

Table 2.1 Determinands tested and how many animals from each batch were tested. 'Mix' = number of additional animals for which duplicate samples were submitted in more than one batch.

		Batch number									
Determinand	Mix	E523	E588	E651	E698	EX0042	EX0450	EX0520	EX0659	EX0720	Total
Ext Lipid%	25	26	0	14	17	55	123	65	9	4	338
DM%	6	26	7	0	0	0	0	0	0	0	39
Endo A	16	26	8	14	17	55	0	0	0	0	136
Endo B	13	17	0	14	6	0	0	0	0	0	50
1,2,3 TCB	12	26	8	9	9	55	0	0	0	0	119
1,2,4 TCB	12	26	8	13	10	55	0	0	0	0	124
1,3,5 TCB	15	26	8	13	17	55	0	0	0	0	134
Alpha-HCH	25	26	8	14	17	55	126	64	9	4	348
Beta-HCH	25	26	0	14	17	47	126	64	9	4	332
Delta-HCH	12	0	0	0	0	0	126	64	9	4	215
Gamma-HCH	25	26	7	14	17	55	126	64	9	4	347
pp'DDE	25	26	8	14	17	55	126	64	9	4	348
op'DDT	25	26	8	13	17	55	126	64	9	4	347
pp'DDT	25	26	8	12	17	55	126	64	9	4	346
pp'TDE	25	26	8	14	17	55	126	64	9	4	348
op'DDE	12	0	0	0	0	0	126	64	9	4	215
op'TDE	12	0	0	0	0	0	126	64	9	4	215
Aldrin	25	26	5	14	17	55	126	64	9	4	345
Dieldrin	25	26	8	14	17	55	126	64	9	4	348
Endrin	25	26	4	13	17	55	126	64	9	4	343
Isodrin	25	26	4	13	17	47	126	64	9	4	335
Atrazine	4	26	0	0	0	0	0	0	0	0	30
Malathio	2	8	0	0	0	0	0	0	0	0	10
Para Eth	5	26	0	0	0	0	0	0	0	0	31
Para Met	4	26	0	0	0	0	0	0	0	0	30
Simazine	4	26	0	0	0	0	0	0	0	0	30
HC Buta	15	26	8	14	17	55	0	0	0	0	135
Triflura	15	26	7	14	11	55	0	0	0	0	128

						Batch number					
Determinand	Mix	E523	E588	E651	E698	EX0042	EX0450	EX0520	EX0659	EX0720	Total
HC Benz	25	26	8	14	17	55	126	36	9	4	320
PCB8	12	0	0	0	0	0	126	64	9	4	215
PCB18	12	0	0	0	0	0	126	64	9	4	215
PCB20	12	0	0	0	0	0	126	64	9	4	215
PCB28	25	26	8	13	17	55	126	64	9	4	347
PCB31	25	26	7	12	17	55	126	64	9	4	345
PCB35	12	0	0	0	0	0	126	64	9	4	215
PCB44	12	0	0	0	0	0	126	55	9	4	206
PCB52	25	26	8	13	17	55	126	64	9	4	347
PCB66	12	0	0	0	0	0	126	48	9	4	199
PCB77	12	0	0	0	0	0	126	64	9	4	215
PCB101	25	26	8	13	17	55	126	64	9	4	347
PCB105	18	0	0	0	17	55	125	64	9	4	292
PCB118	25	26	8	14	17	55	123	63	9	4	344
PCB126	12	0	0	0	0	0	126	64	9	4	215
PCB128	11	0	0	0	0	0	125	64	9	4	213
PCB138	25	26	8	14	17	55	120	62	9	4	340
PCB149	12	0	0	0	0	0	126	64	9	4	215
PCB153	25	26	8	14	17	23	120	63	9	4	309
PCB156	25	26	8	14	17	55	126	57	9	4	341
PCB169	11	0	0	0	0	0	118	59	9	4	201
PCB170	12	0	0	0	0	0	121	58	9	4	204
PCB180	25	26	8	14	17	55	124	58	9	4	340
PCB187	11	0	0	0	0	0	122	62	9	4	208
Arsenic	16	26	7	14	17	55	0	0	0	0	135
Cadmium	16	26	8	13	17	55	0	0	0	0	135
Chromium	16	26	7	14	16	55	0	0	0	0	134
Copper	16	26	8	13	17	55	0	0	0	0	135
Lead	16	26	7	14	17	55	0	0	0	0	135
Mercury	16	26	8	14	17	55	0	0	0	0	136

	Batch number										
Determinand	Mix	E523	E588	E651	E698	EX0042	EX0450	EX0520	EX0659	EX0720	Total
Nickel	16	26	7	14	17	55	0	0	0	0	135
Zinc	16	26	8	14	17	55	0	0	0	0	136

Table 2.2 Years of origin of animals within each sample batch for chemical analysis.

	Year of sample origin (year in which otter was found)												
Batch	’92	’93	’94	’95	’96	’97	’98	’99	’00	’01	’02	’03	All
E523	1	2	14	9									26
E588			1	1	6								8
E651				1	12	1							14
E698	1			1	6	9							17
EX0042	1	1		3	3	11	27	9					55
EX0450	1					1	1	12	46	28	38		127
EX0520								1		1	17	46	65
EX0659												9	9
EX0720									2		1	1	4
Mix		1	2	1	10	2		1	3	1	4		25
Total	4	4	17	14	35	24	27	22	46	29	58	56	350

Notes: ‘Mix’ refers to the number of animals for which replicate samples were submitted in more than one batch

3 Otter submissions

A summary of basic data (date and location found, sex, age, weight, length and reproductive status) is given for all otters found in 1992-2003 in Appendix 2. Those found in 2001-2003 (n = 250) are mapped by Environment Agency water management Region and year, labelled by UWC (University of Wales Cardiff) reference number (Appendix 3).

3.1 Change over time

A total of 609 otters were received at Cardiff University between 1992 and 2003. Numbers received per year have increased during this time (Figure 3.1), peaking at 94 animals in 2000. Since then, annual numbers have declined slightly but remain higher than those before 2000.

3.2 Seasonal variation

Seasonal variation in numbers follows patterns previously documented (Simpson 1998, Bradshaw and Slater 2002) with the largest proportion found during the winter months. Totals for each month, pooled for years 1992-2003 (Figure 3.2) show that 10 to12 per cent of the total have been found in each of the months from November to February and only four to six per cent in each month from May to September. Females show peaks in mortality in February and November, while males peak from October to December.

3.3 Distribution

The distribution of otters retrieved between 1992 and 2003 is mapped in Figure 3.3. Some casualties were received with locations that are clearly anomalous, such as in the sea. Attempts are being made to verify locations where possible.

In all years the majority of otters received have been found in EA Wales. However, the proportion found in other Regions has increased from less than 25 per cent in 1992 to1995, to nearly 50 per cent between 1999 and 2003 (Figure 3.4). Numbers found in Midlands, Anglian and North East Regions have each contributed between 8 and 20 per cent in these years.

Table 3.1 shows the numbers of otters found in each Region.

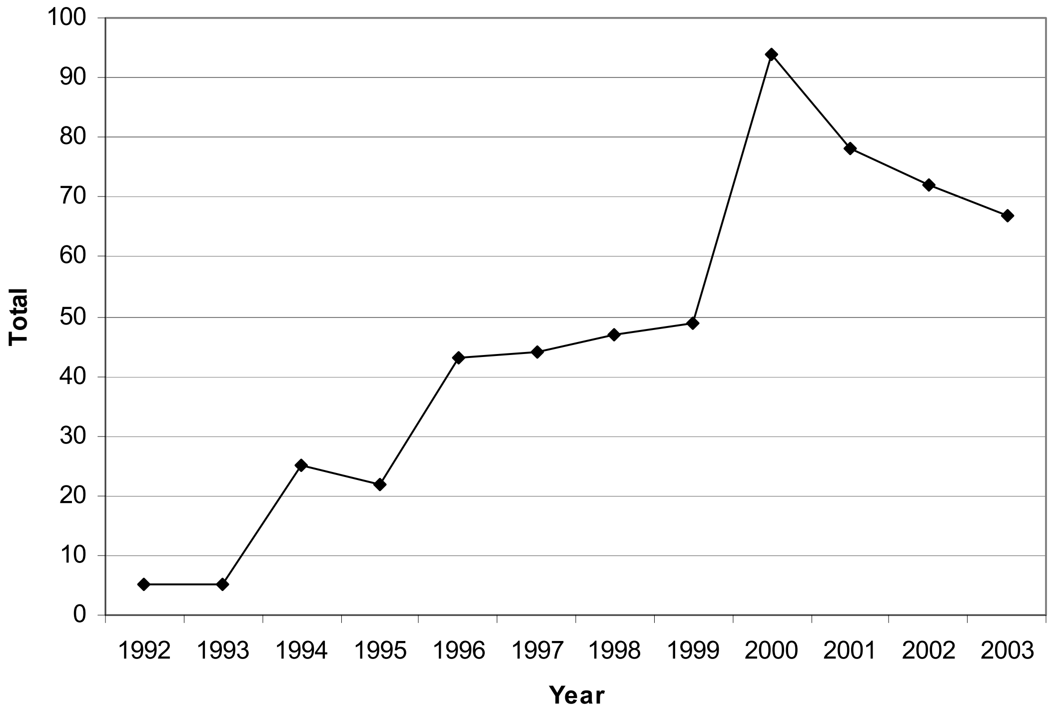

Figure 3.1 Change in the number of otters collected over time. Based on the 551 otters for which year was recorded

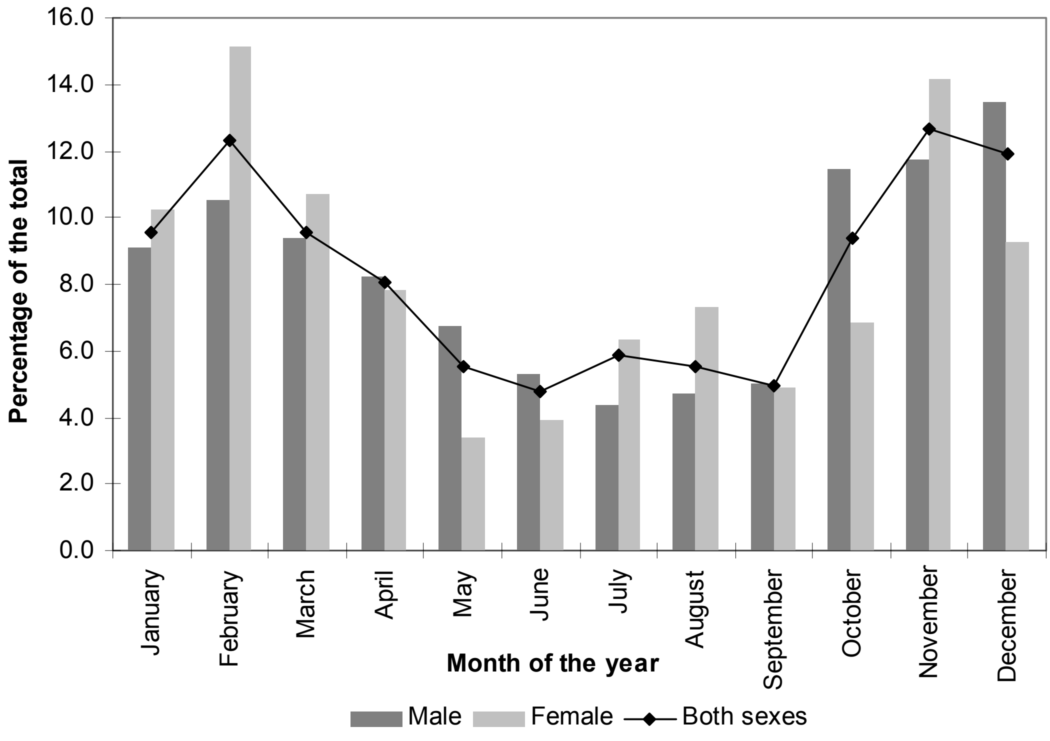

Figure 3.2 Seasonal variability in number of otters found. Based on 545 otters from 1992 to 2003 for which month was recorded.

Figure 3.3 Distribution of otter casualties received.
Outlines show Environment Agency Area boundaries. Regions are differentiated by colour, as labelled on the first map. Samples from Southern and South West Regions are reported in Simpson (2006a).

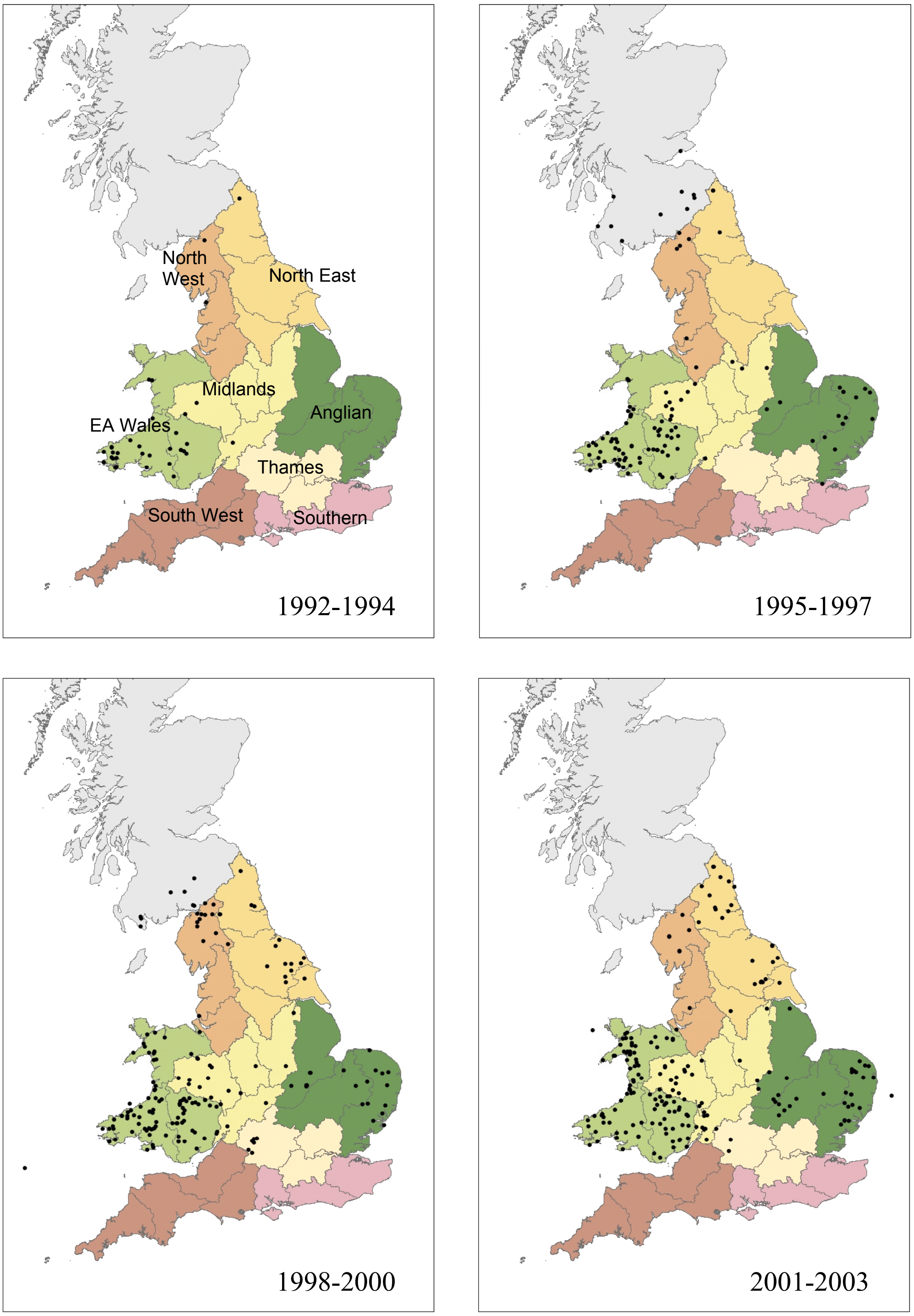

Figure 3.4 Percentage of otter casualties from each Environment Agency region, based on the 548 otters from 1992 to 2003 for which both region and year were recorded (see data Table 3.1)

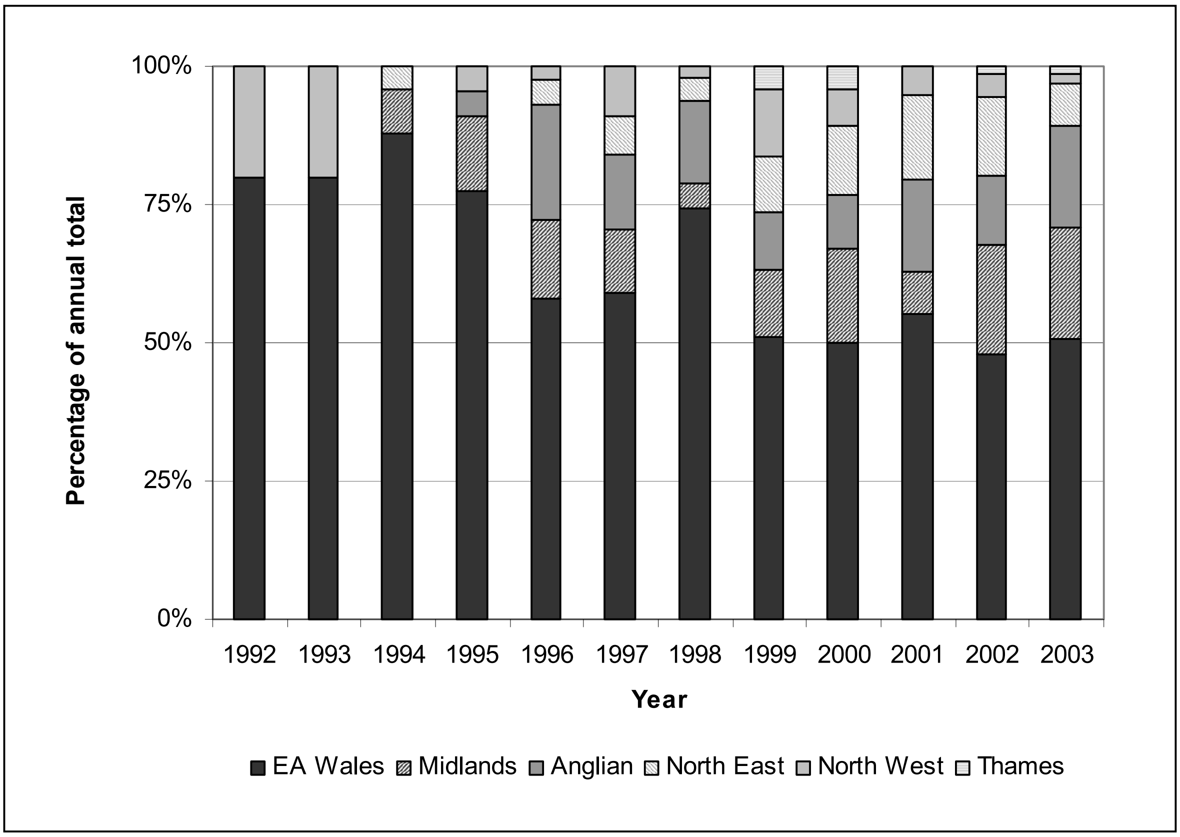

Table 3.1 Total number of otter casualties found in each Environment Agency Region and year

Region	Year '92	'93	'94	'95	'96	'97	98	'99	'00	'01	'02	'03	Totals Known year	Year not known	Total
Anglian	0	0	0	1	9	6	7	5	9	13	9	12	71	3	74
EA Wales	4	4	22	17	25	26	35	25	47	43	34	33	315	34	349
Midlands	0	0	2	3	6	5	2	6	16	6	14	13	73	10	83
North East	0	0	1	0	2	3	2	5	12	12	10	5	52	7	59
North West	1	1	0	1	1	4	1	6	6	4	3	1	29	3	32
Thames	0	0	0	0	0	0	0	2	4	0	1	1	8	0	8
TOTALS															
Known Region	5	5	25	22	43	44	47	49	94	78	71	65	548	57	605
Unknown region	0	0	0	0	0	0	0	0	0	0	1	2	3	1	4
Overall total	5	5	25	22	43	44	47	49	94	78	72	67	551	58	609

Note: for comparisons of data between periods 1992-4, 1995-7, 1998-2000 and 2001-3, animals for which 'year found' was not recorded were counted as if found in the year they were received by Cardiff University.

4 Post-mortem findings

4.1 Sex and age class

The total numbers collected within each sex and age class (male and female, adult, sub-adult and juvenile) are shown in Table 4.1 for each year since 1992.

Of animals received between 1992 and 2003, 60 per cent were male and 38 per cent female (Figure 4.1). By age class, 62 per cent were adult, 32 per cent sub-adult, and four per cent juvenile. Neither sex or age class were recorded for two per cent of animals (Figure 4. 2).

Data were grouped into four periods: 1992-1994, 1995-1997, 1998-2000 and 2001-2003). Chi-squared analysis was used to test whether there were any differences in the population structure between these periods. The results indicate that there was no significant departure in any period from the expected proportions of either males and females ($p = 0.064$) or adults and young otters ($p = 0.707$). However, sub-adults and juveniles were pooled in the latter analysis, to ensure that counts were above five, rendering it a weak assessment of changing age structure.

4.2 Length and weight

Mean values for length and weight are shown in Figure 4.3 and Table 4.2. The results of Kruskal-Wallis tests indicated that for all groups (adult, sub-adult and juvenile), males were significantly larger than females of the same age-class. The p value was less than 0.001 in comparisons of both length and weight for male and female adults and sub-adults. In the juvenile class, $p = 0.010$ for length and 0.003 for weight. Descriptive statistics for length, weight and condition data are shown in Table 4.2.

Correlations between length and weight were significant for all sex and age groups ($p < 0.001$). Correlations were weaker for older animals. The correlation between length and weight for adults was poor, with a correlation coefficient of $r = 0.384$ for adult males and $r = 0.363$ for adult females ($p < 0.001$ for both groups). These compare to high correlation coefficients for sub-adults ($r = 0.800$ and 0.791 for males and females respectively, $p < 0.001$ in both cases) and juveniles ($r = 0.678$ and 0.817 for males and females respectively, p 0.022 and p 0.025) (Figures 4.4 and 4.5). Data for adult weight (both males and females) and for adult and subadult length of females were non-normally distributed so Spearman's rank correlations were used.

To assess whether the size structure of the population has changed over time, length and weight were compared for four periods: 1992-4, 1995-7, 1998-2000 and 2001-3 (Figure 4.6 and 4.7). A slight trend of decreasing length is apparent for sub-adult females and for adult females in the first three periods, but these are not statistically significant ($p = 0.959$ and $p = 0.060$ respectively). Trends towards decreasing weight are apparent for adult males, adult females and sub-adult females, and the trend is statistically significant for adult males (correlation coefficient $r = -0.169$, $p = 0.009$) but not for other groups ($p = 0.103$ for adult females, and $p = 0.186$ for subadult females).

4.3 Reproductive status

Of 125 adult females found between 1992 and 2003 whose reproductive status was recorded, 26 (21 per cent) were lactating, 11 (nine per cent) were pregnant and 88 (70 per cent) were quiescent (no sign of current reproductive activity). Of the 11 pregnant females, three foetuses were found in one female, two in two females, one in three females. In five cases the number of foetuses was unrecorded.

Most reproductively active females were found during winter and spring (Figure 4.8). However, when seasonality in the total number found was accounted for, there was no significant difference between seasons in reproductive activity. An expected number of reproductively active and quiescent females was calculated for each season, based on the total number of females found in each season and the total number of reproductively active and quiescent females overall. Months were pooled to ensure that counts were above five so analyses were based on January-March, April-June, July-September and October-December. A chi-squared test showed no significant difference between the observed and expected values in the different seasons ($p = 0.117$).

Of 270 males for which baculum length was recorded, 67 per cent had baculae longer than 60 mm (indicative of adult status) and 33 per cent had baculae shorter than 60 mm. The length frequency distribution is bi-modal, with peaks at 40-44 mm and 65-69 mm (Figure 4.9).

To assess whether baculum length has changed over time, median values were compared between years (Figure 4.10). Although there is a slight trend towards longer baculae over time, with medians of 60mm in 1994-95, ≥ 61mm in 1996-97, ≥ 62 mm in 1998-99 and ≥ 63 mm in 2000-03, variation is large and this trend is not statistically significant.

4.4 Renal calculi

Of the 252 animals found between 2001 and 2003, 10 (four per cent) had renal calculi, of which seven were miniscule and three moderate. No animals were found during this time with 'staghorn' calculi (large concretions that occupy several lobules and join up between them, causing some distortion of the kidney). From animals collected between 1992 and 1994, renal calculi were found in 10.3 per cent of animals (39 animals). In 1995-97, 11.7 per cent of animals (111) had renal calculi, and in 1998-2000 9.7 per cent (207) had calculi. The incidence rate is clearly much lower in casualties found during 2001-03. In all cases, renal calculi were found in adult animals.

Where locations were given accurately and could be mapped (there were 45 otters with mappable locations and renal calculi) distribution was not noticeably different to the distribution of all corpses found. However those with staghorn calculi were predominantly from East Anglia, or from coastal locations in Wales (Figure 4.11). Of two additional animals with staghorn calculi for which grid references were not provided, one was from Anglian Region (UWC 174), and the other from Wales (UWC 6, no location details provided other than south Wales).

4.5 Fighting injuries

Of the 250 animals found between 2001 and 2003, 16 had fighting injuries (6.4 per cent), 10 minor and six severe. Of those severely injured, two had broken baculae (UWC 589, 603) two had lacerations to the anogenital region (UWC 457, 585), one had both facial and anal wounds with associated septicaemia (UWC 494) and one had severe wounds to the head, with a broken occipital bone on the left side and associated infection and necrosis of the tissue (UWC 638).

Between 1992 and 2000, 31 of 359 animals had fighting injuries (8.6 per cent). Again, injuries were mainly to the anogenital and facial areas. One animal had suffered complete removal of the testes (see Bradshaw & Slater (2002) for photograph) and the other had a severe oedematous infection following wounds to the face.

4.6 Causes of mortality

Of the 250 animals found between 2001 and 2003, 231 (92 per cent) died from severe trauma - 229 from road traffic accidents and 2 on train lines. This percentage was identical to that calculated from deaths between 1992 and 2000, when 332 of 359 animals were recorded as having died due to road traffic accidents.

In both periods, the second most common cause of death was abandonment and subsequent starvation of juveniles. This was recorded in six of the 250 cases (2.4 per cent) in 2001-2003, and 10 of the 359 cases (2.8 per cent) in 1992-2000.

Various other causes of death were recorded, sometimes in combination. These included drowning, septicaemia (often following intraspecific fighting injuries and occasionally dog bites) and respiratory infection. In four cases animals were euthanased, once due to severe fighting injuries, twice due to injuries sustained during a road traffic accident (RTA) and once due to severe emaciation for which the cause could not be determined. In two instances, the cause of death was shooting (UWC 398, year 2001, Anglian Region, Ely Ouse; UWC 106, year 1997, Wales, Carmarthen area).

4.7 Health indicators

4.7.1 Condition factor (k)

From all data collected from 1992 to 2003, the median condition for adult males was 1.08 and for adult females, 1.14 (Table 4.2).

Condition varied between age and sex classes as previously documented (Bradshaw and Slater 2002), with females consistently having a higher condition factor than males within each age class and condition declining from adults to sub-adults to juveniles (Figure 4.12). Condition also varied with reproductive status, being highest in pregnant (mean 1.29 ± 0.17, $n = 11$) and lactating females (1.19 ± 0.14, $n = 28$), lower in quiescent females (1.11 ± 0.14, $n = 90$) and lowest in those that had never reproduced (0.99 ± 0.17, $n = 101$). High ‘condition’ in pregnant females may partly reflect the inclusion of foetus weight in overall body weight.

As would be expected, otters that met with violent death (RTA, train crash or shot, referred to as the RTA group) were in significantly better condition than otters that died of ill health or starvation (referred to as the non-RTA group) (Figure 4.13).

To assess whether the condition of the population has changed over time, condition factor was compared for four periods: 1992-4, 1995-7, 1998-2000 and 2001-3 (see Figure 4.14). Trends towards decreasing condition are apparent for adult males and sub-adult females, particularly in the latter three periods. These trends are statistically significant (correlation coefficient $r = -0.241$, $p < 0.001$ [adult males], and $r = -0.300$, p 0.005 [sub-adult females]).

To assess whether condition varies seasonally, monthly values were calculated for males and females, and compared (Figure 4.15). Condition in males is lowest in May, and rises to a peak in November and December. For females a trend is less clear. Female condition was lowest in September, but if this is excluded as a possible outlier, condition was lowest in May and peaks in October and November.

4.7.2 Adrenal factor

Adrenal weight was recorded for an insufficient number of animals between 2001 and 2003 to use in analytical results ($n = 23$). Analysis of adrenal factor prior to 2001 is presented in Bradshaw & Slater (2002).

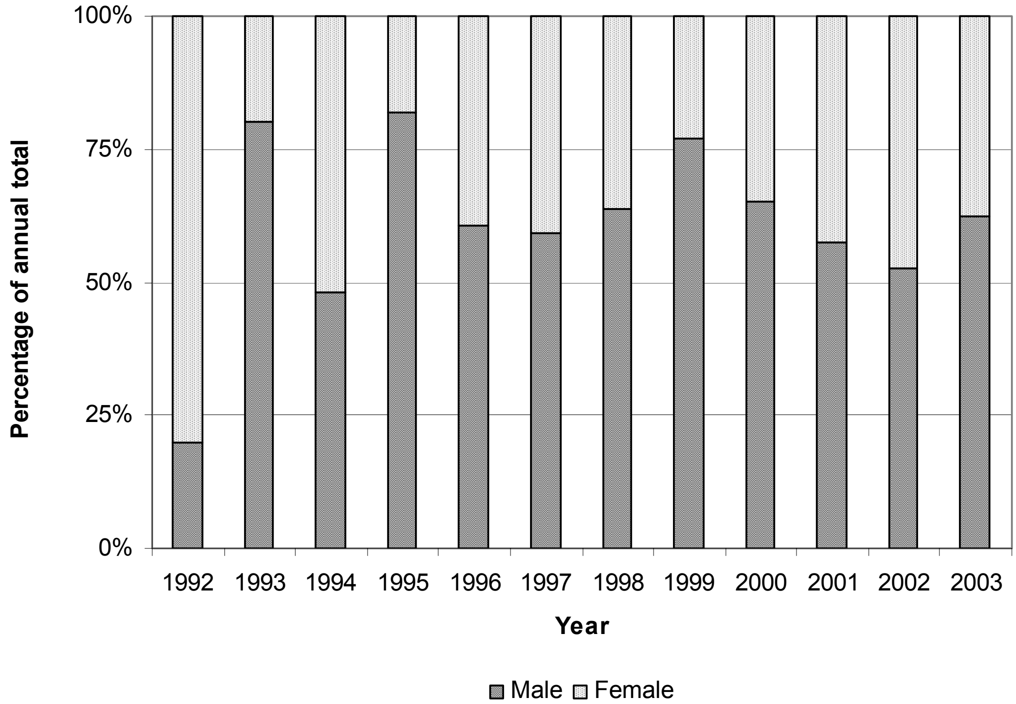

Figure 4.1 Percentage of males and females in each year. Based on data from 1992-2003, for 540 otters for which sex and year were known. See Table 4.1 for breakdown.

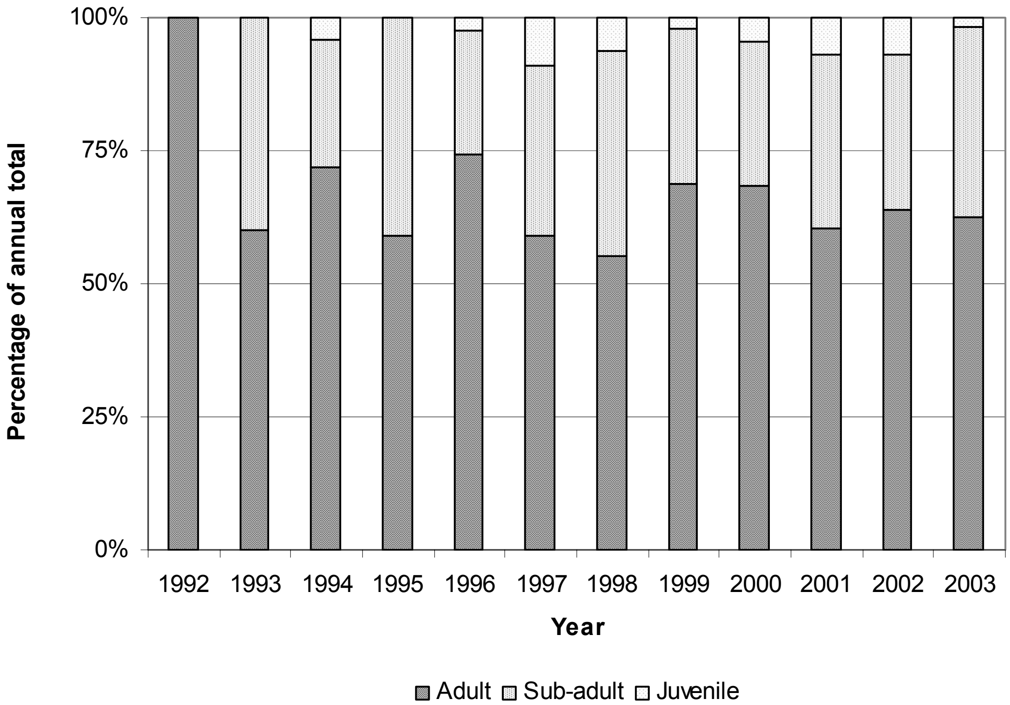

Figure 4.2 Percentage of adults, sub-adults and juveniles in each year. Based on data from 1992-2003, for 540 otters for which year and age class were known. See Table 4.1 for breakdown.

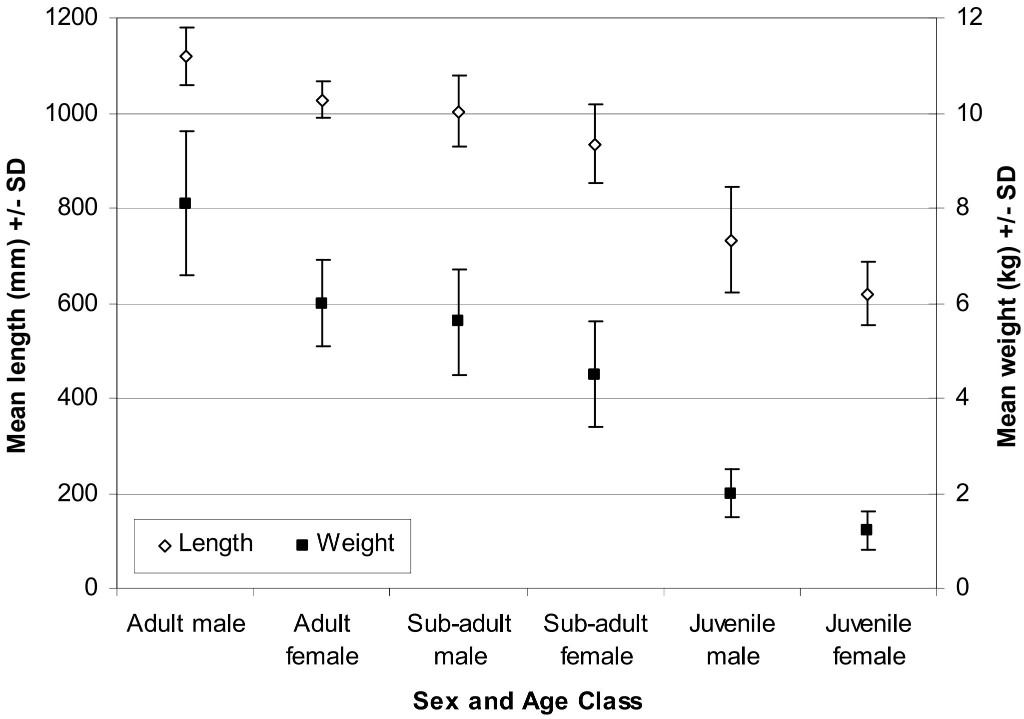

Figure 4.3 Mean length and weight of otters by sex and age class. For number of animals in each category, see Table 4.2.

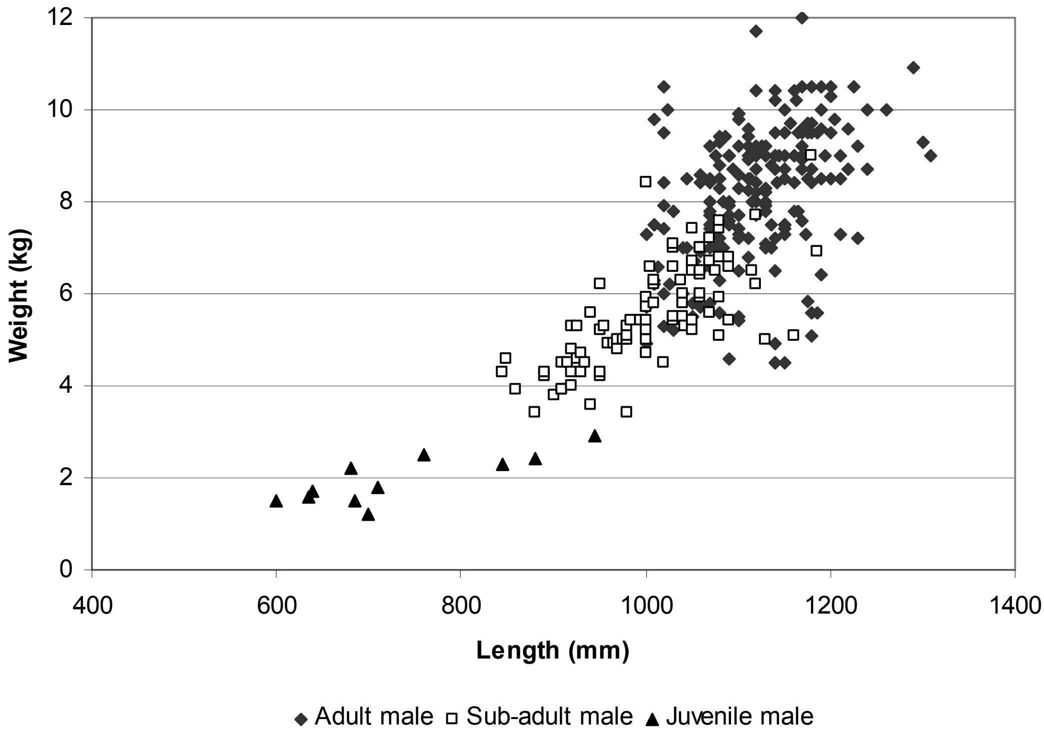

Figure 4.4 Relationship between length and weight for males. Data are pooled from 1992-2003, for 314 otters for which length and weight are known.

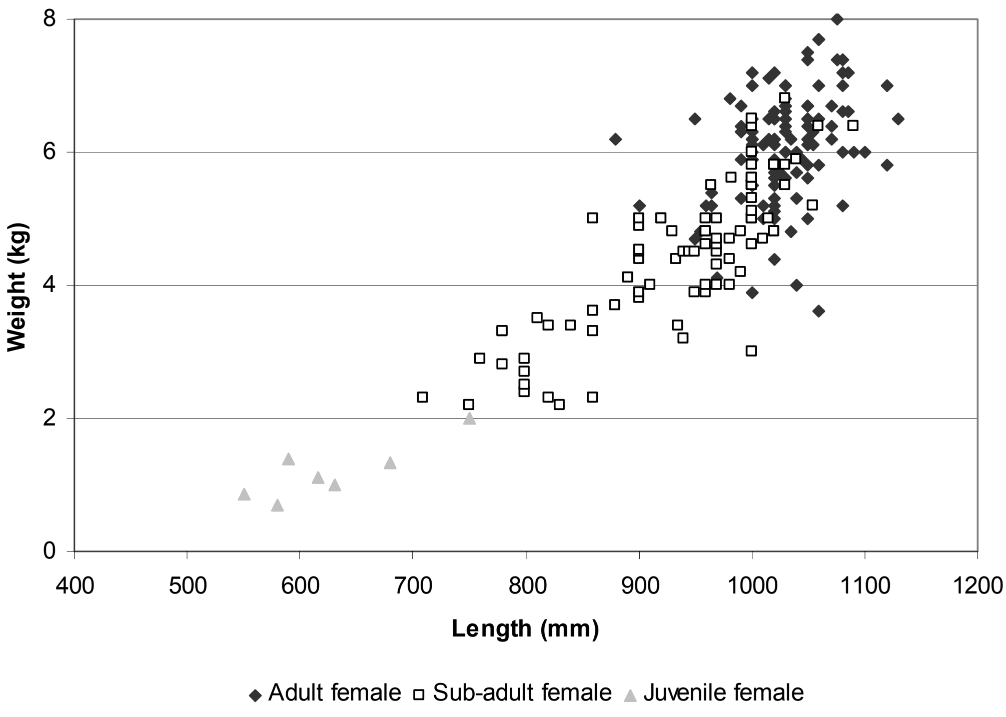

Figure 4.5 Relationship between length and weight for females. Data are pooled from 1992-2003, for 207 otters for which both length and weight are known.

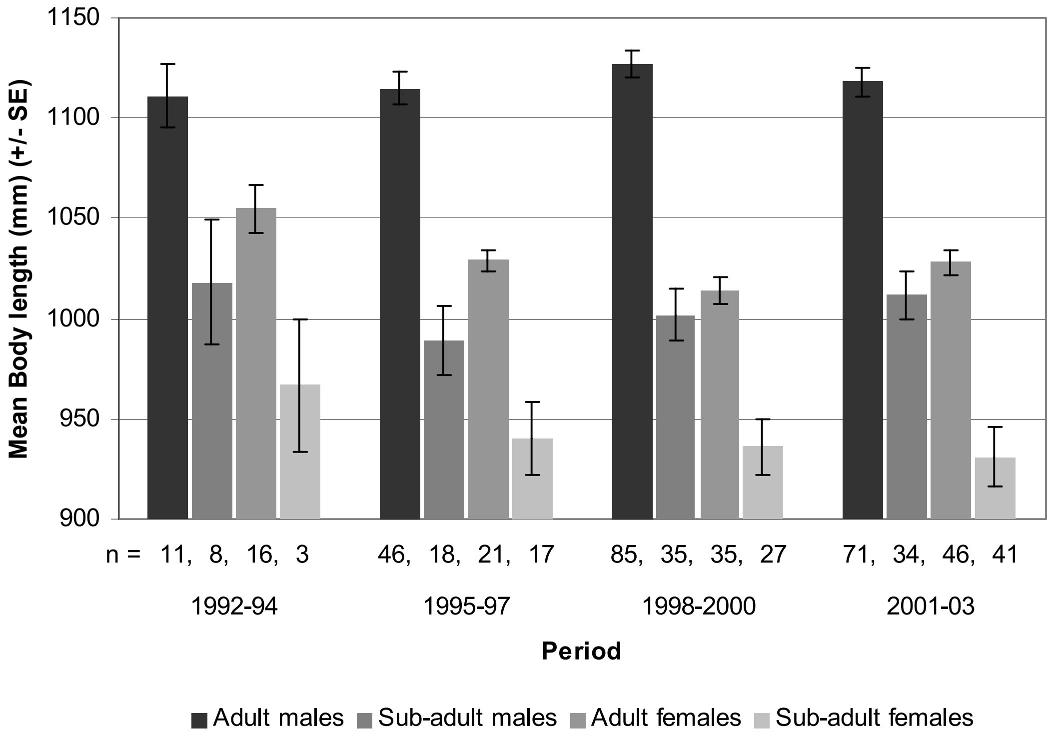

Figure 4.6 Change in mean body length over time

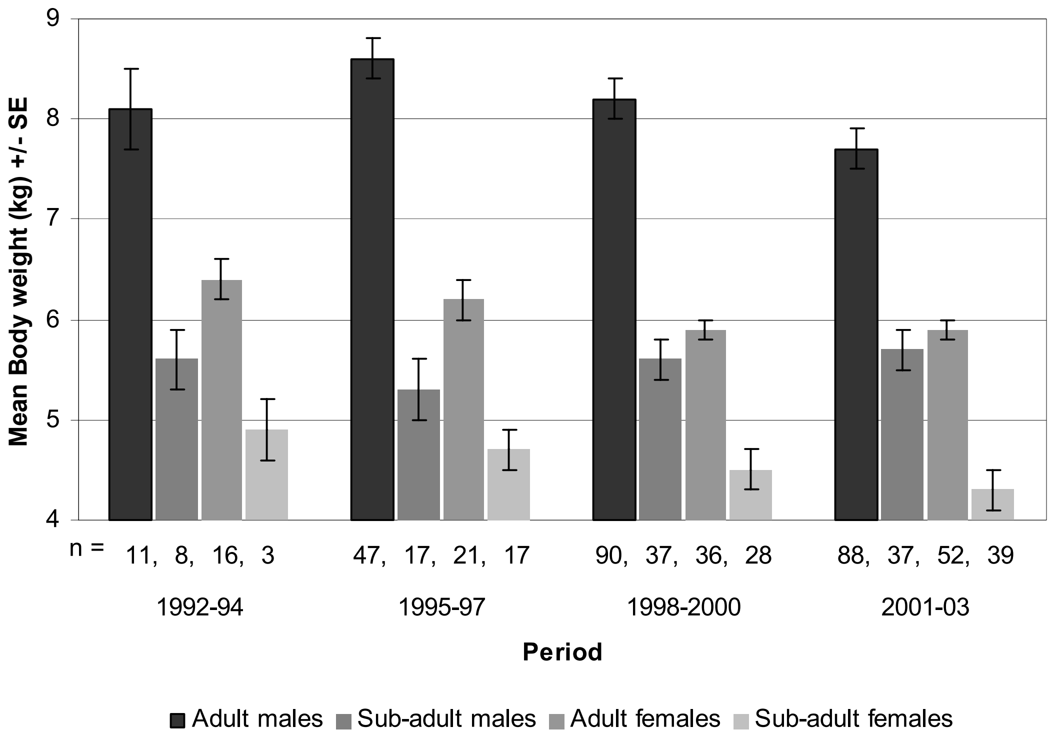

Figure 4.7 Change in mean body weight over time

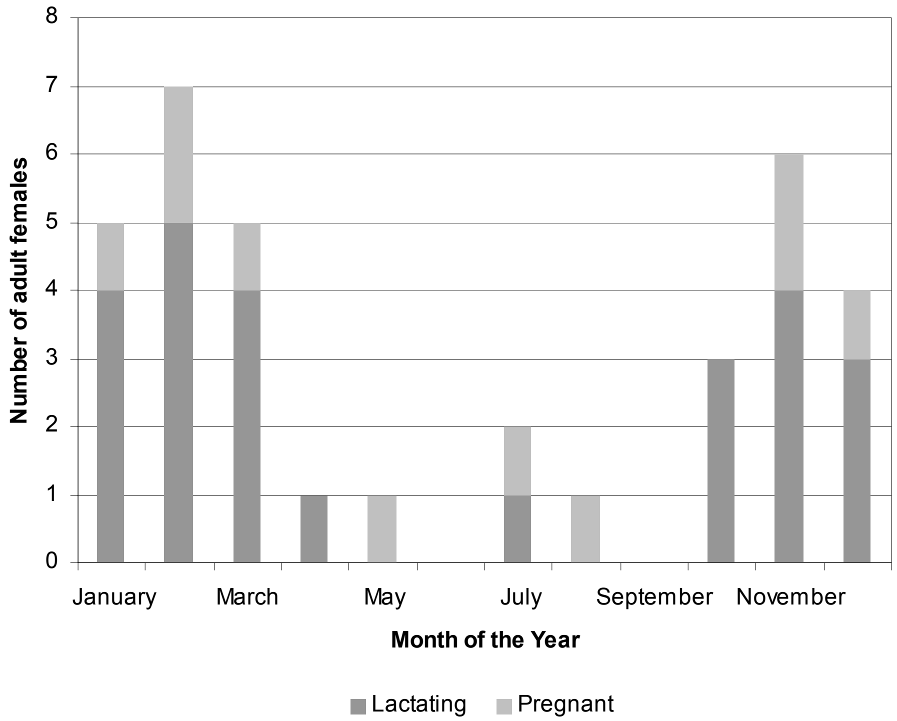

Figure 4.8 Seasonality of reproduction.
Reproductive activity and month were recorded for 37 female otters between 1992 and 2003. Once seasonality in numbers found was accounted for, there was no statistical evidence for seasonal reproduction.

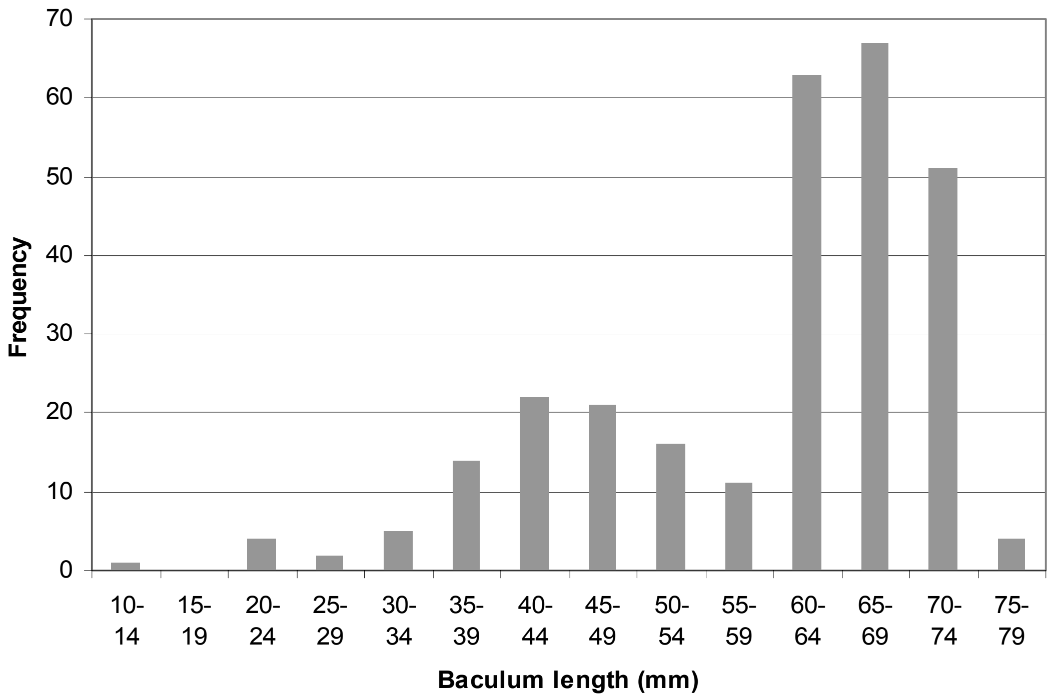

Figure 4.9 Length frequency distribution for baculae. Data pooled for 1992-2003, for 281 otters in which baculum length was recorded.

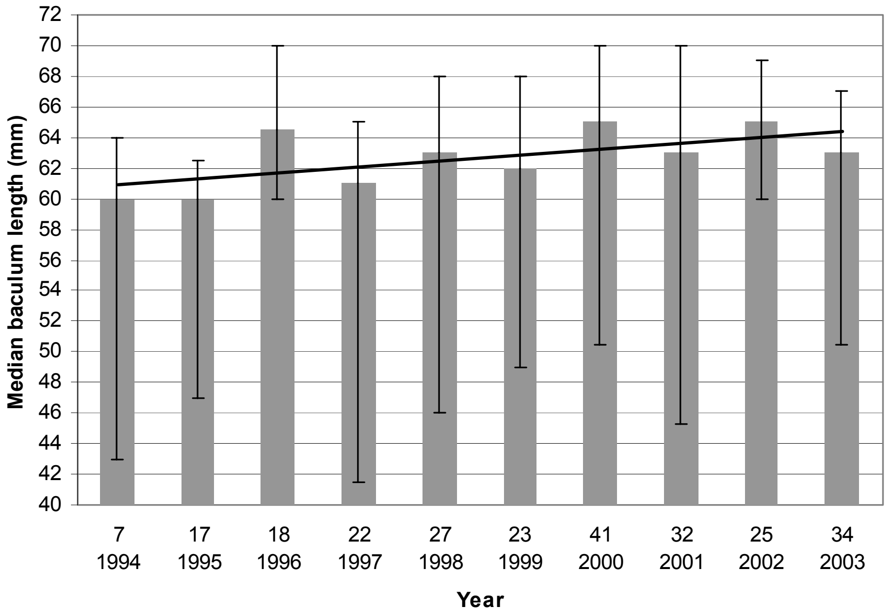

Figure 4.10 Change in baculum length over time. Y-error bars indicate upper and lower quartiles (25 and 75 per cent of the data distribution). The slight increasing trend is not statistically significant.

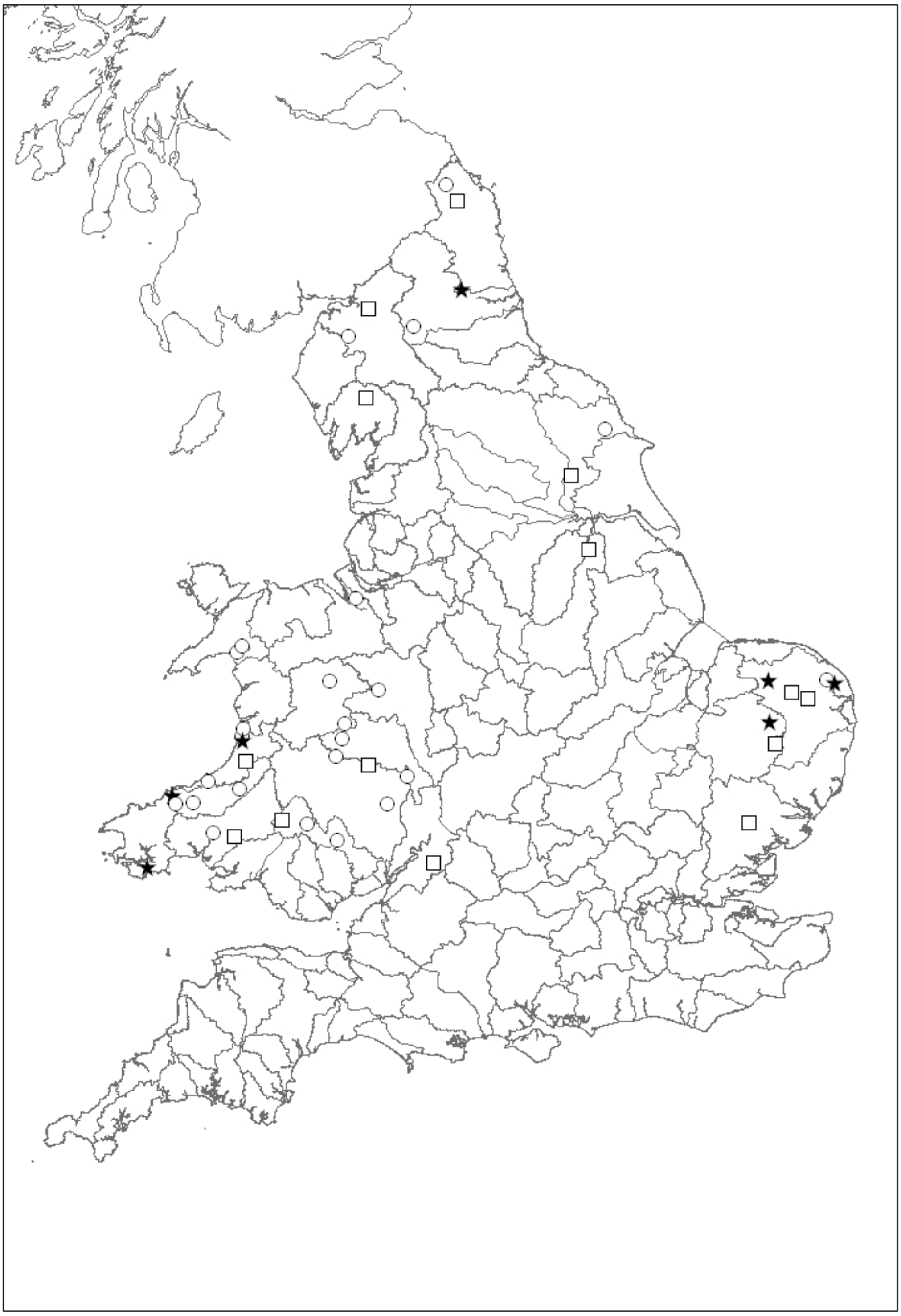

Figure 4.11 Distribution of 45 animals with renal calculi.
Staghorn calculi (★), moderate calculi (□) and miniscule calculi (○). Water catchments are outlined.

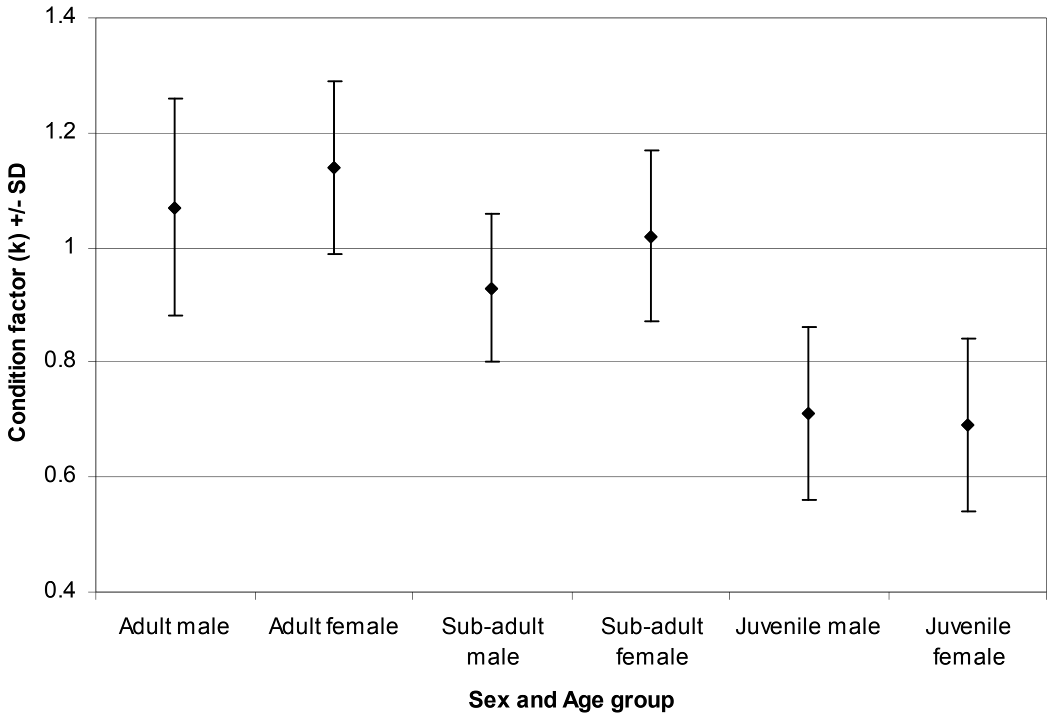

Figure 4.12 **Difference in condition factor with sex and age** for all animals 1992-2003. For sample sizes and descriptive statistics see Table 4.2.

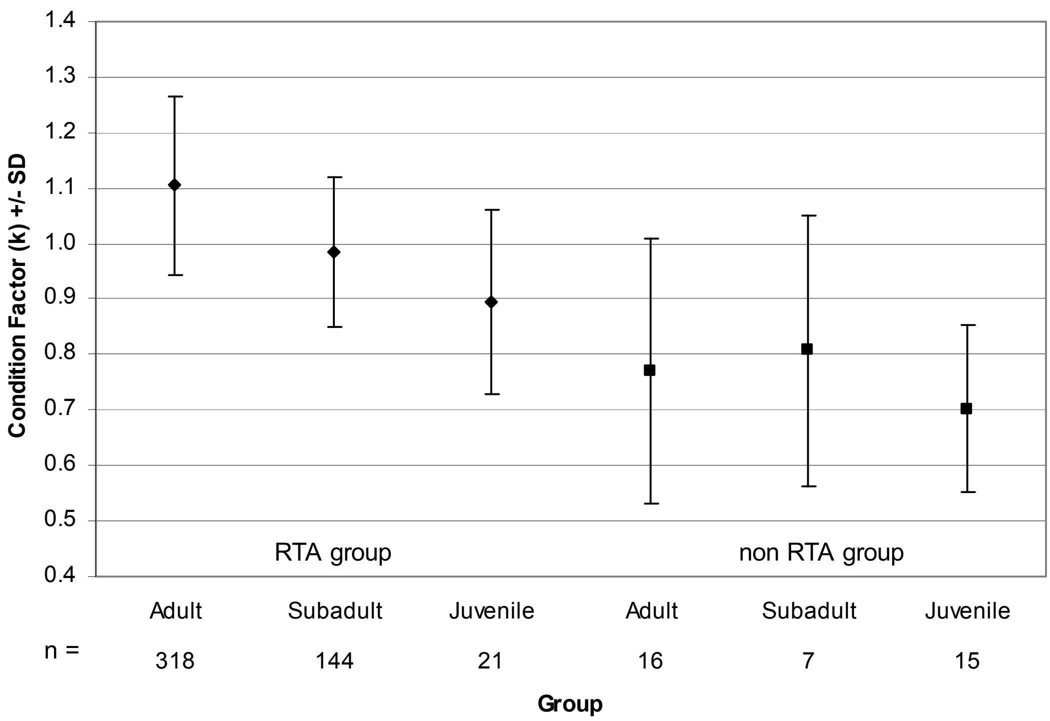

Figure 4.13 **Difference in condition factor with cause of death and age.** All animals, 1992-2003.

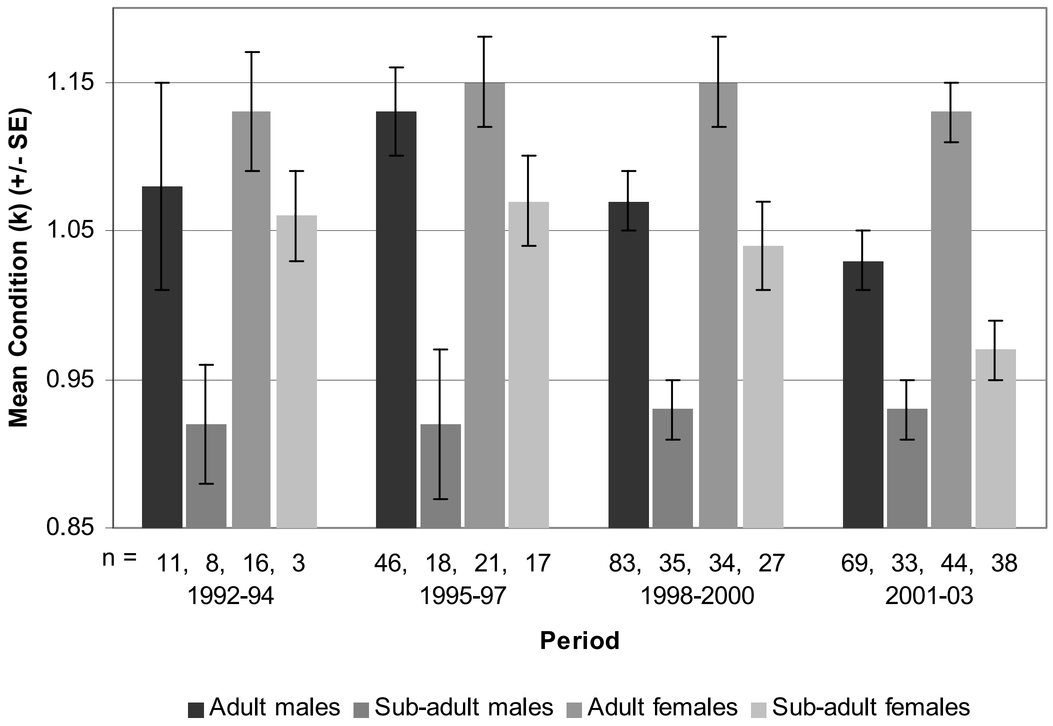

Figure 4.14 Change in body condition over time

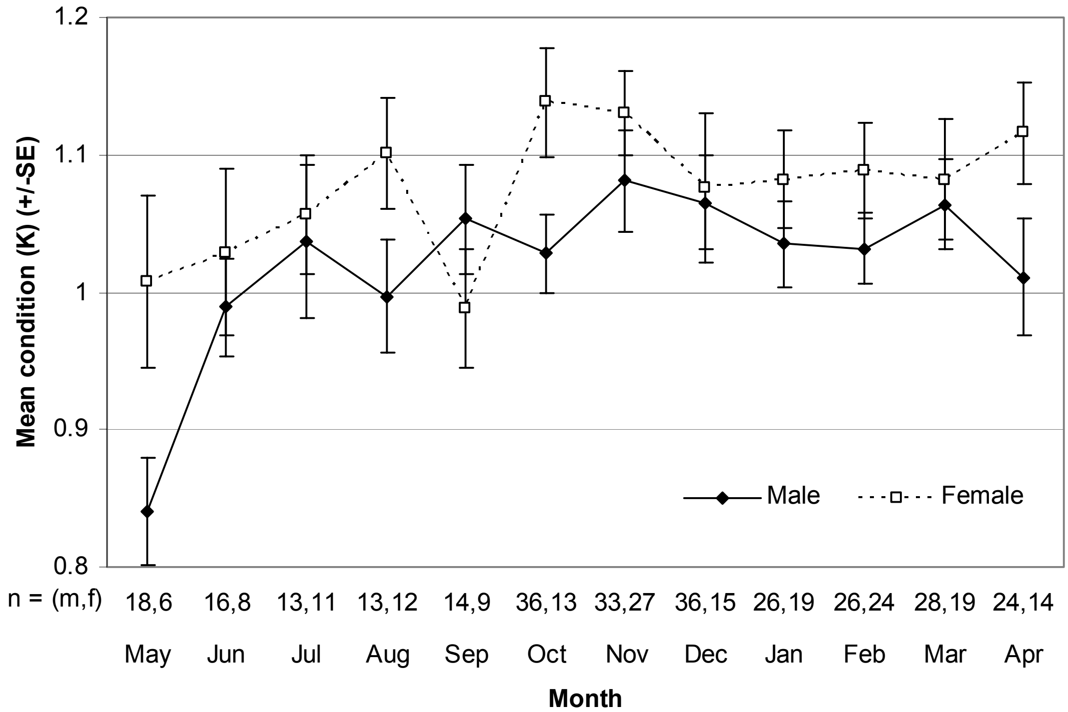

Figure 4.15 Seasonality in body condition. Juveniles are excluded and data are pooled for adults and sub-adults, 1992-2003.

Table 4.1 Totals found in each year, grouped by sex and age class

Sex and age class	Year '92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	Totals Known year	Year not known	Total
Adult male	1	3	8	11	23	16	19	27	45	29	27	27	236	21	257
Adult female	4	0	10	2	9	10	7	6	18	15	19	13	113	14	127
Sub-adult male	0	1	4	7	3	6	8	9	13	10	8	12	81	10	91
Sub-adult female	0	1	2	2	7	7	8	4	11	10	9	8	69	7	76
Juvenile male	0	0	0	0	0	4	3	1	2	3	3	1	17	0	17
Juvenile female	0	0	1	0	1	1	2	1	3	6	6	3	24	3	27
Totals															
Known sex and age class	5	5	25	22	43	44	47	48	92	73	72	64	540	55	595
Sex and age class unknown	0	0	0	0	0	0	0	1	2	5	0	3	11	3	14
Overall total	5	5	25	22	43	44	47	49	94	78	72	67	551	58	609

Table 4.2 Descriptive statistics for length, weight and condition. (Data are pooled from 1992-2003).

	Sex & Age-class	**n**	**Mean**	**SD**	**Min**	**Median**	**Max**	**Skew**	**Kurtosis**
Length (mm)	**Adult male**	213	1120	60	1000	1120	1308	0.23	0.16
	Adult female	118	1028	39	880	1028	1130	-0.44	1.88
	Sub-adult male	95	1004	74	845	1000	1185	0.07	-0.37
	Sub-adult female	88	935	83	710	960	1090	-0.76	-0.27
	Juvenile male	13	733	111	600	700	945	0.65	-0.77
	Juvenile female	8	620	67	550	603	750	1.14	0.86
Weight (kg)	**Adult male**	236	8.1	1.5	4.4	8.4	12.0	-0.43	-0.19
	Adult female	125	6.0	0.9	2.1	6.1	8.0	-0.90	2.37
	Sub-adult male	99	5.6	1.1	3.1	5.4	9.0	-0.25	-0.44
	Sub-adult female	87	4.5	1.1	2.2	4.6	6.8	-0.25	-0.44
	Juvenile male	13	2.0	0.5	1.2	1.8	2.9	0.23	-1.31
	Juvenile female	8	1.2	0.4	0.7	1.1	2	1.23	1.62
Condition (k)	**Adult male**	209	1.07	0.19	0.55	1.08	1.71	-0.01	1.18
	Adult female	115	1.14	0.15	0.63	1.14	1.66	-0.19	1.47
	Sub-adult male	94	0.93	0.13	0.61	0.93	1.43	0.38	1.94
	Sub-adult female	85	1.02	0.15	0.60	1.02	1.42	-0.27	0.50
	Juvenile male	11	0.71	0.15	0.48	0.70	0.94	0.02	-1.50
	Juvenile female	7	0.69	0.15	0.50	0.68	0.95	0.80	1.26

n = The number of animals for which data are available in a known sex & age-class
SD = Standard deviation, a measure of how dispersed the data are around the mean
Min = Minimum value
Max = Maximum value
Skew = Skewness, a measure of how skewed the data are from a normal distribution.
(Negative values indicate data are skewed to the left, positive values indicate that data are skewed to the right).
Kurtosis = A measure of how sharply peaked the distribution is.
(Negative values indicate the distribution is flattened, positive values indicate the peak is sharper than normal).

5 Chemical analysis

5.1 Changes to analytical methods

Because of changes in methodology (section 2.2) it was necessary to evaluate differences in chemical data before and after 2001.

The percentage occurrence of each determinand was assessed for samples measured prior to 2001 (batches E523 to EX0042) and samples measured after 2001 (batches EX0450 to EX0720). As shown in Table 2.2, samples analysed after 2001 include all samples from animals found in 2000 and over half those found in 1999.

Given a decrease in detection limits, it would be expected that percentage occurrence would increase for all determinands. The most marked change is in levels of isodrin, which prior to changes in methodology was found in less than one per cent of samples and after the change is found in 55 per cent of samples. Similarly, beta-HCH was found in less than one per cent of samples before the change and in 44% of samples after the change. Clearly, data from the two periods are not comparable for these determinands. This is true to a lesser extent for a number of others (Table 5.1). However, for pp'DDE and pp'TDE, percentage occurrence decreases after the change in method.

Data from these two periods are presented separately where possible and compared.

5.2 Exclusion of outliers

Preliminary screening of the data revealed a number of outliers, or extreme values. Post mortem information from all outliers was screened to see if there was a justifiable reason for excluding these data from analysis.

For example, data from UWC 212 were considerably higher than the median for several determinands. In this sample, the measured concentration of pp'DDE was 16,400 µg/kg, compared to <1100 µg/kg in 95 per cent of samples. Similarly, for pp'TDE, this sample measured 8500 µg/kg, compared to < 127 µg/kg in 95 per cent of samples. The animal in question was severely decomposed, and it is likely that this affected the resulting data.

Data from all samples were examined and outliers for each determinand are discussed. Where outliers originated from animals that were decomposed or in poor condition, with a condition factor significantly less than average, these values were excluded from further analysis of medians, trends over time or differences between Regions, so that they did not bias the conclusions. (It is known that when animals are poorly nourished and mobilise fat reserves, lipophilic compounds such as OCs and PCBs are released into the circulation and may be absorbed into the liver, causing elevated liver concentrations (Malcolm et al., 2003)). A small number of outliers originated from females that were pregnant or lactating. These were also excluded, because there were too few data to analyse the groups separately. Where there was no biological reason to exclude the data, they were included in further analyses.

5.3 Mean values

Given the skewed distribution of the data (see frequency distributions in the following sections), median values were used rather than arithmetic means, for most comparisons. These are less affected by extreme values than the arithmetic mean and are a more realistic measure of the average in extremely skewed distributions. It was not possible to use geometric means due to zero values. For comparison with other studies, arithmetic means are given alongside medians and maxima, for selected determinands (Table 5.2).

Table 5.1 **Percentage occurrence of each determinand.** Percentage occurrence is compared between samples analysed before and after changes in analytical procedure in 2001.

Determinand	Percentage occurrence Before 2001	After 2001	Change
Organochlorine pesticides			
op'DDT	1.5	17.0	+15.5
pp'DDT	9.2	3.3	-5.9
op'DDE	*	0.9	
pp'DDE	96.2	100.0	+3.8
op'TDE	*	3.8	
pp'TDE	76.7	66.0	-10.7
Alpha-HCH	1.5	3.8	+2.3
Beta-HCH	0.9	44.3	+43.4
Delta-HCH	*	2.4	
Gamma-HCH	3.0	9.0	+6.0
1,2,3 TCB	5.1	*	
1,2,4 TCB	0.8	*	
1,3,5 TCB	0.8	*	
Aldrin	0.8	0.0	-0.8
Dieldrin	97.0	99.0	+2.0
Endrin	1.6	1.9	+0.3
Isodrin	0.8	54.7	+53.9
Endo-A	2.3	*	
Endo-B	0.0	*	
PCBs – congener number			
8	*	0.5	
18	*	0.0	
20	*	0.5	
28	*	0.5	
31	0.8	0.0	-0.8
35	*	0.0	
44	*	0.0	
52	6.8	17.9	+11.1
66	*	8.2	
77	*	0.9	
101	15.9	32.1	+16.2
105	81.0	95.7	+14.7
118	91.0	98.0	+7.0
126	*	24.1	
128	*	95.3	
138	86.5	98.0	+11.5
149	*	11.3	
153	97.0	99.5	+2.5
156	74.4	96.6	+22.2
169	*	1.0	
170	*	99.5	
180	97.0	98.5	+1.5
187	*	100.0	
Other pollutants			
Atrazine	0.0	*	
Malathion	0.0	*	

	Percentage occurrence		
Determinand	Before 2001	After 2001	Change
Parathion Ethyl	0.0	*	
Parathion Methyl	0.0	*	
Simazine	0.0	*	
Trifluralin	2.4	*	
HC Benz	66.9	99.5	+32.6
HC Buta	1.5	*	

Note: * = not analysed

Table 5.2 Descriptive statistics for selected determinands. All concentrations are in µg/kg wet weight.

		Female							Male						
Pollutant	Period	n	Mean	SE	Q1	Median	Q3	Max	n	Mean	SE	Q1	Median	Q3	Max
pp'DDE	1	14	135.8	49.9	36	74	124	647	10	302.2	54.6	110	312	417	610
	2	23	155.5	34.5	65	113	215	754	44	316.2	55.6	122	190	305	1590
	3	36	241.1	45.3	65	111	304	1100	56	274.2	38.1	102	188	357	1620
	4	48	436.0	161	44	153	307	6360	79	351.1	61.0	81	189	361	4010
pp'TDE	1	14	12.2	4.1	3	6	15	52.6	10	46.1	15.8	7	15	93	124.3
	2	23	28.4	8.9	4	17	25	186	44	39.5	7.0	6	22	53	179
	3	36	15.6	4.8	0	0	18	96.1	56	25.6	6.4	0	0	34	254
	4	48	22.9	5.2	1	6	35	162	79	25.7	4.7	0	9	36	247
Dieldrin	1	14	127.0	46.0	32	61	129	531	10	181.7	78.4	54	88	228	854
	2	23	111.9	20.8	41	82	177	367	44	192.3	28.8	92	130	229	1020
	3	36	99.7	10.3	61	80	116	260	56	154.7	20.8	55	107	202	911
	4	48	164.1	26.4	48	103	233	943	79	169.5	22.8	51	112	224	1360
PCB118	1	14	20.3	6.1	8	14	21	75.2	10	49.4	11.5	13	52	88	105
	2	23	19.3	5.1	2	10	25	92.4	44	34.4	4.9	16	25	43	167
	3	36	26.4	7.7	6	10	24	205	54	32.8	5.0	11	22	39	213
	4	48	22.8	5.9	7	13	20	277	77	40.6	5.7	10	22	52	250
PCB153	1	14	84.9	25.3	38	46	88	304	10	247.3	93.7	42	98	422	958
	2	21	69.2	18.5	16	40	79	319	40	121.2	15.7	57	87	153	508
	3	25	131.8	49.9	26	49	96	1200	40	155.3	24.2	40	97	224	581
	4	45	86.1	24.5	26	42	87	1080	77	152.0	22.6	35	100	183	1170

Pollutant	Period	Female n	Mean	SE	Q1	Median	Q3	Max	Male n	Mean	SE	Q1	Median	Q3	Max
PCB180	1	14	34.5	8.2	12	28	46	120	10	128.8	61.6	22	33	220	631
	2	23	46.0	11.4	13	26	49	192	44	98.0	13.9	40	73	118	484
	3	36	76.1	30.9	17	25	42	997	56	106.1	17.9	28	58	129	647
	4	47	45.4	8.1	16	25	68	340	74	103.9	14.2	20	58	136	667

Note: Time period 1 = 1992-1994, 2 = 1995-1997, 3 = 1998-2000, 4 = 2001-2003.

Q1 and Q3 are the lower and upper quartiles (25% and 75%) of the of the data distribution

6 Organochlorine pesticides

Samples were tested for a variety of organochlorine pesticides, their derivatives and isomers. These included ortho-para (op) and para-para (pp) isomers of DDT and its derivatives DDE and TDE; the alpha, beta, gamma and delta isomers of HCH (gamma HCH is commonly referred to as lindane) and its derivatives (1,2,3 TCB, 1,2,4 TCB and 1,3,5 TCB); aldrin and its metabolite dieldrin, and their respective isomers isodrin and endrin and the alpha and beta isomers of endosulphan (referred to as endosulphan A and B).

Occurrence of most determinands, that is the percentage of samples with a concentration above the detection limit, was less than ten per cent both before and after changes in laboratory procedure (see Table 5.1). The exceptions to this were pp'DDE (96 per cent prior to the move and 100 per cent after), pp'TDE (77 per cent and 66 per cent), dieldrin (97 per cent and 100 per cent), op'DDT (1.5 per cent and 17 per cent), beta-HCH (0.9 per cent and 44 per cent) and isodrin (0.8 per cent and 55 per cent).

In terms of relative concentration, pp'DDE was the dominant contaminant, with a median concentration of 181 µg/kg wet weight, as compared to 103 µg/kg of dieldrin and 9 µg/kg of pp'TDE. For all other OCs, median values were below detection limits.

6.1 DDT (ortho-para isomer)

Of the 132 samples tested prior to the change in methodology, only two (1.5 per cent) tested positive.

One of these was from UWC 41, which was found near a trout farm and submitted as a suspected poisoning. It was a sub-adult male in poor condition, with grass in the stomach and no obvious injuries. However, it was extremely decomposed so detailed assessment was not possible and the state of the liver samples submitted is likely to have affected the accuracy of the results. The other positive sample was from UWC 65, which was also extremely decomposed. It seems likely that these positive results are erroneous, due to the state of the samples rather than the presence of op'DDT.

Following changes in analytical methods in 2001, op'DDT was found in 36 of 212 samples tested (17 per cent).

The frequency distribution of concentrations in Figure 6.1 suggests that values of up to 50 µg/kg are relatively normal. Six values tested above this, none of which were from decomposed or poor condition animals. The highest value (137 µg/kg) was from UWC 303, from the South East area of Wales. The spatial distribution of high values does not suggest any particular area of concern, with samples originating from EA Wales, the Midlands, North West and North East Regions. Too few values tested positive for further statistical analysis.

6.2 DDT (para-para isomer)

Of 133 samples tested prior to 2001, 12 tested positive (nine per cent). Of 212 samples tested after 2001, seven tested positive (three per cent).

Given that the decrease in detection limits should give an increase in positive sample identification, this suggests that the actual occurrence of pp'DDT has declined. However too few values tested positive to investigate this statistically.

Of the 19 positive values, 15 measured 7.5 µg/kg or below. Four values were higher than this. These were UWC 69 (14.1 µg/kg), 212 (31.1 µg/kg), 502 (51.2 µg/kg) and 540 (38.3 µg/kg). UWC 212 was decomposed and can be excluded. UWC 69 was a juvenile female in poor condition (k = 0.78), possibly abandoned. UWC 502 was a sub-adult male, also in poor condition (k = 0.84) with fighting injuries. Fat mobilisation due to malnutrition is likely to have affected these results, which should therefore be treated with caution. However, UWC 540 was an adult male, in normal condition with no abnormalities (found in Wales, Northern Region, Dee catchment, in 2002).

6.3 DDE (ortho-para isomer)

Prior to 2001, op'DDE was not tested for, so all data for this compound are from after the change in analytical methods.

Of 215 samples tested post-2001, three samples tested positive (1.4 per cent), all at a low level (2-4 µg/kg).

These were UWC 317 and 97 (2 µg/kg), and UWC 540 (4 µg/kg). UWC 317 was very decomposed so results may be erroneous. Animal UWC 97 was an adult male in normal condition. UWC 540 was also an adult male in normal condition (see section 6.2 above). There was no spatial correlation, as these animals came from the Midlands, the North West and EA Wales, respectively.

6.4 DDE (para-para isomer)

Of the samples tested prior to the change in analytical procedure, 128/133 tested positive (96 per cent). After the change, all 212 sample tested positive (100 per cent). Data were pooled for the two periods, because levels were above detection limits in virtually all samples prior to the change, so a drop in detection limits would have had little effect on the earlier data.

The frequency distribution in Figure 6.2 shows that the data are extremely skewed. The majority of values are between 100-200, with a steadily declining frequency after this to around 2200.

Outlying values were found in six individuals. Of these, UWC 8 and 69 were both juvenile females in poor condition (k = 0.66, and 0.78) and it is likely that mobilisation of fat reserves has produced anomalous results (2840 and 7110 µg/kg respectively).

The remaining four were all in normal condition, with no abnormalities, and tissues in a reasonable state (UWC 100, adult male, Anglian Region, North Essex catchment, 4050 µg/kg; UWC 579, sub-adult female, Anglian Region, East Suffolk catchment, 6360 µg/kg; UWC 614, adult female, Midlands Region, Severn Vale catchment, 4725 µg.kg and UWC 615, adult male, Anglian Region, North Essex catchment, 4010 µg/kg). It should be noted that three of these four extreme values were from Anglian Region.

Following exclusion of outliers UWC 8 and 69, the remaining values were pooled for further analyses.

6.4.1 Differences with sex, age class and length

Median levels of pp'DDE were significantly higher for males than for females (median values 193 and 117 µg/kg for males and females respectively, Kruskal Wallis test $p < 0.001$).

Differences between age classes show that levels were highest among juveniles, with median levels of 473, 135 and 203 µg/kg for juvenile, sub-adult, and adult males, and 484, 111 and 123.5 for juvenile, sub-adult, and adult females respectively. These differences were statistically significant for males but not for females (Kruskal Wallis test $p = 0.002$ [males] and 0.490 [females]).

Values for juveniles were excluded from further analyses and males and females examined separately.

Classification according to length shows no consistent trends for either sex (Figure 6.3) and a Kruskal Wallis test shows no significant differences in median values between length classes (for females, $p = 0.263$, for males $p = 0.678$).

6.4.2 Regional differences

For both males and females, levels were highest in the Midlands Region and this difference is considerable for males (Figure 6.4). Following exclusion of Thames Region due to small sample size, a Kruskal Wallis test showed that differences between Environment Agency Regions were significant for both sexes ($p = 0.009$ for males, $p = 0.016$ for females.

6.4.3 Change over time

Median values suggest a decline over time for males between 1992 and 1999, followed by an increase, and then a continued decline (Figure 6.5). It is likely that the increase in 2000 is due to the changing analytical procedure (although the change occurred in 2001, samples from 2000 were analysed after the change, see Table 2.2). However, no decline is apparent for females, in either period.

6.4.4 DDE

Neither males nor females showed any trend towards decreasing condition at higher concentrations of pp'DDE (Figure 6.6).

6.5 TDE (ortho-para isomer)

Prior to 2001, op'TDE was not tested for, so all data are from after the change in analytical methods.

Of 215 samples, only nine tested positive (four per cent), all at low level (1-9 µg/kg). The highest concentrations were measured in UWC 97, 445 and 540 (5, 7 and 9 µg/kg respectively). These were all fresh animals, with no abnormalities. Of the remainder, UWC 494, 528, 533 and 542 all had concentrations of only 1 µg/kg and UWC 317 and 542 had 2 µg/kg. UWC 317 was decomposed. UWC 494 was in poor condition, with fighting injuries and UWC 528 was pregnant. These factors may have affected the measured data. The sites of origin included the North West, Midlands, EA Wales and Anglian Regions.

6.6 TDE (para-para isomer)

Of 133 samples prior to the change, 102 (77 per cent) tested positive. Of 212 samples after the change, 140 (66 per cent) tested positive. Given that the decrease in detection limits should give an increase in positive sample identification, this suggests that the actual occurrence of pp'TDE has declined.

Because the change in detection limits has not had a marked impact on percentage occurrence, it is assumed that the data are comparable and both datasets are pooled for further analysis.

A frequency distribution showed the data to be skewed (Figure 6.7), with the majority of data (65 per cent) below 20 µg/kg. Frequencies decline steadily to approximately 250 µg/kg, above which there were only two samples, with concentrations of 409 and 430 µg/kg. These were both from poor condition juveniles (UWC 8 and 69). Sixteen other samples measured in the upper five per cent, with concentrations between 127 and 254 µg/kg. Of these, three were from decomposed animals so results can probably be discounted (UWC 45, 96 and 100) and one was a young animal in poor condition (UWC 547, sub-adult female, $k = 0.86$). The highest value for a normal condition animal was for UWC 156, from Wales (Cleddau and Pembs coast catchment), with a concentration of 254 µg/kg.

Data from decomposed or poor condition animals were excluded prior to further analysis.

6.6.1 Differences with sex, age class and length

The median level of pp'TDE is higher for males than for females (median values of 10.8 and 5.3 µg/kg for males and females respectively). This difference is close to statistically significant (Kruskal Wallis test, $p = 0.067$).

Median values of 17.8, 6.6 and 12.1 µg/kg were recorded for juvenile, sub-adult, and adult males, and 5.4, 7.6 and 5.2 µg/kg for juvenile, sub-adult and adult females respectively. Differences between age classes were not statistically significant for either males or females (Kruskal Wallis test $p = 0.232$ for males and $p = 0.966$ for females).

Values for juveniles were excluded from further analyses and males and females were examined separately.

Classification according to length shows no consistent trends for either sex (Figure 6.8) and the Kruskal Wallis test shows no significant differences in median values between length classes ($p = 0.435$ for females, $p = 0.487$ for males).

6.6.2 Regional differences

Percentage occurrence was similar between Environment Agency Regions, ranging from 67 per cent in North East and Midlands Regions, to 72 per cent in EA Wales.

Median concentrations in the North East, EA Wales and Anglian Regions were low (7-10 µg/kg), while those in the Midlands and North West were higher, up to 18 µg/kg for males in the Midlands and 23 µg/kg for females in the North West (see Figure 6.9). The latter median was based on a low sample size. Variability was high and the Kruskal Wallis test showed no significant difference in concentrations between Regions ($p = 0.450$ for males, $p = 0.400$ for females).

6.6.3 Change over time

Values of pp'TDE recorded in different years are shown in Figure 6.10. While there seems to be some drop in extreme values, the data were extremely variable over time, with no clear trend either before or after 2000.

6.6.4 Effect on condition

Neither males nor females showed any trend towards decreasing condition at higher concentrations of pp'TDE (Figure 6.11).

6.7 Alpha HCH

The occurrence of detectable alpha HCH was less than five per cent both before and after the change in analytical methods, so all the data were pooled.

Of 347 samples, only 10 tested positive (less than three per cent). All values were below 10, except one, UWC 103, which had a value of 41.8 µg/kg. This otter was an adult male from the Llyn catchment, North Wales. It had no abnormalities.

6.8 Beta HCH

Of 117 samples analysed prior to 2001, only one (less than one per cent) tested positive for beta HCH. After the upgrade in equipment in 2001, 94 of 212 (44 per cent) samples tested positive, indicating a reasonably high level of occurrence.

The single sample that tested positive prior to 2001 was from a juvenile female in poor condition from the North East Region (UWC 69, 84 µg/kg, $k = 0.78$).

All further analyses were carried out using only data measured after 2001.

Data from after 2001 show a skewed distribution, with 95 per cent of the data falling below 10 µg/kg, and 99 per cent below 30 µg/kg (Figure 6.12). Three individuals had values above this, UWC 502 (56 µg/kg), 376 (66 µg/kg) and 579 (174 µg/kg). Of these, animal 502 was an adult male in poor condition ($k = 0.836$) with fighting injuries. Animal 376 was a juvenile female in poor condition ($k = 0.682$) that had probably been abandoned. However, the highest level was recorded in animal 579, which was a sub-adult female in normal condition ($k = 1.008$), found in Anglian Region.

6.8.1 Differences with sex, age class and length

Since the majority of values were low or below detection limits, comparisons between sexes were made on the basis of percentage occurrence of beta HCH, rather than mean or median values.

For females, only 33 per cent of values were above the detection limit, while for males 47 per cent were above detection limit. Males and females were therefore analysed separately in comparisons between Regions and change over time.

There were too few values for juveniles to make any valid age comparisons and too few data to compare between length classes.

6.8.2 Regional differences

For females, the percentage occurrence was 33-34 per cent in EA Wales, the Midlands, North East and North West Regions and 50 per cent in Anglian Region. In Thames Region, none of the three samples tested were above the detection limit. However, sample size was low for several of the Regions (Figure 6.13).

For males, sample size was greater and the highest percentage occurrence was in Midlands Region (60 per cent, n = 20) followed by EA Wales (49 per cent, n = 57) (Figure 6.13). Levels in Anglian, North East and North West Regions were 44, 40 and 20 per cent respectively. Only one male sample originated from Thames and measured below the detection limit.

Differences between Environment Agency Regions were inconsistent between sexes, and are therefore not conclusive.

6.8.3 Change over time

Only four years' data are available since the change in methodology, so the evidence for change over time is limited and must be treated with caution (Figure 6.14). However, females show a decline in percentage occurrence from 52 per cent in 2000 to 21 per cent in 2003. Evidence for a decline in males is unclear, as levels in 2000 were low, but a declining trend is evident between 2001 and 2003, from 74 per cent to 47 per cent.

6.9 Delta HCH

Delta HCH was not tested for prior to 2001, so all data are from after the change in methods. Of 215 samples, only five tested positive (two per cent).

Values were low, ranging from one to 18. 3 µg/kg. Positive samples were from EA Wales (UWC 393, 528, 540), the Midlands (UWC 317) and the North East (UWC 455).

6.10 Gamma HCH

Prior to 2001, 132 samples were tested of which only four were positive (three per cent). Since 2001, 212 samples have been tested, of which 19 were positive (nine per cent).

The change in methodology clearly affects comparisons between the two periods, but occurrence remains low, and there are too few data in either period to perform statistical analyses.

The majority of values were below 10. Three samples had significantly higher values. Of these, two were juveniles in poor condition (UWC 499, a juvenile male from the

Cheviot catchment of the North East Region, with a gamma HCH value of 110 µg/kg, k = 0.56 and UWC 516, a juvenile female from Meirionydd catchment in Wales, gamma HCH 28.5 µg/kg, k = 0.50). The remaining sample (UWC 303, 33.7 µg/kg) was from an adult male, in good condition, from Wales (Wye area). The only abnormality in this case (UWC 303) was moderate renal calculi.

6.11 1,2,3 TCB

1,2,3 TCB was not tested for after 2001, so all data are from the period before the change in analytical methods. Of 118 samples, only six tested positive (five per cent).

Of these, three came from very decomposed animals (UWC 45, 57 µg/kg; UWC 87, 5 µg/kg and UWC 96, 36 µg/kg). The remaining three samples were reasonably fresh and the animals were in good condition. Two had renal calculi (UWC 64, 6 µg/kg, Anglian Region, Broadland Rivers and UWC 123, 9 µg/kg, Wales, N Ceredigion). The animal with the highest level of 1,2,3 TCB (73 µg/kg) was UWC 227, a sub-adult female in good condition with no abnormalities, from the North East Region.

6.12 1,2,4 TCB and 1,3,5 TCB

Neither 1,2,4 TCB or 1,3,5 TCB were tested for after 2001, so all data are from the period before the change in analytical methods. Of 123 samples tested for 1,2,4 TCB, and 133 samples tested for 1,3,5 TCB, only one sample (less than one per cent) tested positive, for both determinands.

This was UWC 201, a sub-adult male with no abnormalities, from the East Suffolk catchment of Anglian Region.

6.13 Aldrin

Of 130 samples tested before the change in methodology, only one tested positive (less than one per cent), at a low level (4.5 µg/kg). The animal (UWC 41) was the suspected poisoning discussed previously (Section 6.1). This result is likely to be erroneous due to decomposition of the sample.

Of 212 samples tested following the change in methodology, none tested positive.

6.14 Dieldrin

Of 133 samples tested prior to the change in methodology, 129 tested positive for dieldrin (97 per cent). Of 212 samples tested following the change 210 tested positive (99 per cent).

Since over 95 per cent of samples were above detection limits during both periods, the change in methodology probably had a negligible effect on the data, so all the data were pooled for further analysis.

The frequency distribution of concentrations is skewed (Figure 6.15), with 50 per cent of values below 100 µg/kg, and 95 per cent of values below 500 µg/kg.

Of the 22 samples with values above 500 µg/kg, four had renal calculi, an incidence rate of 22 per cent (compared to 11 per cent of all animals found between 1992 and

2000 and only 4 per cent of all animals found between 2001 and 2003). Most were from fresh samples, from animals in good condition with no abnormalities. The exceptions to this were UWC 69 (a juvenile female in poor condition, 786 μg/kg), UWC 564 (a pregnant female, 866 μg/kg) and UWC 572 (a sub-adult female in poor condition, 572 μg/kg). The two highest values were both from decomposed animals (UWC 96, 1400 μg/kg and UWC 100, 1710 μg/kg).These values were excluded prior to further analyses for regional and temporal differences.

6.14.1 Differences with sex, age class and length

Comparisons show that median dieldrin levels are significantly higher for males than for females (median values 121 and 80.5 μg/kg for males and females respectively, Kruskal Wallis test p = 0.018).

Data from males and females are therefore treated separately in all further analyses.

Median levels of 134, 93.3 and 145.5 μg/kg were recorded for juvenile, sub-adult and adult males, and 161, 69.3 and 91.3 for juvenile, sub-adult, and adult females respectively. These differences were not statistically significant for either males or females (Kruskal Wallis test p = 0.194 for males and p = 0.098 for females).

Levels of dieldrin increase with increasing length in male otters, for the first five length classes, after which they drop. Females showed no consistent pattern of dieldrin level related to length (see Figure 6.16). Kruskal Wallis tests showed no significant differences in median values between length classes (for females, p = 0.196, for males p = 0.511).

6.14.2 Regional differences

Concentrations were considerably higher in samples from the Midlands Region than from any other Region (Figure 6.17). A Kruskal Wallis test showed this different was significant (p = 0.019). Thames Region was excluded from the test because it had too few samples.

6.14.3 Change over time

Median values varied widely, with no decline over time (Figure 6.18). Examination of the data measured since 2000 suggests a possible downward trend for males, but not for females, and the degree of decline is well within the variability of the data.

6.14.4 Effect on condition

Neither males nor females showed any trend towards decreasing condition at higher concentrations of dieldrin (Figure 6.19).

6.15 Endrin

Prior to 2001, 128 samples were tested for endrin, of which only two were positive (1.6 per cent). Since 2001, 212 samples have been tested, of which four were positive (1.9 per cent).

Occurrence is clearly low and too few samples tested positive for statistical analysis.

Of the six samples that tested positive for endrin, all results were at low levels (0-9 µg/kg). Two were from very decomposed animals (UWC 57 & 317, both adult males) and two were in poor condition, one being a sub-adult female (UWC 512, k = 0.86) and the other an adult female with septicaemia (UWC 480, k = 0.73). The remaining two, UWC 84 (sub-adult female) and UWC 540 (adult male), were both in normal condition with no abnormalities.

6.16 Isodrin

Of the 120 samples tested for isodrin prior to 2001, only one tested positive (less than one per cent). Of the 212 samples tested since 2001, 116 tested positive (55%). Clearly the changes to the method made a large difference to interpretation of the data.

Data prior to 2001 were therefore excluded and all further analyses carried out using only data measured after the change in detection limits.

All values were below 30 µg/kg and show a gradually declining frequency distribution with no obvious outliers (Figure 6.20). The highest value (28.9 µg/kg) was from UWC 504, which was decomposed. Records were examined for the remaining top 5% of values and showed no unusual factors.

6.16.1 Differences with sex, age class, and length

Median values for males and females were 1.9 and 1.6 µg/kg respectively, and show no significant difference (Kruskal Wallis p = 0.615). Data for both sexes were therefore examined together.

Levels were higher for juveniles than for either sub-adults or adults (median values 6.9, 1.5 and 1.6 µg/kg respectively). Although these showed only a close to significant difference (Kruskal Wallis p = 0.076), data from juveniles were excluded prior to further analyses. There were too few data to examine differences with length.

6.16.2 Regional differences

Levels of occurrence and concentration were too low to make a meaningful comparison based on median values. Percentage occurrence varies from 38 per cent in Midlands Region (n = 32), to 67 per cent in North East Region (n = 27) (see Figure 6.21). In Thames Region only four samples were submitted, with two testing positive.

6.16.3 Change over time

Values prior to 1999 were not comparable. Since then, there has been a dramatic decline, from 92 per cent in 1999 (11/12 samples), through 79, 85, and 54 per cent in 2000-2002 (sample size 42, 27 and 48) to only 2 per cent (1/53 samples) in 2003 (Figure 6.22). Of the samples that tested positive, mean concentrations were between 8.1 and 8.9 µg/kg in 1999-2001, and 6.5 µg/kg in 2002. The single sample to test positive in 2003 had a concentration of only 2.9 µg/kg.

6.17 Endosulphan A

Endosulphan A was not tested for after 2001, so all data are from before the change in analytical methods.

Of 135 samples only three (two per cent) tested positive. These were UWC 13, 64 and 65. All values were low (four, seven and four µg/kg respectively). Animal 13 was an old female from Dyfed in Wales, found in 1994 with renal calculi and a respiratory infection, but its condition was reasonable (k = 1.09). Animals 64 and 65 were both from Anglian Region (one from Norfolk, one Suffolk, both in 1996). Both were in good condition (k above average) although animal 64 had moderate renal calculi. Animal 65 was very decomposed, which may have affected the chemical data.

6.18 Endosulphan B

Endosulphan B was not tested for after 2001, so all data are from the period before the change in analytical methods.

Of 50 samples tested, none tested positive.

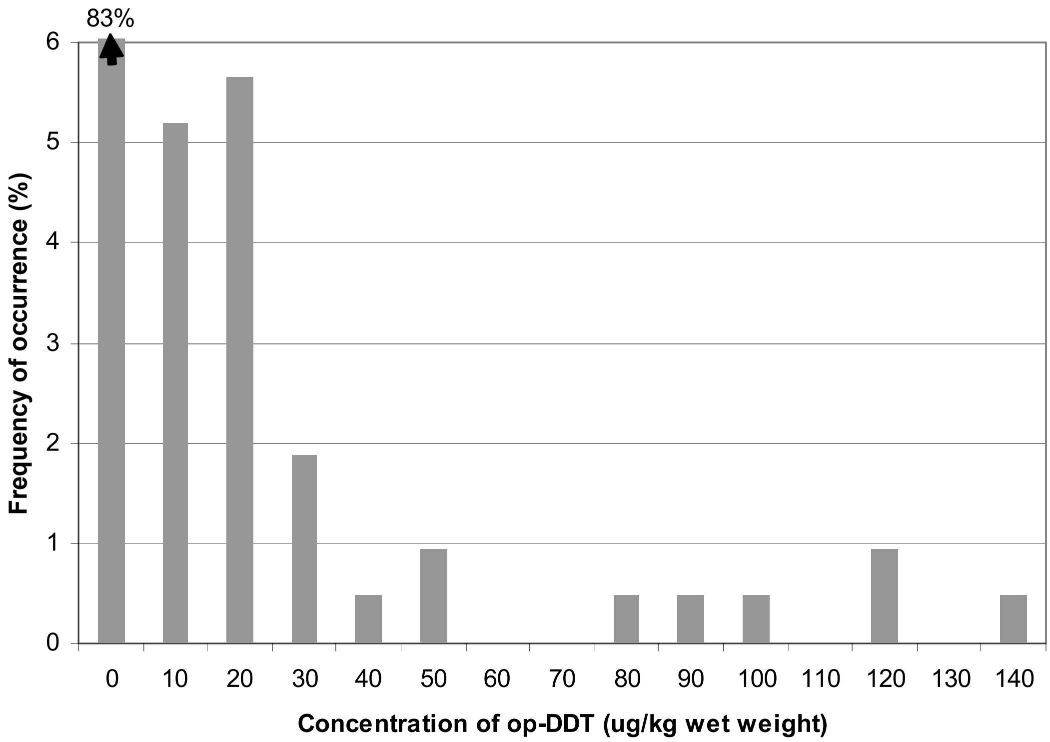

Figure 6.1 Frequency distribution of op'DDT concentrations. Values given along the x-axis are the upper limit of concentration for samples in that category. The category ranges are 0, 0.01-10, 10.01-20 and so on.

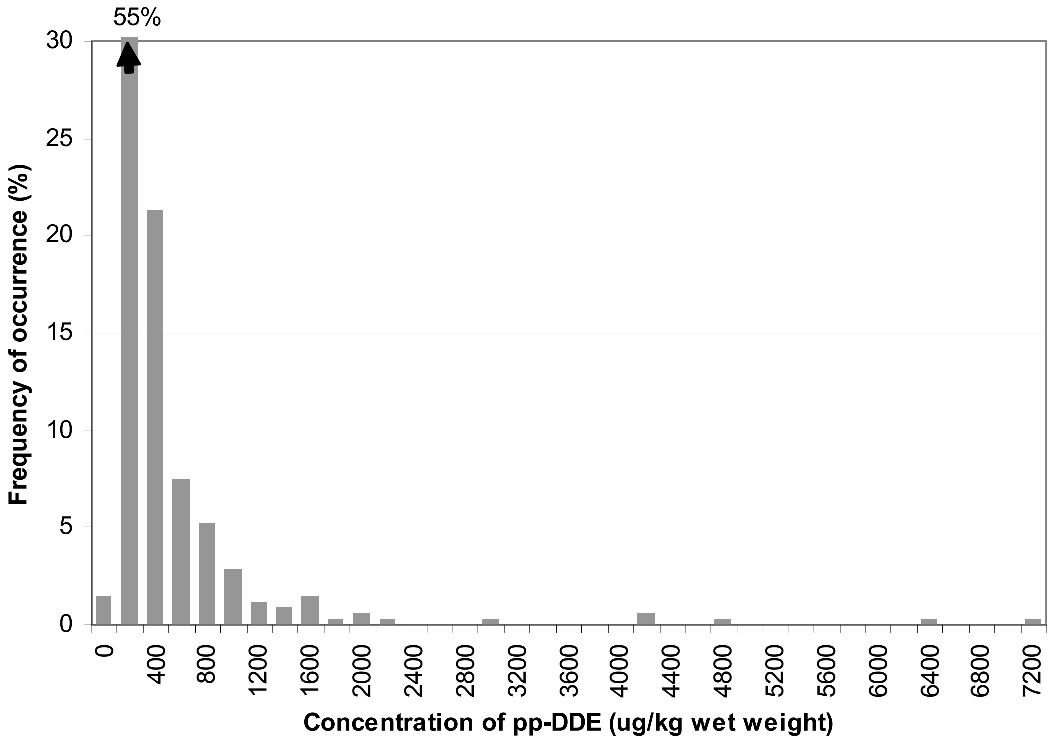

Figure 6.2 Frequency distribution of pp'DDE concentrations. Values along the x-axis are the upper limit of concentration for samples in that category.

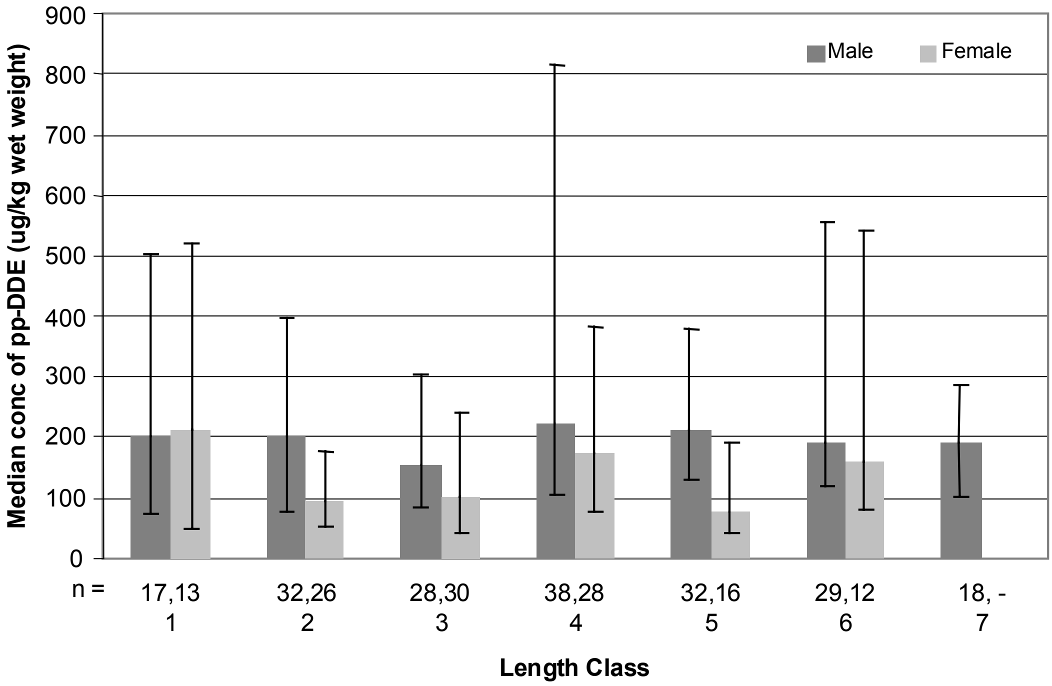

Figure 6.3 Difference in pp'DDE with sex and length. Length classes are defined in mm as follows: males 1 = 600-940, 2 = 941-1030, 3 = 1031-1070, 4 = 1071-1110, 5 = 1111-1140, 6 = 1141-1180, 7 = 1181-1310; females 1 = 550-870, 2 = 871-960, 3 = 961-1000, 4 = 1001-1030, 5 = 1031-1060, 6 = 1061-1120. Y-error bars indicate the upper and lower quartiles of data distributions.

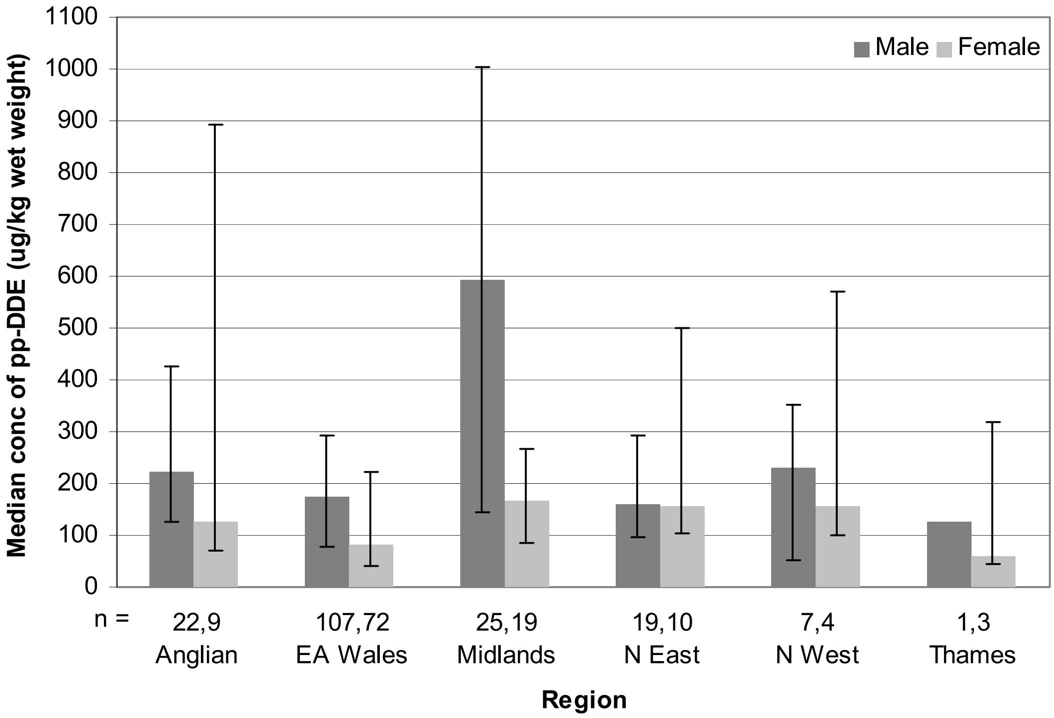

Figure 6.4 Difference in pp'DDE between Environment Agency Regions. Y-error bars indicate the upper and lower quartiles of data distributions.

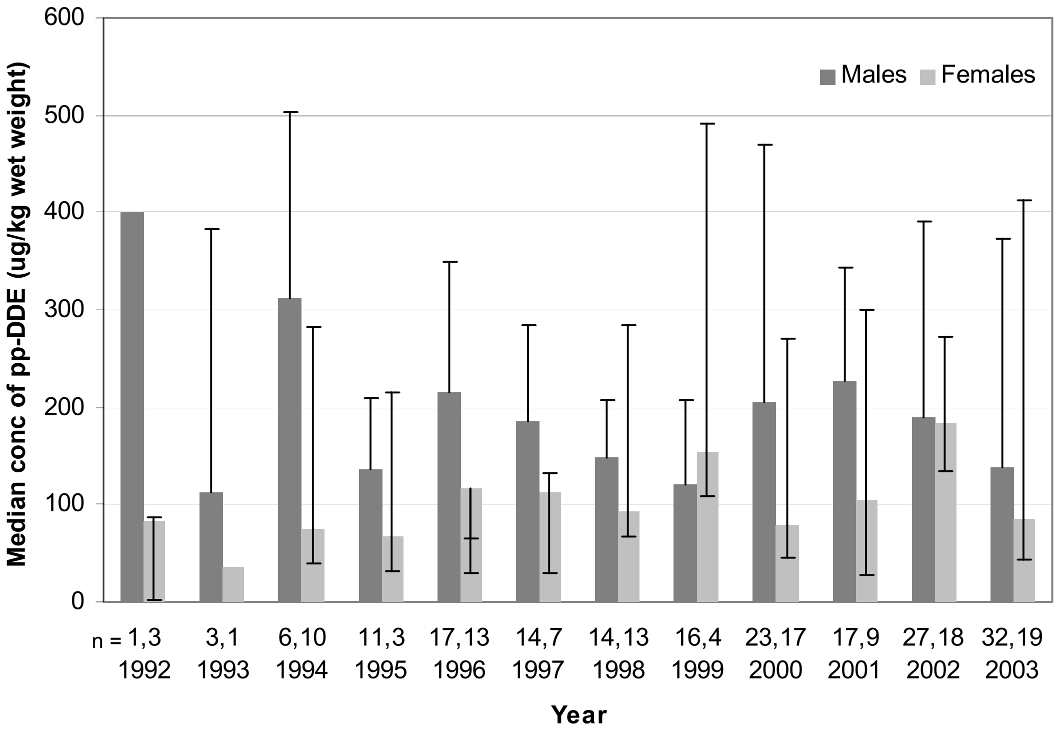

Figure 6.5 Change in pp'DDE with time. Y-error bars indicate the upper and lower quartiles of data distributions.

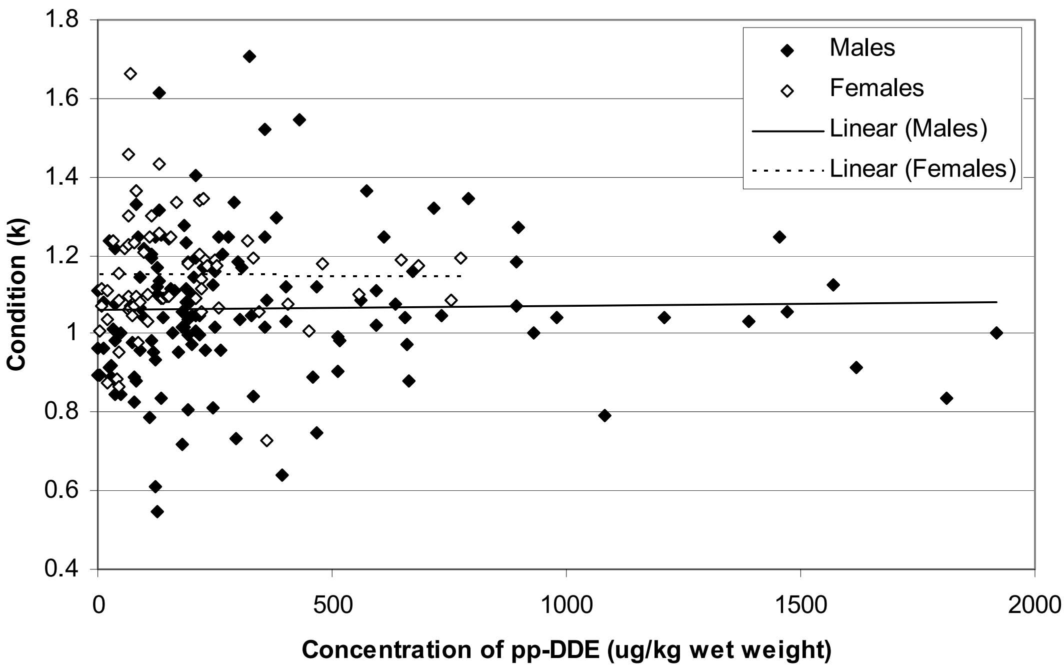

Figure 6.6 Concentration of pp'DDE versus otter condition (k).

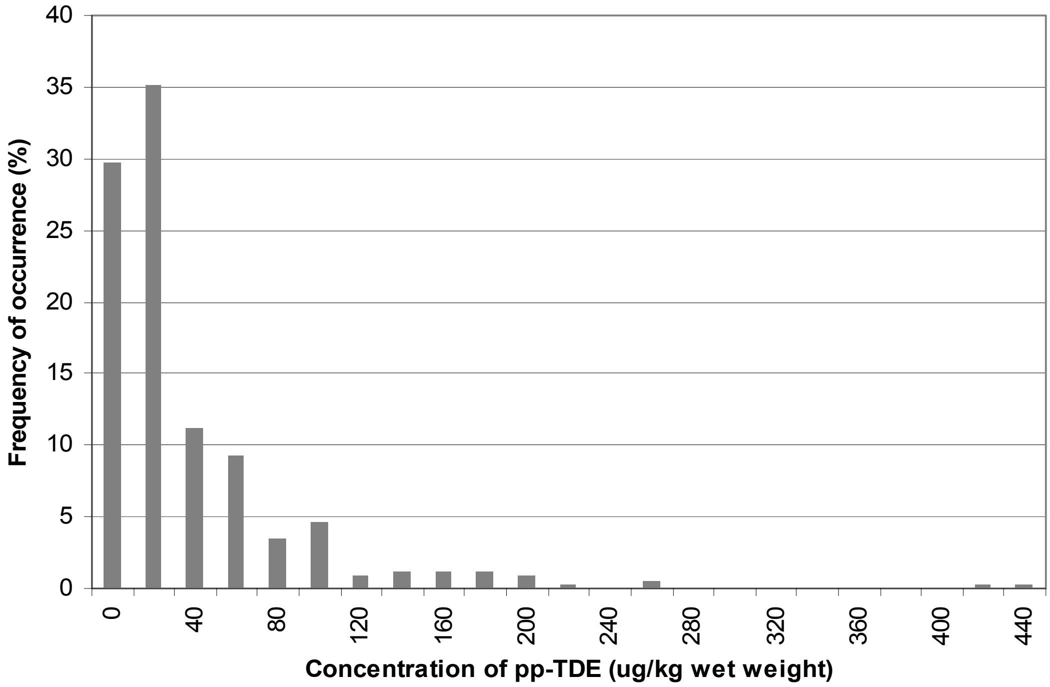

Figure 6.7 **Frequency distribution of pp'TDE concentrations.** Values given along the x-axis are the upper limit of concentration for samples in that category.

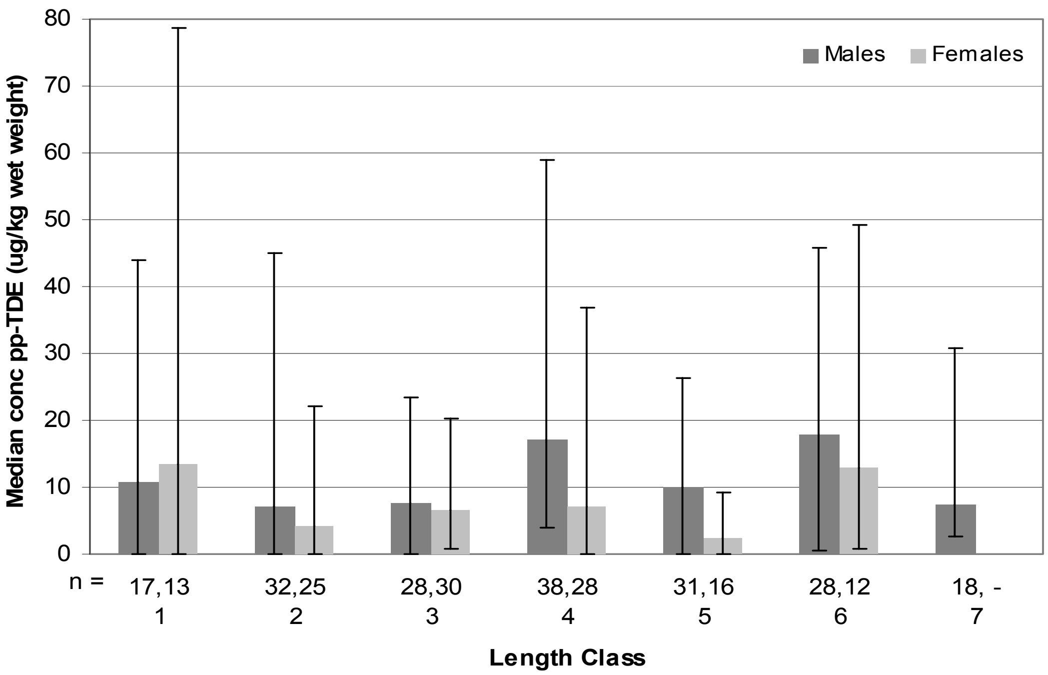

Figure 6.8 **Difference in median pp'TDE with sex and length.** Length classes are defined as in Figure 6.3. Y-error bars indicate the upper and lower quartiles of data distributions.

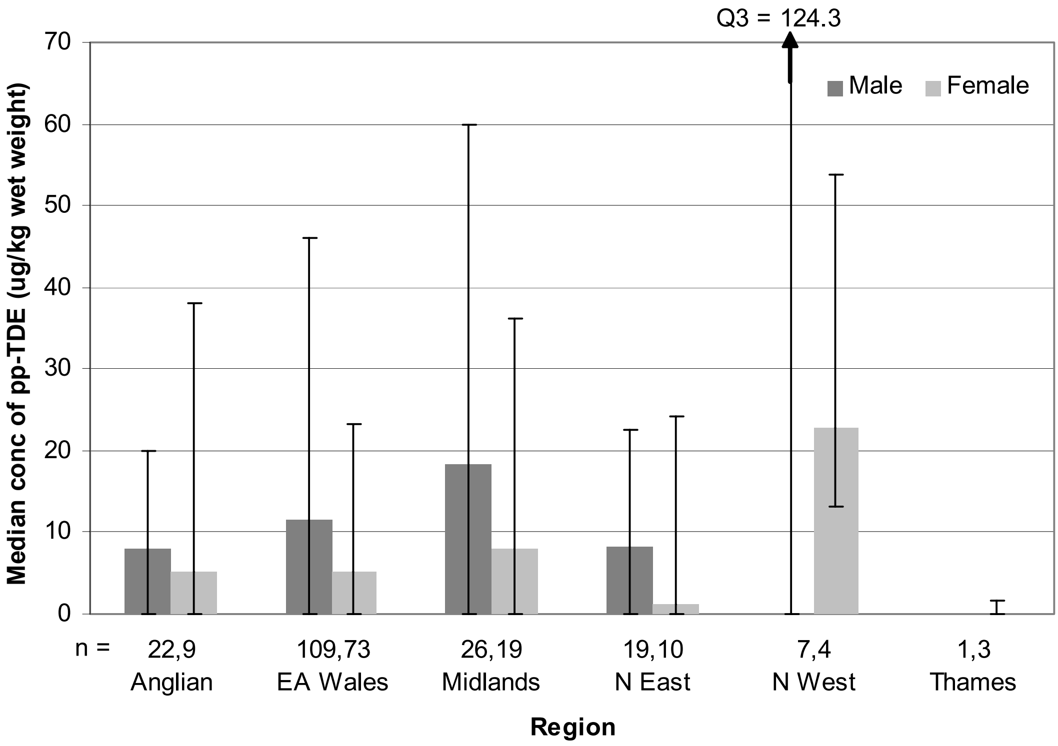

Figure 6.9 **Difference in pp'TDE between Environment Agency Regions.** Y-error bars indicate the upper and lower quartiles of data distributions.

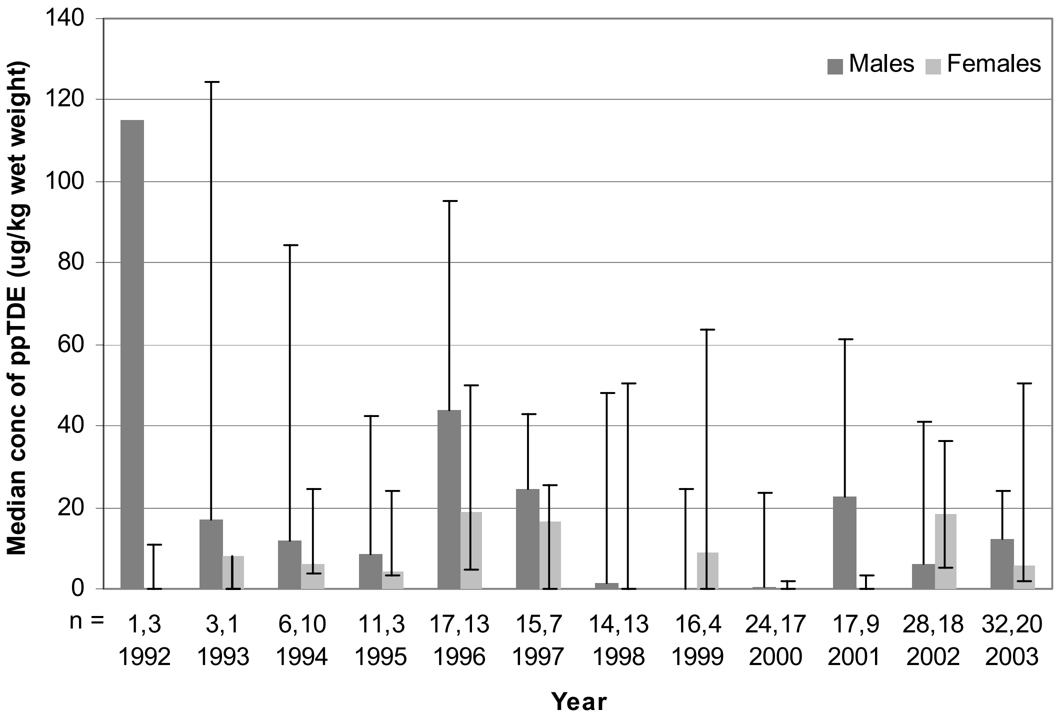

Figure 6.10 **Change in pp'TDE with time.** Y-error bars indicate the upper and lower quartiles of data distribution.

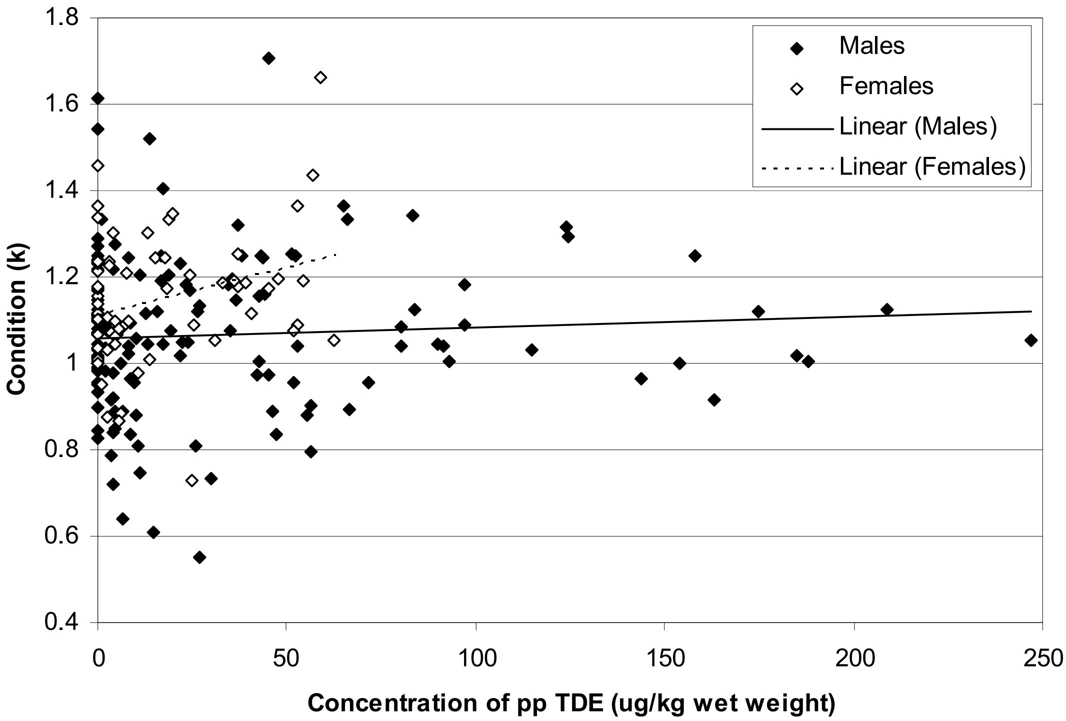

Figure 6.11 Concentration of pp'TDE versus otter condition (k).

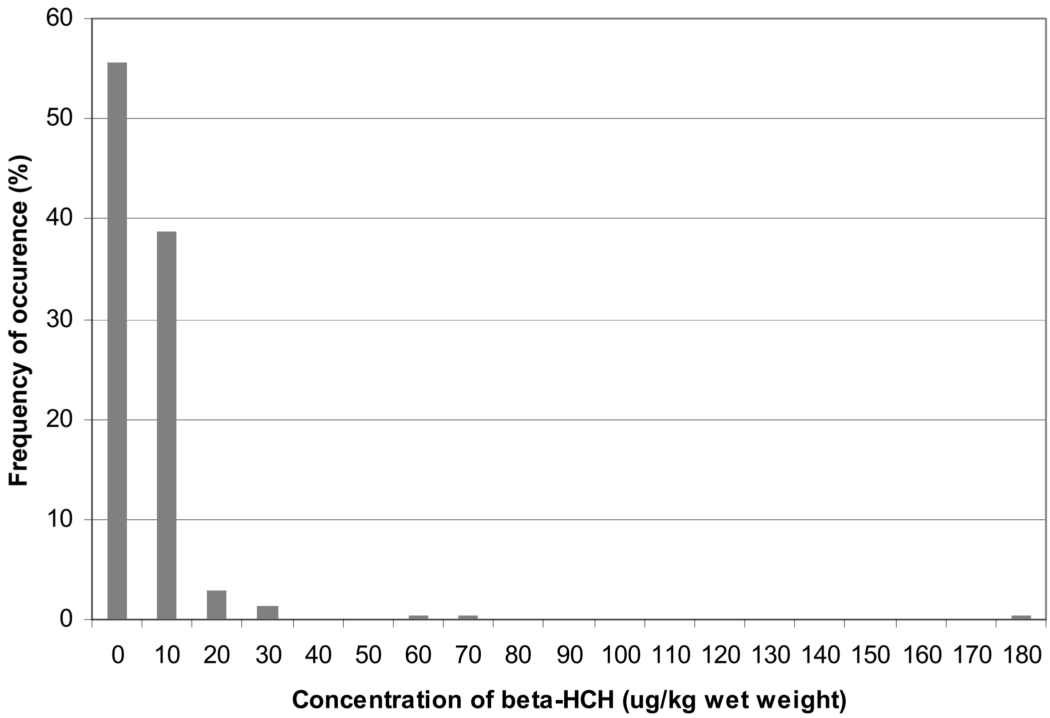

Figure 6.12 Frequency distribution of beta-HCH concentrations Y-error bars indicate the upper and lower quartiles of data distributions.

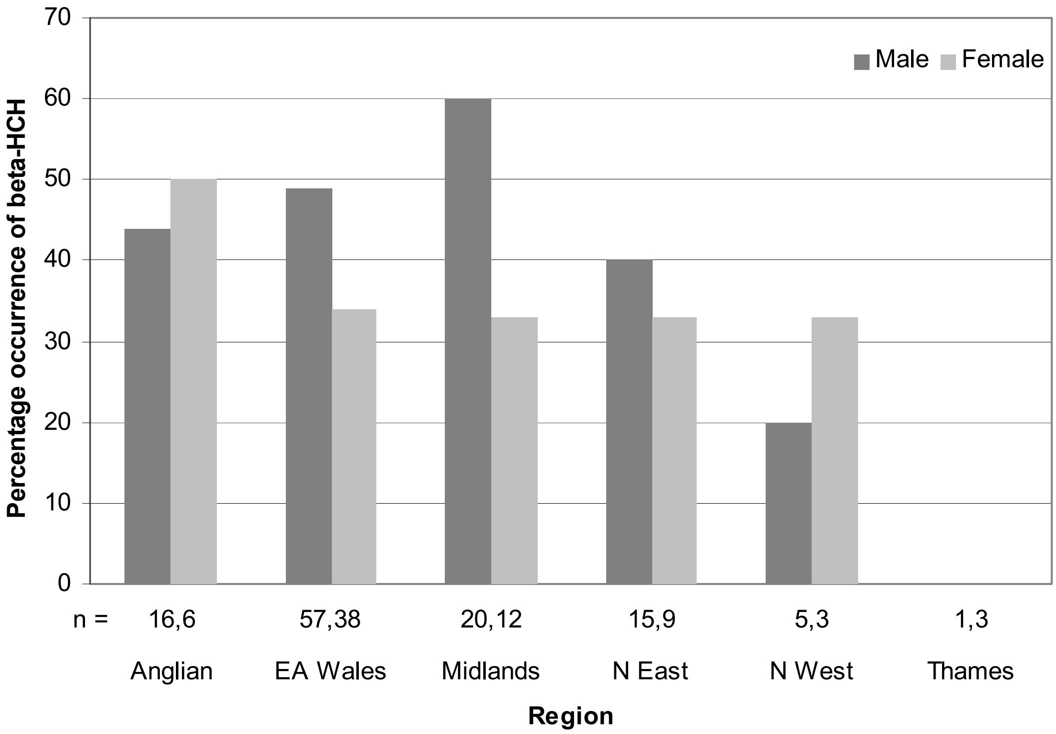

Figure 6.13 Difference in beta-HCH between Environment Agency Regions. Values are given as percentage occurrence rather than median concentrations due to the low number of values above zero.

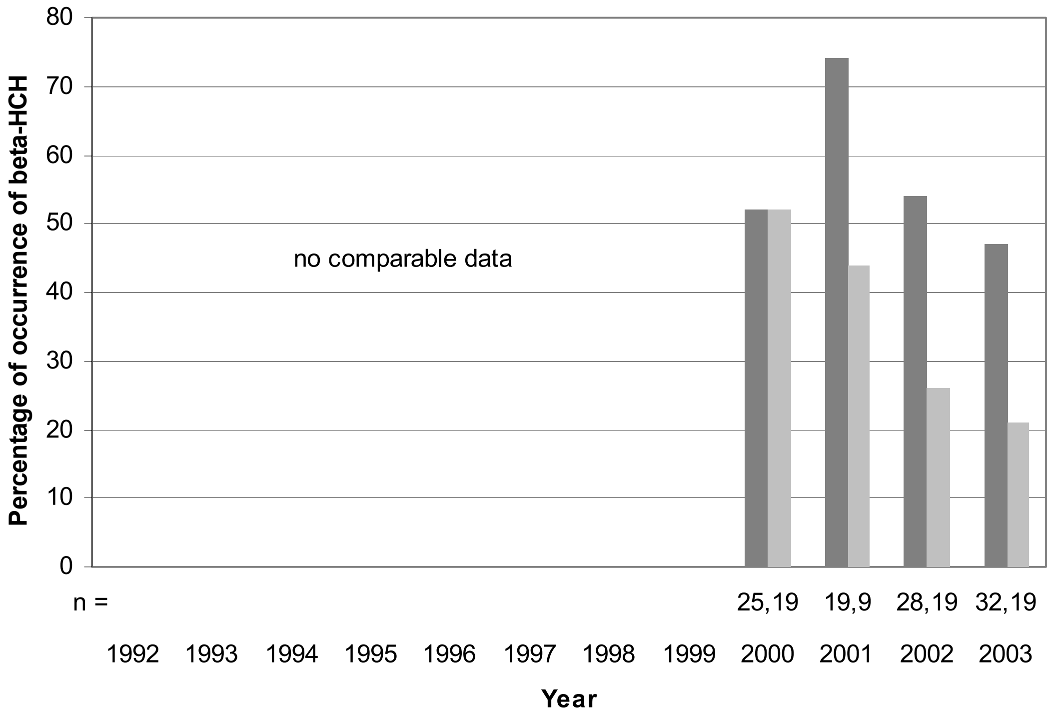

Figure 6.14 Change in beta-HCH over time. Values are given as percentage occurrence rather than median concentrations due to the low number of values above zero

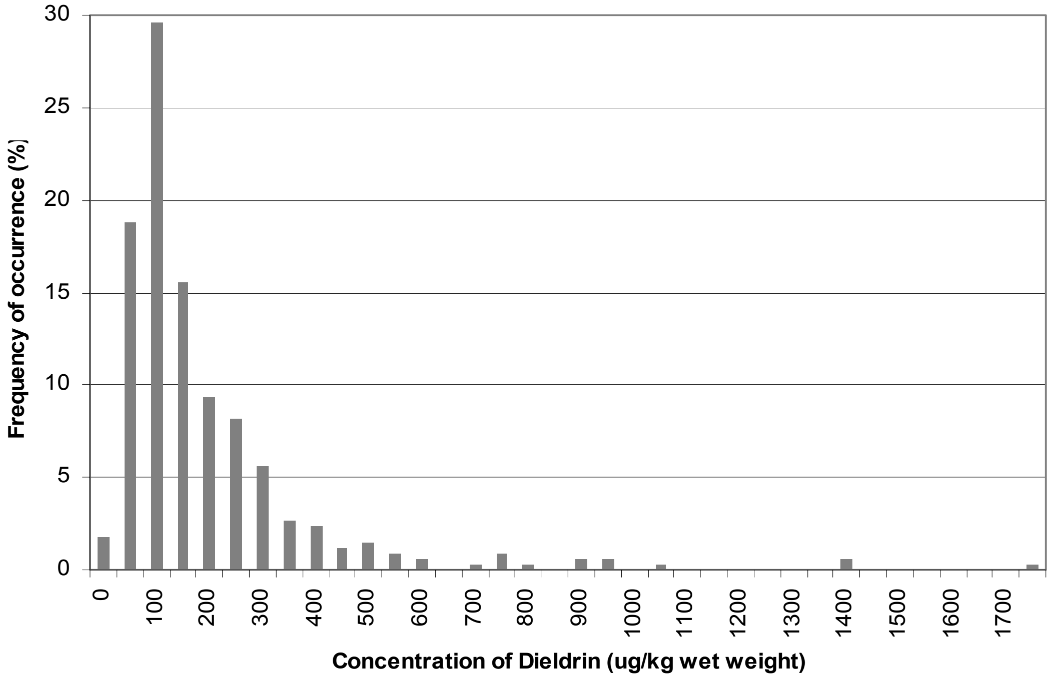

Figure 6.15 Frequency distribution of dieldrin concentrations. Values given along the x-axis are the upper limit of concentration for samples in that category.

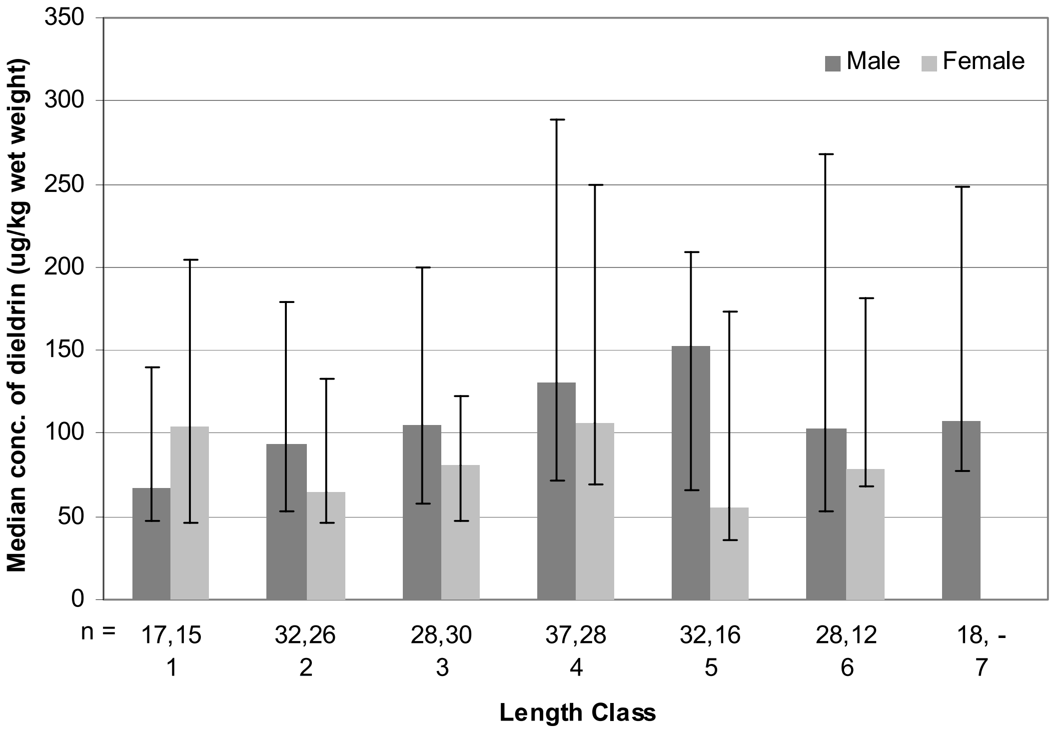

Figure 6.16 Difference in dieldrin with sex and length. Length classes are defined as in Figure 6.3. Y-error bars indicate the upper and lower quartiles of data distribution.

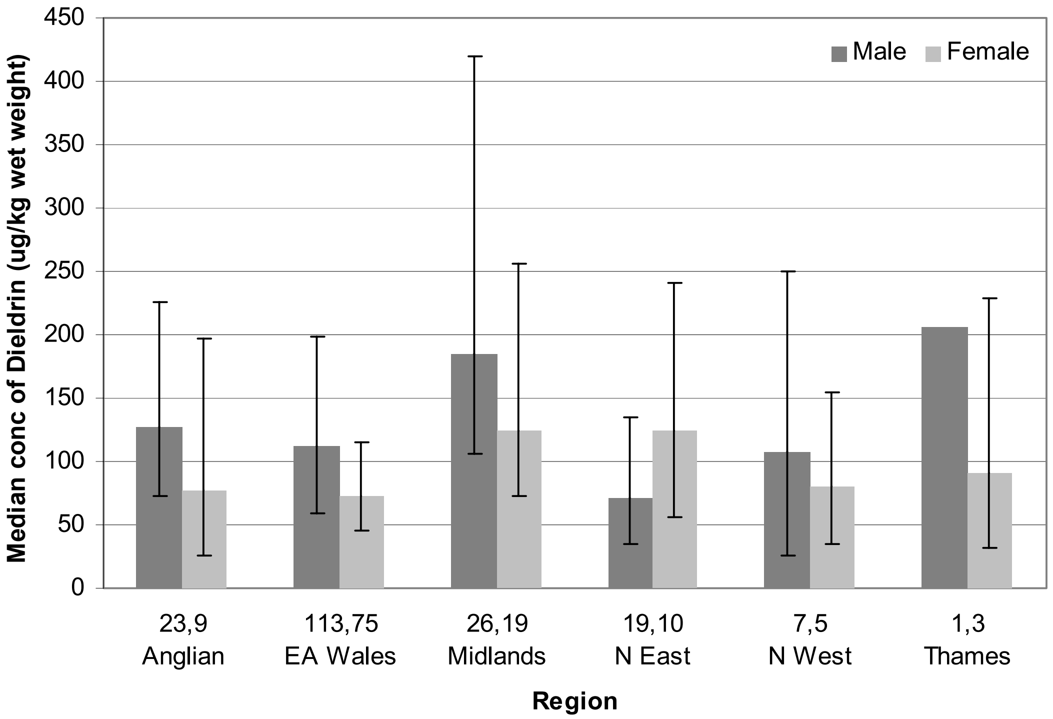

Figure 6.17 Differences in dieldrin between Environment Agency Regions. Y-error bars indicate the upper and lower quartiles of data distribution.

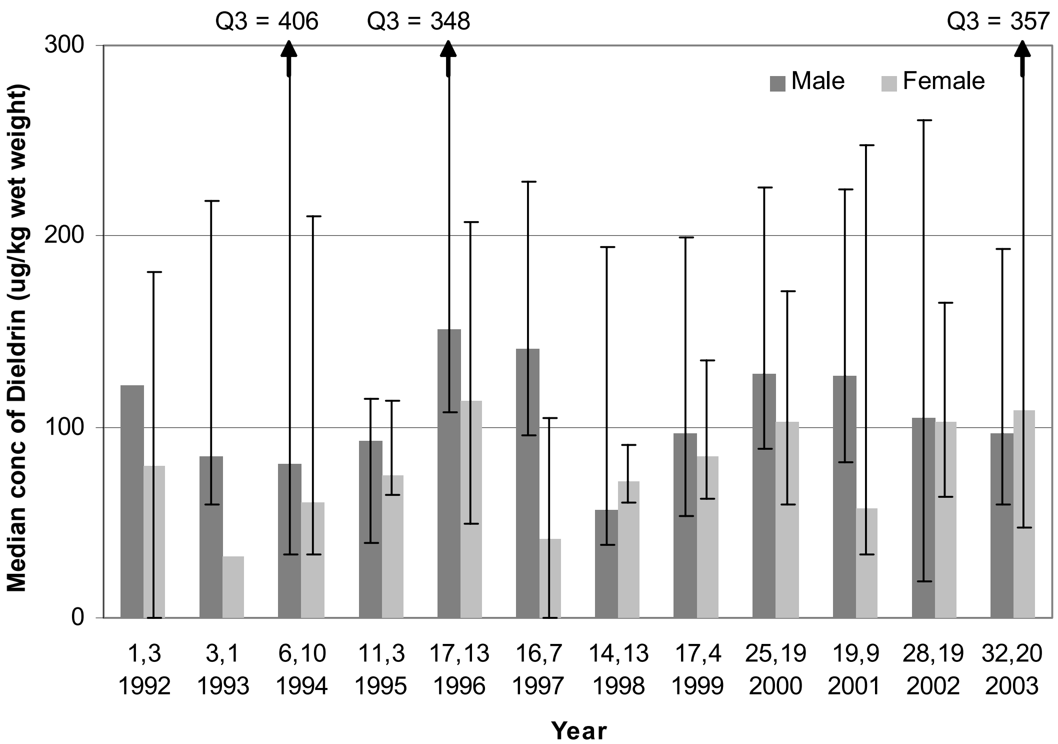

Figure 6.18 Change in dieldrin concentration over time. Y-error bars indicate the upper and lower quartiles of data distribution.

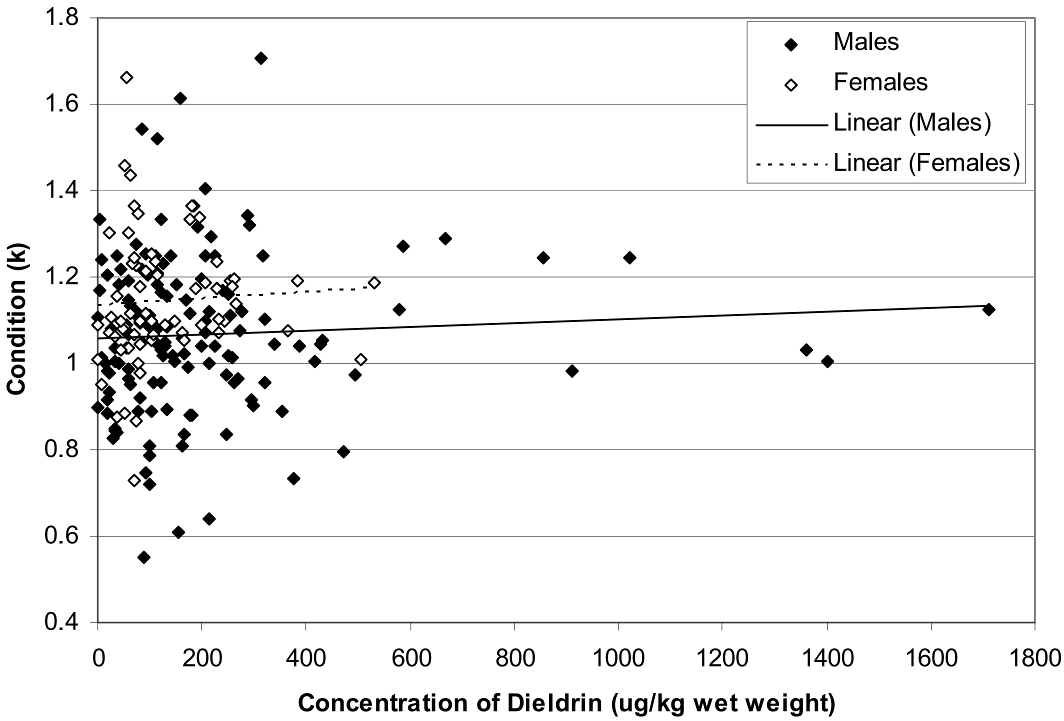

Figure 6.9 Concentration of dieldrin versus otter condition (k).

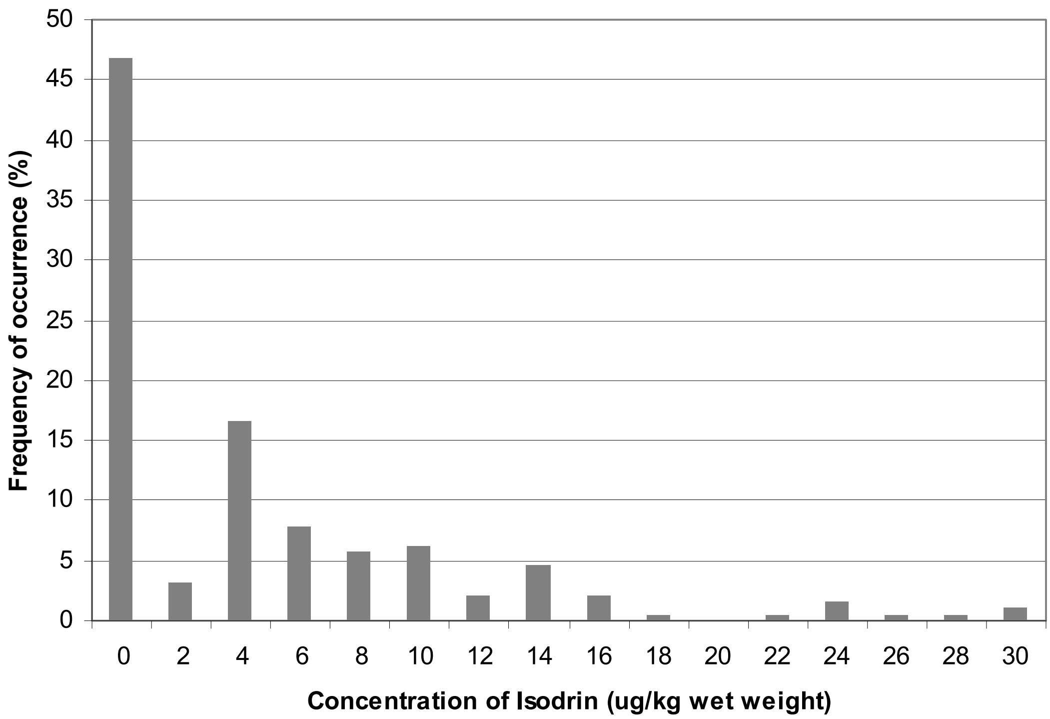

Figure 6.20 Frequency distribution of isodrin concentrations. Values given along the x-axis are the upper limit of concentration for samples in that category.

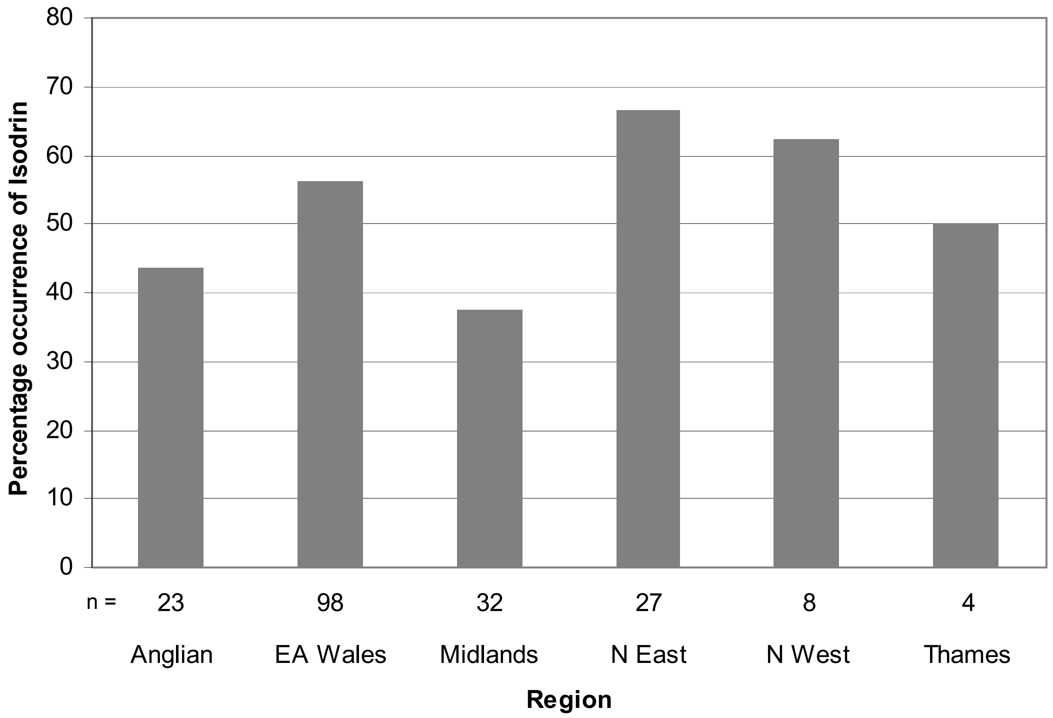

Figure 6.21 Differences in isodrin occurrence between Environment Agency Regions.

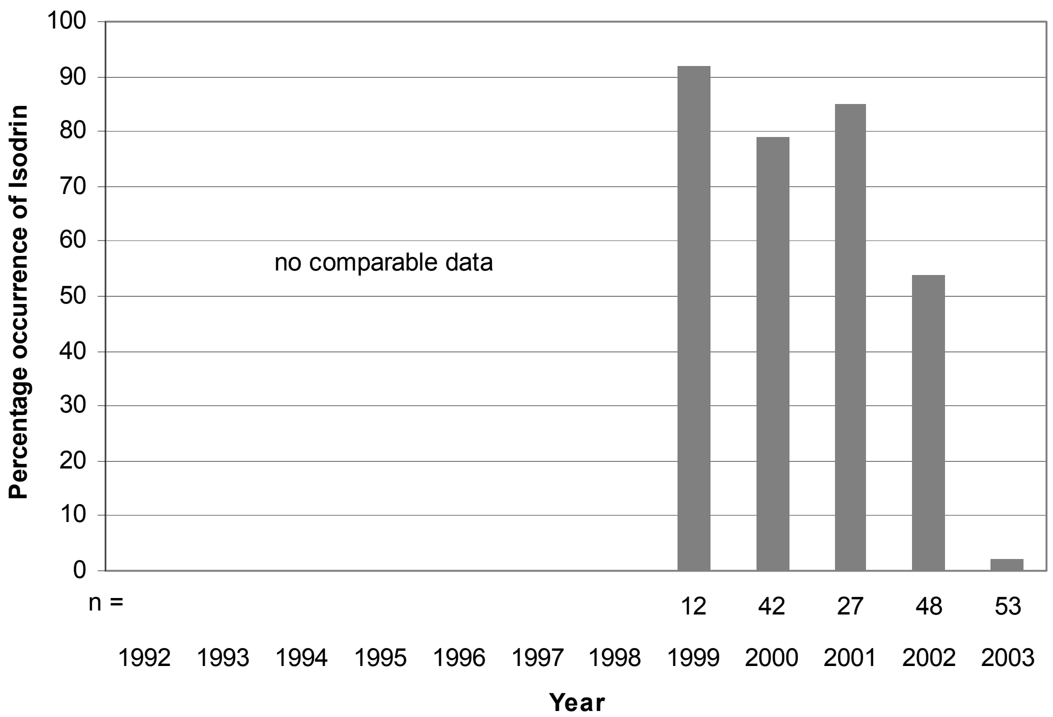

Figure 6.22 Change in isodrin occurrence over time.

7 Polychlorinated biphenyls

7.1 Percentage occurrence and concentration

Levels of nine PCB congeners have been monitored since the outset of this project. Currently 23 congeners are monitored (See Table 2.1).

Of these, congeners 8, 18, 20, 28, 31, 35, 44, 77 and 169 were found in one per cent or less of samples and are not considered in any further analyses.

During the period following changes in analytical technique, nine PCB congeners were found in more than 95% of samples. These were congeners 105, 118, 128, 138, 153, 156, 170, 180 and 187. Of these, congeners 128, 170 and 187 were not monitored before the change and congeners 105, 138 and 156 were previously found at lower levels of occurrence (81, 87 and 74 per cent respectively). This increase in occurrence reflects the decrease in detection limits.

In terms of relative concentrations, the dominant congener was 153, with a median concentration of 72 µg/kg wet weight. This compares to 52 µg/kg for congeners 187 and 138, 45 µg/kg (congener 180), 22 µg/kg (congener 170), 18 µg/kg (congener 118) 9 µg/kg (congener 128), 7µg/kg (congener 156) and 6ug/kg (congener 105). All other congeners had medians below detection limits.

7.2 Approach to analysing PCB levels

For congeners where concentrations were measurable in more than 10 per cent of samples in either period, Spearman’s rank correlation coefficients were calculated for each pair of values. Values are highly correlated between different PCB congeners (Table 7.1). Correlation coefficients are low only for the less commonly occurring PCBs where the number of measured values on which the correlation was based was low.

As a result of these correlations between different congeners, analyses that are based on a restricted number of congeners can be considered likely to reflect the whole.

Two approaches were taken in analysing PCB levels:

1) To maximise the period of time spanned by analyses, congeners that were not monitored throughout were excluded. Also, congeners detected in less than 95 per cent of samples in either period were excluded, to minimise bias due to changing detection limits. The remaining congeners were 118, 153 and 180, for which there were, respectively, 311, 278 and 313 data points.

2) To maximise the number of significantly occurring congeners in an index of ‘total PCB’, the nine most commonly occurring congeners (listed above) were summed. However, this excludes data prior to 2001, when all nine were not measured, so it substantially reduces the sample size to 178 samples.

For samples where ‘total PCB’ was calculated and data for congeners 180, 153 and 118 were available, Spearman’s rank correlation shows that ‘total PCB’ values are highly correlated with the values for these individual congeners (r = 0.915, 0.972 and

0.924 respectively, $p < 0.001$ in all cases). It therefore seems likely that 'total PCB' is representative of individual congeners.

7.3 Differences with age, length and sex

The median concentrations of 'total PCB' and congeners 180, 153 and 118 are given in Table 7.2. Values were consistently higher in males (Kruskal Wallis $p = 0.002$ for 'total PCB', and $p < 0.001$ for congeners 180, 153 and 118). For all further analyses, data from males and females are presented separately.

PCB levels were considerably higher in juveniles than in either sub-adults or adults. For example, for 'total PCB', median values were 609, 177 and 179 µg/kg for juvenile, sub-adult and adult females, and 897, 164 and 509 for juvenile, sub-adult and adult males respectively.

Given that sample size was extremely small for juveniles, which might lead to bias in the data, individuals were reclassified according to total body length. Length is an approximate indicator of age that can provide more classifications, of a more even group size. Median values were calculated for each length class and compared. Because the range in total length and the number of individuals were both greater for males than females, a larger number of classes were defined for males.

This approach shows a clear increase in PCB loading for males with increasing size, to a differing degree depending on the congener examined (Figure 7.1). Congeners 180 and 153 show a six-fold increase, congener 118 shows a less than two fold increase. For females, excluding size class one, there is an increase between size class 2 and 4, followed by a decrease between class 4 and 6. This is true of all three congeners examined (Figure 7.2). 'Total PCB' levels among the largest size class of males are almost five-times greater than the level in the largest size class of females (Figure 7.3).

7.4 Differences between Environment Agency Regions

Median values of 'total PCB' and congeners 180, 153 and 118 were calculated for each Region and compared (Figure 7.4). Differences between the Regions are somewhat inconsistent between congeners and between males and females. However, after the exclusion of Thames Region due to low sample size, congener 180 shows maximum levels in the North East Region, followed by the North West, for both males and females. Congener 153 also has maximum levels in the North East and North West Regions for males, but for females Anglian Region has the highest levels, followed by North East and North West. Congener 118 has maximum levels in Anglian Region, followed by North West, and then North East, for both males and females. Males have the highest levels of 'total PCB' in the North East and EA Wales, followed by the North West. Females have the highest level of 'total PCB' in the North West, followed by Anglian Region and the North East.

Given the large range in the data (illustrated by the upper and lower quartiles shown on each figure) and the inconsistency in these differences, little can be concluded, except a general tendency for higher levels in North East and North West. For males, statistical tests showed no significant differences between the Regions in individual congeners or 'total PCB'. For females, the regional differences were only significant for congener 118 (Kruskal Wallis test p = 0.027). However, both Thames and North West data had to be removed from statistical tests for females due to low sample size. For males only Thames data were removed.

7.5 Change over time

To look for changes in PCB levels over time, data from all Regions were pooled and males and females examined separately. Despite the significant differences with length class for males, there were too few replicates within each class to examine length classes separately. Data from juveniles were excluded.

Median values were calculated for each year for congeners 180, 153 and 118 (Figure 7.5). No clear trends are apparent. Females show no trends for any congener. For males there was a slight downward trend in extreme values, but not in medians, between 1994 and 1999 for congener 180 and 118, but not for congener 153. Too few data were available from 1992 and 1993 for realistic comparison. For all congeners, there is a decline in median values for males between 2001 and 2003, and for congener 118 this trend extends back to 1999.

7.6 Effect on otter condition

The relationship between otter condition and PCB concentration was examined for congeners 118, 153 and 180 by plotting condition (k) against congener concentration (Figures 7.6-8). No trends were evident towards either an increase or decrease in condition with increasing congener concentration.

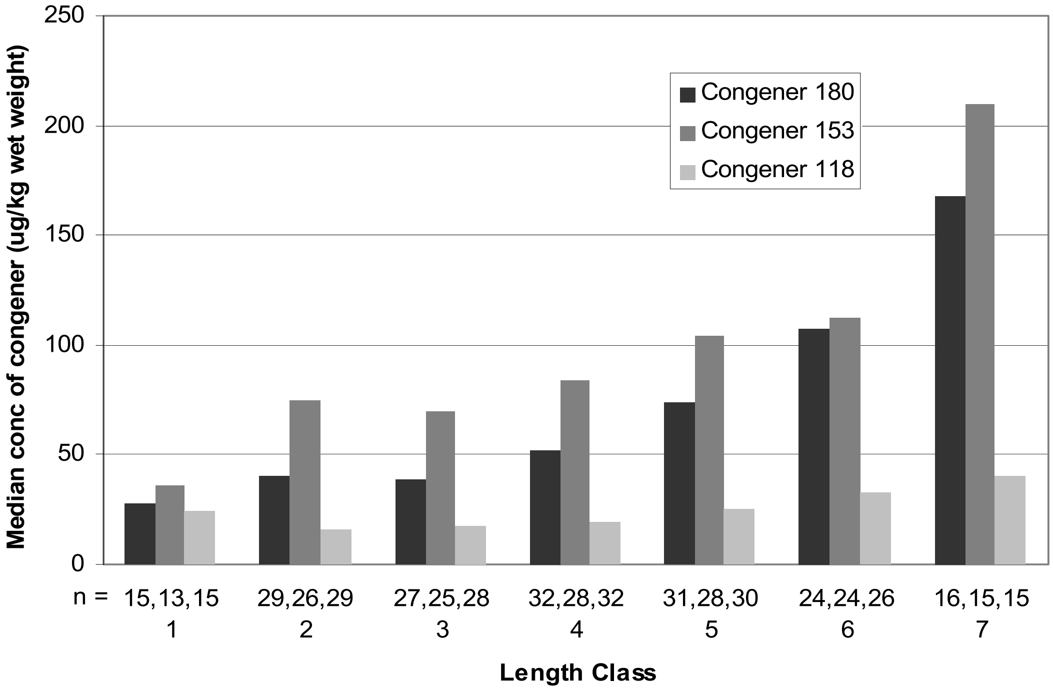

Figure 7.1 Variation in PCB concentrations with length (males). Length classes are defined in mm as follows: 1 = 600-940, 2 = 941-1030, 3 = 1031-1070, 4 = 1071-1110, 5 = 1111-1140, 6 = 1141-1180, 7 = 1181-1310.

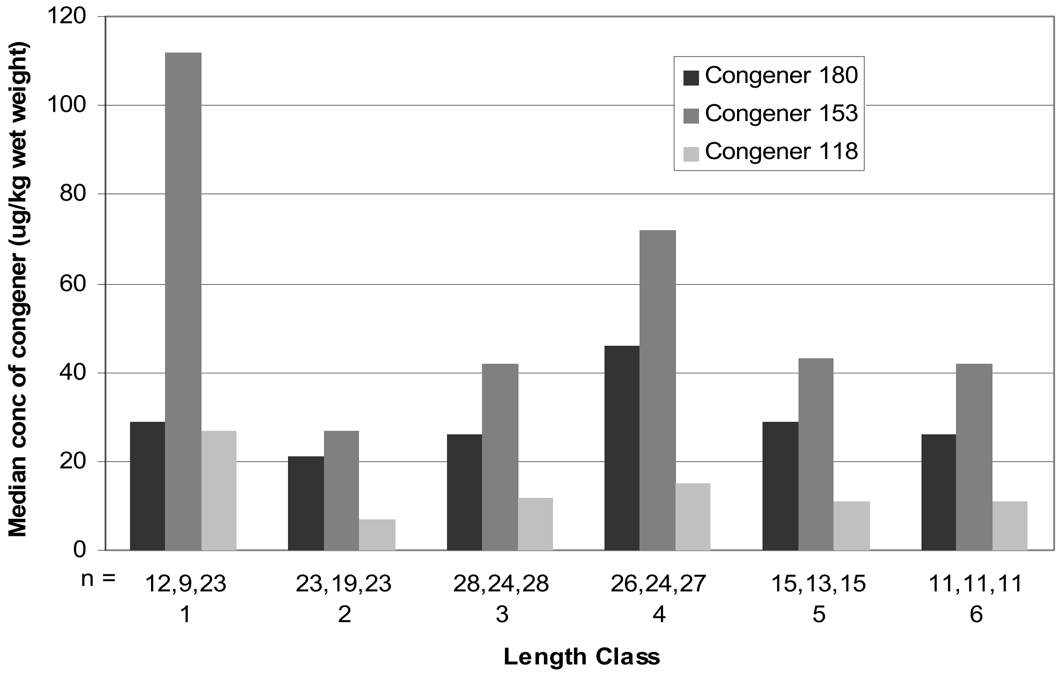

Figure 7.2 Variation in PCB concentrations with length (females). Length classes are defined in mm as follows: 1 = 550-870, 2 = 871-960, 3 = 961-1000, 4 = 1001-1030, 5 = 1031-1060, 6 = 1061-1120.

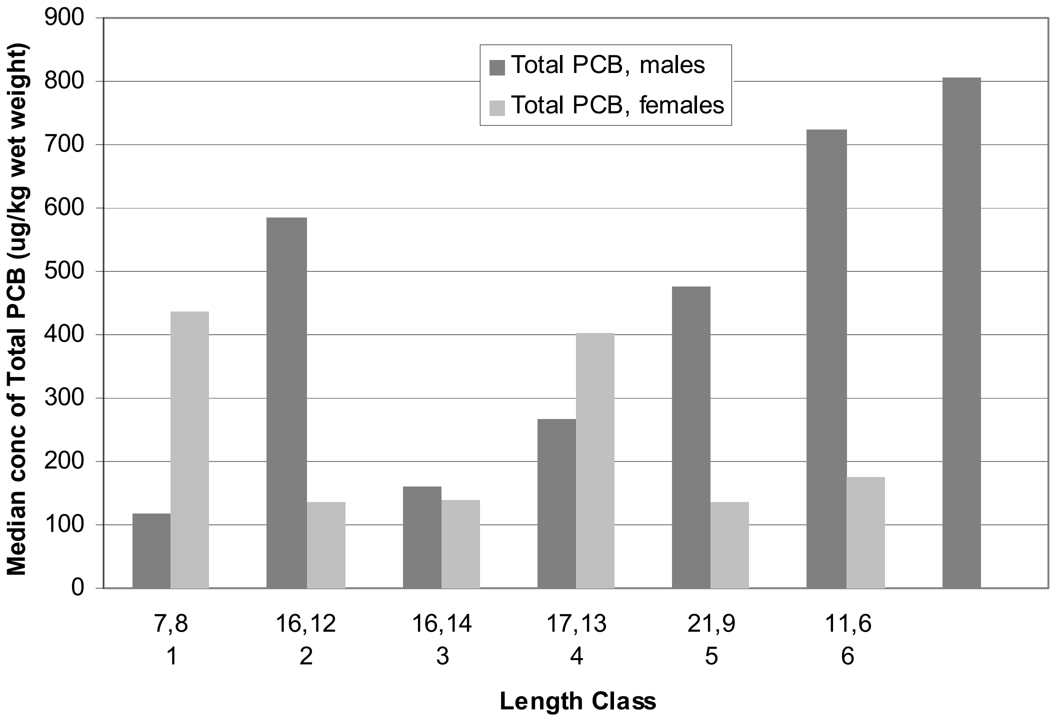

Figure 7.3 **Variation in 'total PCB' with otter length.** Length classes are defined as in Figures 7.1 and 7.2.

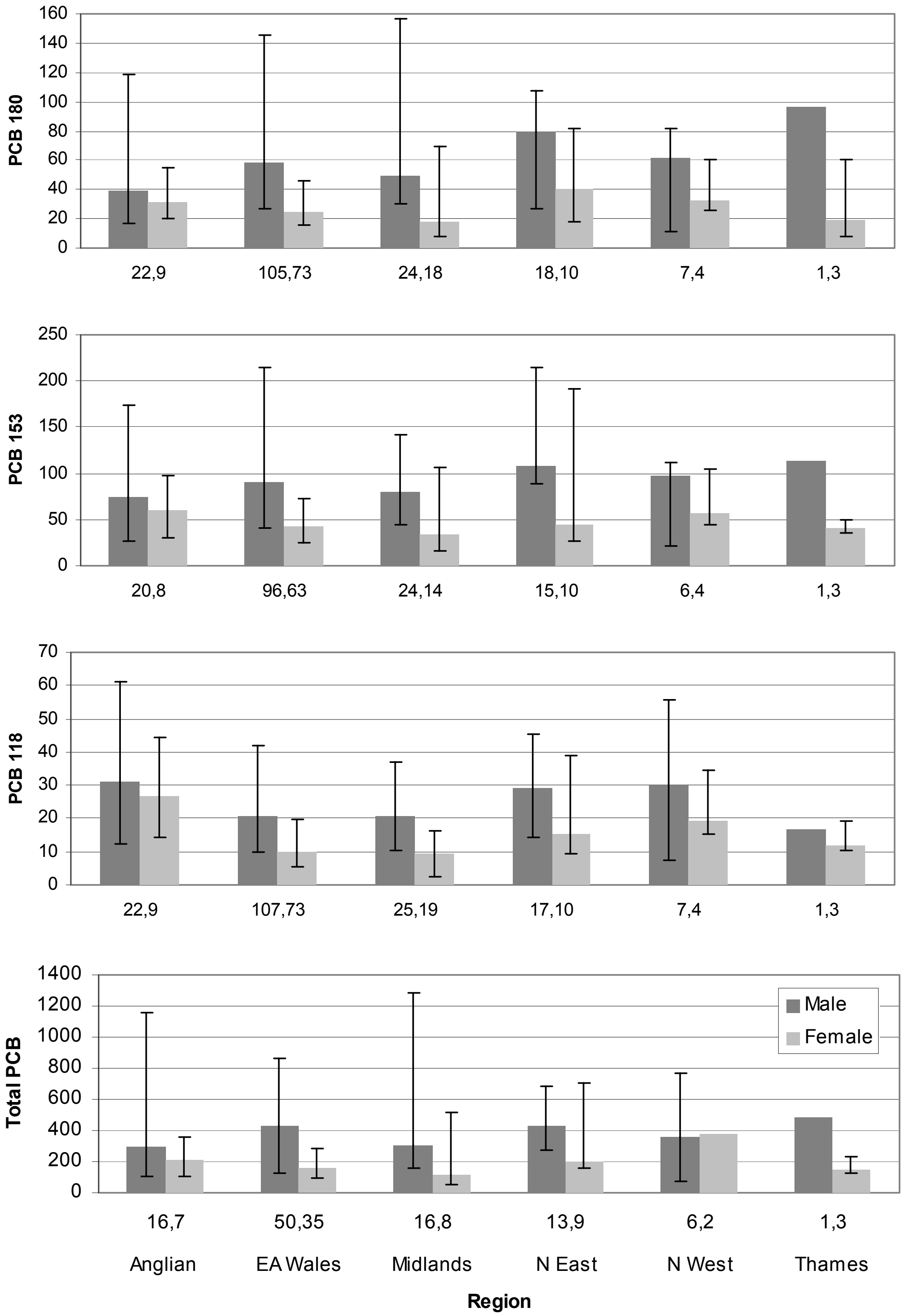

Figure 7.4 Difference in median PCB concentrations between Environment Agency Regions. Y-error bars indicate upper and lower quartiles of the data distribution. All concentrations are in µg/kg wet weight.

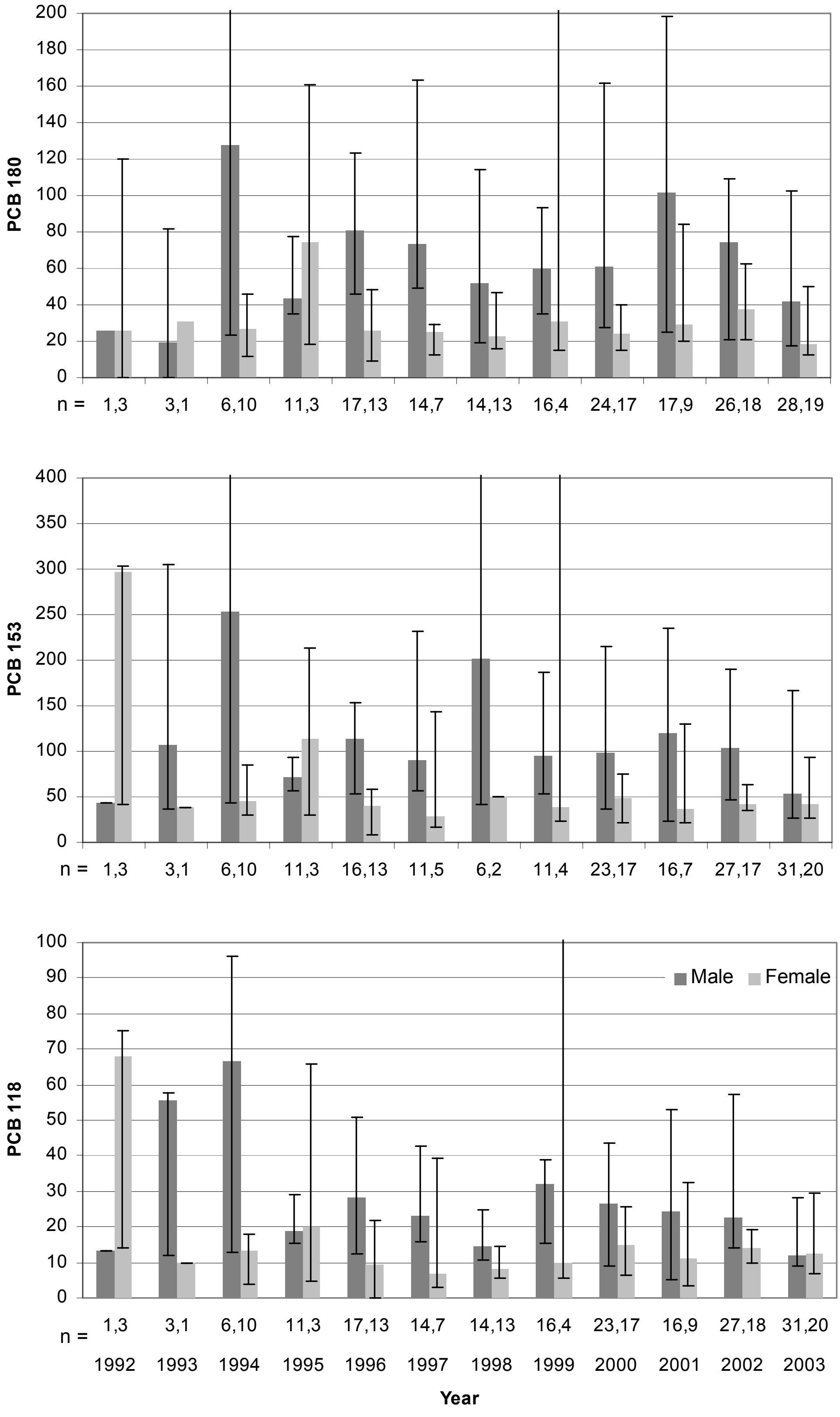

Figure 7.5 Change in PCB concentrations over time. Y-error bars indicate upper and lower quartiles of the data distribution. All concentrations are in µg/kg wet weight.

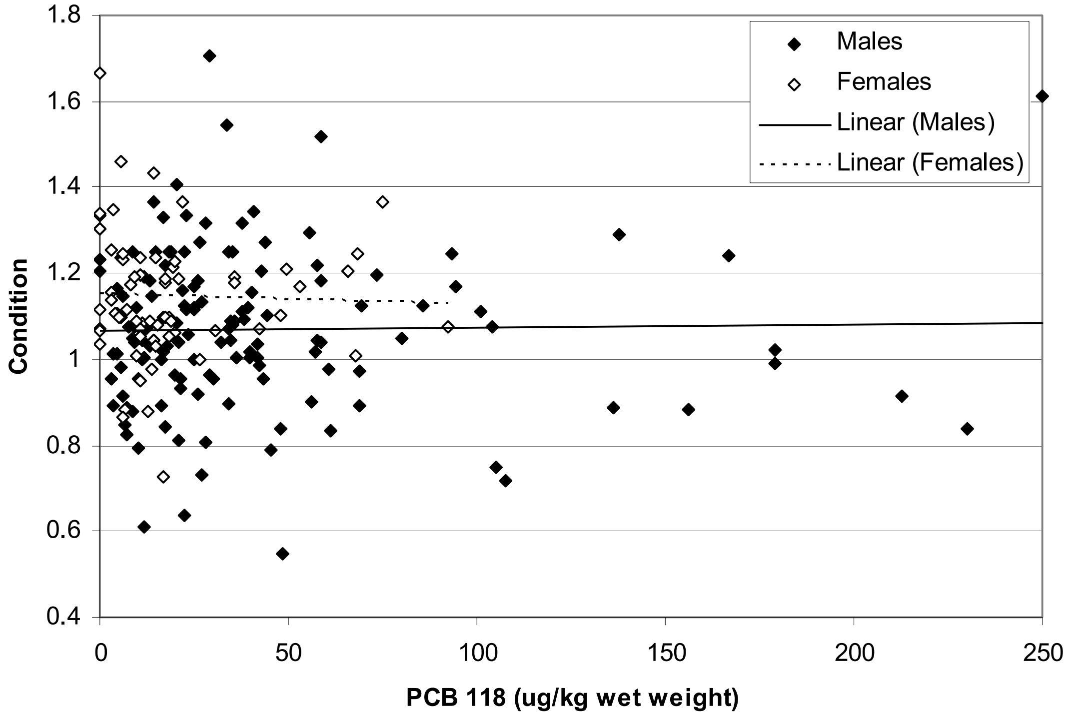

Figure 7.6 Concentration of PCB 118 versus otter condition (k)

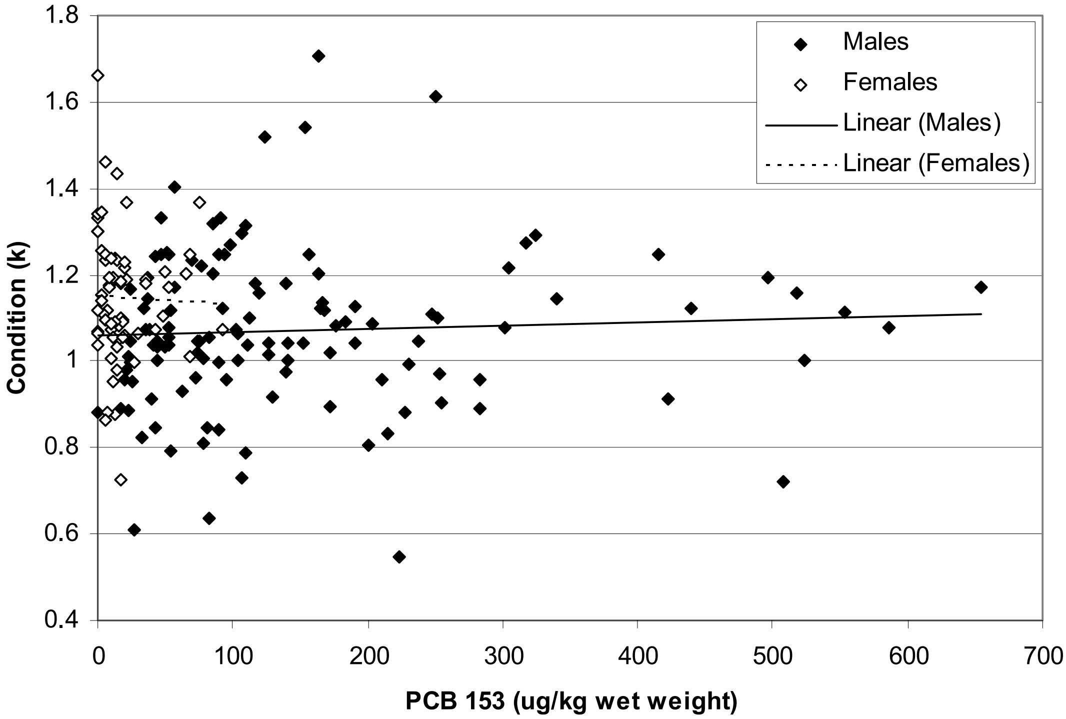

Figure 7.7 Concentration of PCB 153 versus otter condition (k).

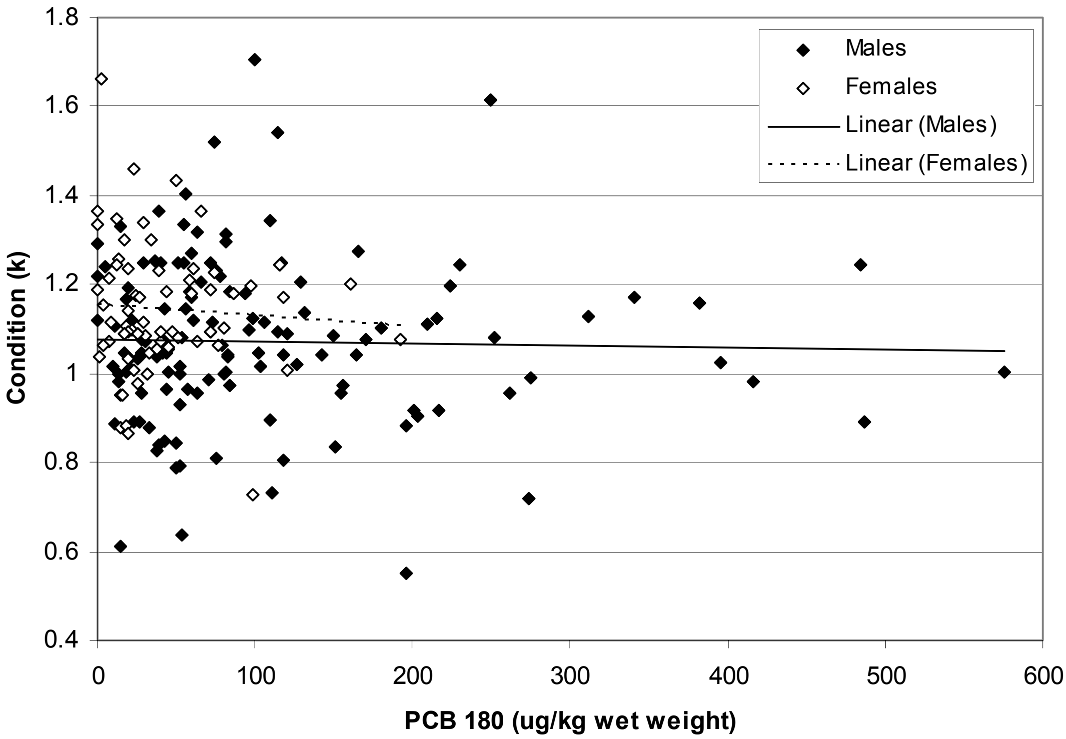

Figure 7.8 Concentration of PCB 180 versus otter condition (k).

Table 7.1 **Correlations between different PCB values.** Spearman's rank correlation coefficients are shown. Higher values indicate a stronger correlation. All correlations are significant at $p<0.05$, with the exception of one, between PCB101 and 126, marked with a §. Congeners marked * indicate PCBs for which occurrence was relatively low, so the correlation is based on a small number of values.

PCB	*52	*101	105	118	*126	128	138	*149	153	156	170	180
*101	0.461											
105	0.356	0.378										
118	0.286	0.294	0.944									
*126	0.137	0.061§	0.489	0.511								
128	0.328	0.341	0.880	0.880	0.484							
138	0.267	0.335	0.790	0.847	0.479	0.901						
*149	0.588	0.469	0.442	0.414	0.139	0.383	0.387					
153	0.251	0.326	0.842	0.889	0.463	0.889	0.929	0.372				
156	0.268	0.304	0.825	0.809	0.510	0.888	0.769	0.320	0.785			
170	0.294	0.322	0.788	0.796	0.469	0.879	0.873	0.304	0.871	0.902		
180	0.239	0.274	0.744	0.773	0.432	0.823	0.810	0.284	0.846	0.830	0.906	
187	0.380	0.471	0.768	0.768	0.415	0.822	0.810	0.358	0.812	0.748	0.789	0.788

Note: § = correlation not significant

Table 7.2 Median concentrations of PCBs in male and female otters.

	Median concentration, µg/kg	
	Males	Females
Total PCB	382	187
Congener 180	61	26
Congener 153	93	44
Congener 118	23	12

8 Other pollutants

Tests were also carried out for atrazine, malathion, parathion ethyl, parathion methyl, simazine, trifluralin, hexachlorobutadiene (HC Buta) and hexachlorobenzene (HC Benz). Of these, atrazine, malathion, parathion ethyl, parathion methyl and simazine were only tested in the first batch (E523, 1995) and were not found in any sample. Trifluralin and HC Buta were tested until batch EX0042 (1999). HC Buta was found in only two samples of 135 tested. Trifluralin was found in three of 129 samples tested.

8.1 Hexachlorobenzene

HC Benz has been tested in all batches to present and has been found in 275 of 320 samples tested (86 per cent). The frequency distribution in Figure 8.1 shows just four outliers with values above 200 µg/kg. All of these animals were adult or sub-adult males, in normal condition with no abnormalities and none of the tissues were decomposed – data from these animals were therefore retained for subsequent analyses. Most values fell below 40, with a median of 14.9 µg/kg.

Comparison of samples tested before and after 2001 showed that HC Benz was present in between 93 and 100 per cent of samples tested in all batches except EX0042, where presence was only 23 per cent. This was assumed to be anomalous and data from this batch were excluded. This left only one sample from 1998. The remaining data analysed before 2001 were assumed to be comparable with data from after 2001.

8.1.1 Differences with sex, age class and length

Median levels of HC Benz are higher for males than for females (median values 19.0 and 9.9 µg/kg for males and females respectively, Kruskal Wallis test, $p = 0.000$).

Different age classes show different levels of HC Benz, with median levels of 42, 14 and 22.4 µg/kg for juvenile, sub-adult and adult males and 17.5, 12.3 and 11.3 µg/kg for juvenile, sub-adult and adult females respectively. Differences for males were statistically significant, while differences for females were not (Kruskal Wallis test, $p = 0.001$ for males and $p = 0.411$ for females).

Classification according to length shows that there is a slight upward trend in values for males with increasing length, but not for females (Figure 8.2). However, the differences are small and Kruskal Wallis tests showed that differences in median HC Benz between length classes were not significant for either sex ($p = 0.350$ for females, $p = 0.284$ for males).

8.1.2 Regional differences

Males and females were considered separately and juveniles were excluded.

For both males and females, levels were high in the North East and North West Regions, while for females but not males levels were also high in Anglian Region (see Figure 8.3). The regional differences were statistically significant for females but not for males (Kruskal Wallis test, $p = 0.149$ for males, $p = 0.027$ for females). Thames Region data were excluded from analyses of both males and females, and North West Region data were also excluded for females, due to low sample sizes.

8.1.3 Change over time

Median values of HC Benz for each year show no indication of change over time for either males or females (Figure 8.4). Measured levels are higher following the change in analytical methods in 2001 and there are signs of a downward trend since this change.

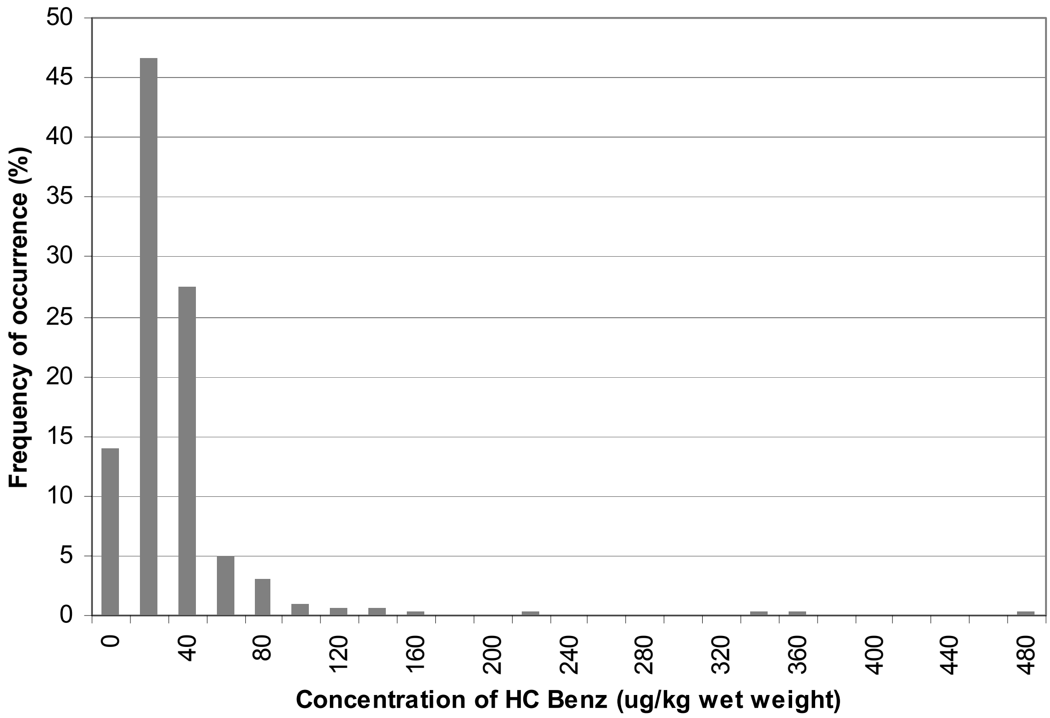

Figure 8.1 **Frequency distribution of HC Benz concentrations.** Values given along the x-axis are the upper limit of concentration for samples in that category.

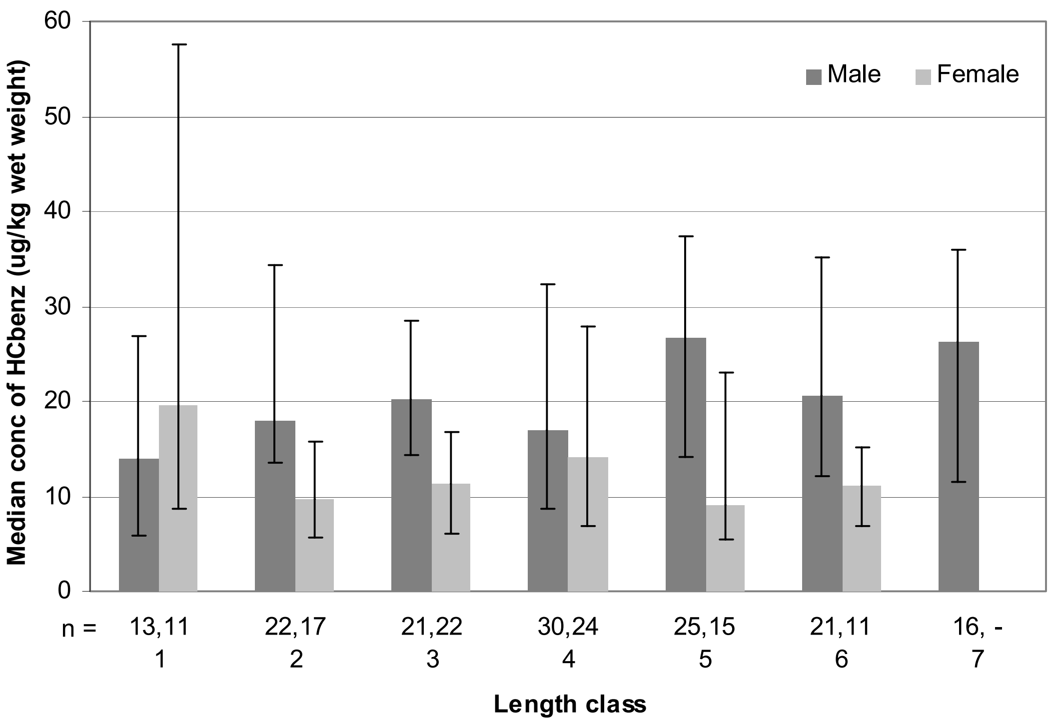

Figure 8.2 **Difference in HC Benz with otter size.** Y-error bars indicate the upper and lower quartiles of data distributions. Length classes as in Figures 7.1 and 7.2.

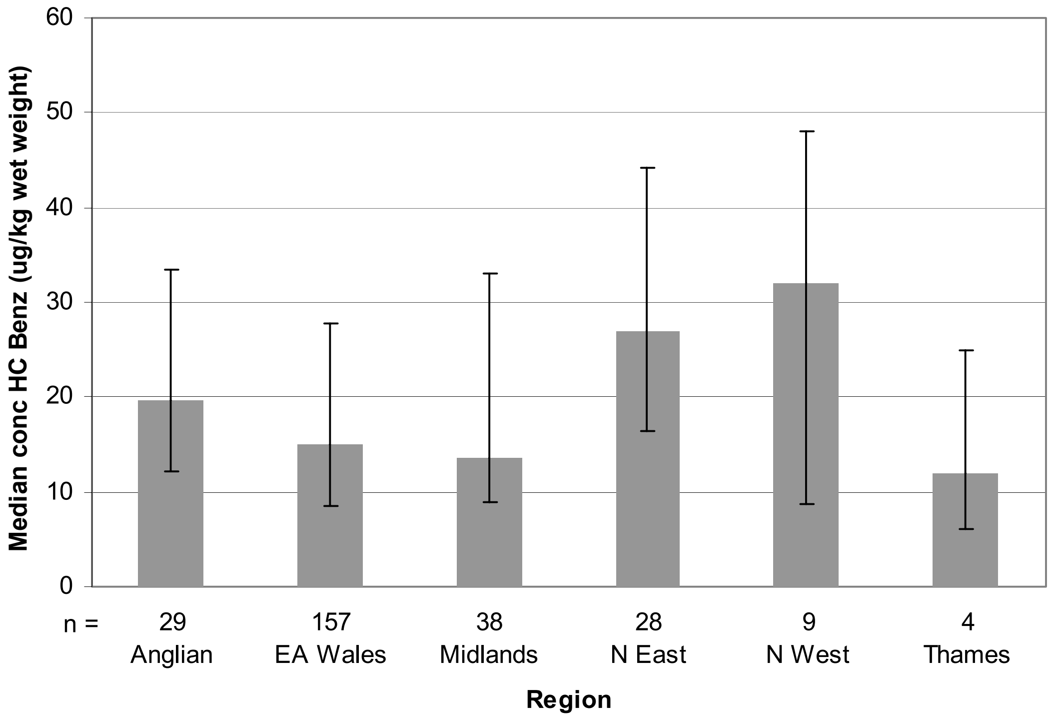

Figure 8.3 **Difference in HC Benz between Environment Agency Regions.** Y-error bars indicate the upper and lower quartiles of data distribution.

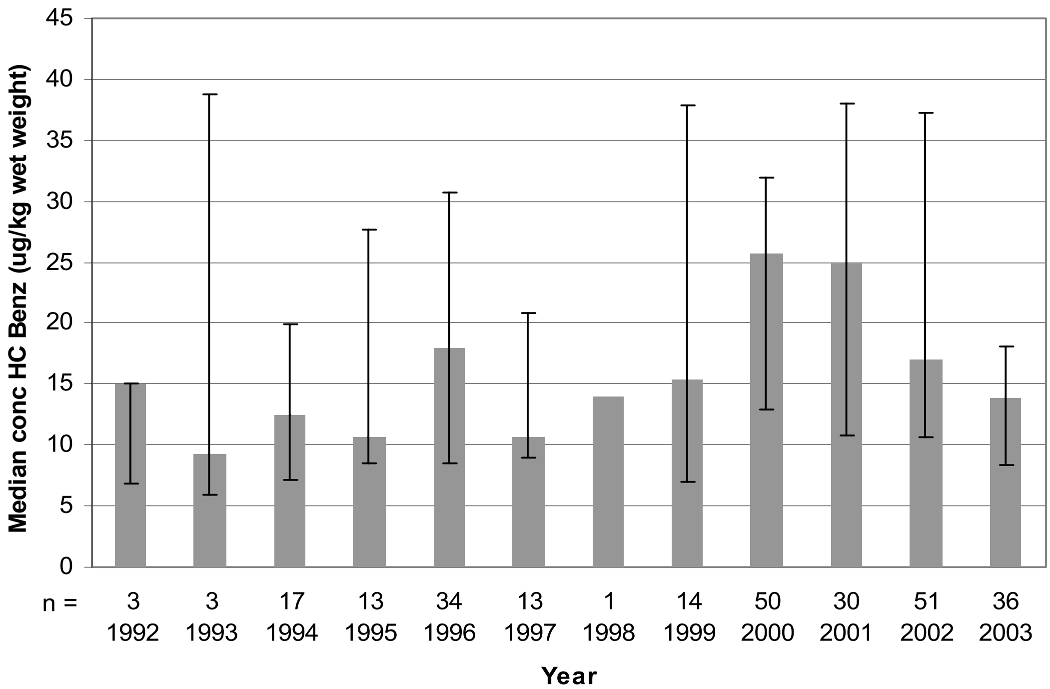

Figure 8.4 **Change in HC Benz over time.** Y-error bars indicate the upper and lower quartiles of data distributions.

9 Discussion

9.1 Change in numbers over time

Using road kill as an index of population size is not always appropriate (Slater 2002). However, several studies have used additional survey methods to verify that road kill surveys can indicate gross trends, for example in amphibians (Gittins 1983) and in mammals such as red foxes (Baker *et al*. 2004), raccoons (Gehrt 2002, Gehrt *et al.* 2002) and bandicoots (Mallick *et al.* 1998). While changes in the number of otter carcasses submitted for post mortem between 1992 and 2003 may be partly due to changes in collection effort, it is likely that the overall increase is also due to an increase in population size.

The decline in numbers received since 2003 may represent a drop in the perceived conservation value of otter carcass collection given increasing populations. Alternatively, it may represent a levelling off in the population size.

9.2 Seasonal variation in numbers

Seasonal variation in the number of otters killed on roads has been previously documented (Bradshaw and Slater 2002, Philcox *et al.* 1999, Simpson 1998), and recent data add little new information. Mortality is highest in the winter months.

The generally accepted interpretation of winter peaks in otter road deaths is that animals are reluctant to pass culverts during high winter river flows and so cross roads instead (Philcox *et al.* 1999). Data from Norway (Heggberget 2005) also show a winter peak in otter road deaths, which is positively correlated with levels of precipitation. However, winter precipitation in most Norwegian watersheds is held as snow until winter thaw and the seasonality of road kill is negatively correlated with river flow rates (Heggberget, 2005). This suggests that increased road deaths may be more strongly influenced by poor winter driving conditions and the overlap in timing between the hours of darkness (when otters are active) and the timing of daily rush-hours, than by increased river flows.

9.3 Distribution

An increasing proportion of otter carcasses have originated in areas of central England where they were previously rarely found. As with changes in the number of carcasses, this might be due to changes in collection effort rather than a changing distribution of the population. However, given the expanding distribution of signs recorded by the otter surveys of England (Crawford 2003) and Wales (Jones and Jones 2004), it seems likely that the expansion of populations has contributed.

A genetics study is currently underway at Cardiff University (See section 10.1), which will enable source populations for this recolonisation to be identified. A combination of molecular population genetics and landscape ecology will be used to provide information about the interaction between landscape features and microevolutionary processes (Manel *et al.* 2003). For example, by mapping genetic discontinuities and comparing these with landscape features, barriers to dispersal might be identified.

9.4 Sex and age class

It appears that the population structure, in terms of sex and age class, has not changed over the course of this study. However, age class categories offer little definition and may be incorrect in some instances. For example, a recent study of skull morphometrics (section 10.6) showed that some individuals classified as adults on the basis of size had partially open sutures on the skull, and should be re-classified as sub-adults. The results of aging analysis using tooth sectioning (section 10.8), in conjunction with re-assessment of other age indicators such as baculum length (section 10.9) and suture closure, should clarify these issues.

The ratio of three males: two females in carcasses received may reflect the fact that males range over larger areas and are therefore more likely to be killed while crossing a road, rather than the true structure of the population. Similar bias towards males in road kill samples has been described in other studies (e.g. Hauer et al. 2002a).

9.5 Length and weight

The average length for adult otters found in this study suggests that they are smaller than otters from some continental European populations (Madsen *et al*. 2000, Sidorovich and Lauzhel 1997). They are also smaller than the average given in the *Handbook of British mammals* (Chanin 1991). They are, however, larger than otters found in Shetland (Kruuk 1995). In these studies, the highest average weight for males is 10.1 kg, given by Chanin (1991) for British otters. This is followed by 9.1 kg in Denmark (Madsen *et al.*, 2000), 8.8 kg in Belarus (Sidorovich and Lauzhel, 1997), 8.1 kg in the present study, and 7.4 kg in Shetland (Kruuk, 1995). For females, the pattern in weights is similar, with the largest (7.0 kg) in Belarus and Britain and the smallest (5.1 kg) in Shetland. In the present study and the Danish study, females weighed on average 6.0 kg. Length data show similar rankings.

Within this study there are slight trends towards decreasing body size in both males and females between 1992 and 2003. This might indicate a decreasing average age, which one might expect in an expanding population, or a decrease in food availability, which might occur where populations approach carrying capacity. Within the 1992-2003 period however, trends were not apparent for all age and sex groups and were not statistically significant for most. Lengths and weights presented by Chanin (1991) include data from hunting records collected during the 1950s and 60s. They enable a longer-term view. Comparisons with these data and consultation with the author (P. Chanin, personal communication) suggest that otter size has decreased considerably since their population decline. Assuming the two datasets are comparable, a decrease in average weight of 2 kg for males and 1 kg for females has occurred, equivalent to a 20 per cent and 14 per cent size reduction. Decreases in length have also occurred, from 1166 mm to 1120 mm (males) and 1034 mm to 1028 mm (females). Percentage reduction in length has been less than the percentage reduction in weight, with males and females showing only a four per cent and a 0.6 per cent reduction, respectively.

9.6 Reproductive status

Seasonal breeding has been recorded in otters from a number of locations including Scotland (Kruuk 1995), Portugal (Beja 1996), Norway (Heggberget and Christensen 1994), Denmark (Elmeros and Madsen 1999) and Germany (Hauer *et al*. 2002b).

In the current study, no direct evidence has been found for seasonality in the number of pregnant or lactating females. Seasonality of breeding in other studies has been shown to relate to seasonality in food availability. It is possible that in the sample area for this study, food availability is not sufficiently seasonal to promote seasonal breeding. Alternatively, there may be geographic variability in seasonality throughout the study area, so that patterns are obscured by pooling the data across Wales and England. The sample size of pregnant or lactating females is too low to analyse the data in greater detail, so this remains inconclusive. However, indirect evidence from condition data does provide a potential indicator of summer breeding (see section 9.10).

From the very small sample where the number of foetuses was recorded in pregnant females, one or two seemed the norm, while three was unusual. In a study in Germany (Hauer *et al.* 2002b), two foetuses occurred most often, but there were frequently three foetuses and up to five were recorded. Litter sizes show little geographical variation, however. Most studies throughout Europe record the mean litter size of cubs following their mother as two (Hauer *et al.* 2002b and citations therein).

Baculum length showed a bimodal frequency distribution, with peaks at 40-44 and 65-69 mm. This may indicate a bias in the age classes of males collected. Sub-adult males may be over-represented in the sample relative to the population as a whole. However, this is not reflected by the frequency distribution of body length data. These data will be reanalysed following morphometric analysis of all baculae (see section 10.9).

Baculum length appears to have increased over the course of the study. This would suggest an increasing average age (van Bree *et al.* 1966), which is unexpected given both an expanding population and decreasing body size. PCBs have the potential to suppress baculum growth (Harding *et al.* 1999), so a gradual lifting of this suppression might lead to an increase in baculum size over time. This is entirely speculative, however. The trend in baculum size was not statistically significant and will be reassessed following further morphometric analysis of all baculae and aging using teeth (see sections 10.8 and 10.9).

9.7 Renal calculi

The incidence of renal calculi (kidney stones) has shown a marked decrease over the course of this study. An increased likelihood of renal calculus formation is associated with age and no sub-adult or juvenile animals were found with calculi during this study. It is therefore possible that a decrease in incidence rates reflects a change towards a younger population structure. However, as discussed above, evidence for a changing age structure of the population is contradictory and further clarification is needed.

In addition to an increase with age, it is likely that the incidence of renal calculi is influenced by diet. Otters with miniscule or moderate calculi originated from widely dispersed areas. However, otters with staghorn calculi came predominantly from coastal west Wales and East Anglia. This might reflect the calcium rich substrate in East Anglia and possibly coastal feeding on shellfish in west Wales. Further analysis of the constituents of renal calculi and diet might clarify this.

As discussed by Bradshaw & Slater (2002), kidney stones are frequently found in captive otters, possibly due to excessive dietary calcium and vitamin D (Keymer *et al.* 1981). The results of this study suggest that in wild otters, kidney stones are associated with aging and diet. They do not appear to be associated with poor health, being found predominantly in healthy animals. However, large staghorn calculi can cause atrophy of the surrounding tissues and might in extreme cases impair kidney function.

9.8 Fighting injuries

Fighting injuries were found infrequently in this study in comparison to observations of otters found dead in the south and south west of England (Simpson 1998, 2006). It is possible that the degree of examination for fighting injuries has been inconsistent between the two studies, so results might not be entirely comparable.

Following a change of project management at Cardiff in 2004, examinations have been carried out following the same methodology used by V Simpson (personal communication). Since then, fighting injuries have been found in approximately 20 per cent of otters submitted. This is a considerable increase on levels noted by Bradshaw between 1992 and 2003. It may represent an increasing incidence of intraspecific aggression, as has been noted in the south west (Simpson 2006). It could also be a result of the change in methodology. The incidence of fighting injuries on animals within this study area does not approach the levels described in otters from the south and south west (Simpson 2006), where over half of the animals submitted in recent years have had fighting injuries.

Differences in the levels of aggression between Regions may represent differences in population density and competition for territory, or may

represent genetic differences between different populations. Continued monitoring of the animals submitted to Cardiff will reveal whether the incidence of fighting injuries remains stable or changes.

9.9 Causes of mortality

The predominant cause of death was road traffic accidents. Of the remainder, death of underweight juveniles was the second largest contributor, with a handful of other causes including shooting, drowning and septicaemia. However it must be recognised that this is biased by the methods of collection. Other causes of death are likely to be more significant than is apparent from this study.

9.10 Health indicators

Condition was calculated for the majority of animals and showed differences between sexes and age classes as previously documented. Females were typically in better condition than males and condition declined from adults to sub-adults to juveniles. In addition, reproductive status and cause of death affected condition. Pregnant and lactating females were in better condition than quiescent females and animals collected as the result of road traffic accidents were in better condition than those that died in other ways. Similar results were found by Hauer *et al.* (2002b) in Germany, where breeding females had a significantly higher body condition than non-breeding females and traffic fatalities had a higher body condition than natural deaths.

Kruuk *et al*'s (1987) condition index is useful as a comparative measure. However, this index was based on their available sample size of only 25 otters from Shetland, where otters are comparatively small (see section 9.5 and Kruuk (1995)). Constants were calculated separately for males and females on the basis that 'k' for both was 1.0 when otters were in normal condition. In this study, the average k is greater than

1 for both males and females and differs with sex and age class. A similar study in Denmark (Madsen *et al.* 2000) also shows mean values higher than 1. Given the far larger size of the dataset now available, recalculation of a more appropriate condition index is warranted, for example using the residuals from a regression analysis of body mass on body length. However, a comparison of subjective and objective body condition indices for the red fox (Cavallini 1996) showed strong concordance between measures. For the purposes of this study, we consider the index used provides a reasonable indication of nutritional status. The data presented in the current study suggest that condition should be compared within rather than between age and sex classes. A typical (assumed normal condition) k value calculated using Kruuk's constants is lower for males than for females but does not mean that males are in worse condition.

Trends of decreasing condition were apparent over the course of the study for adult males and sub-adult females. As with decreasing length and weight, this might be indicative of changing age structure in the population, or food limitation due to populations approaching carrying capacity.

Seasonal trends in condition were apparent, particularly for males. In a study of reproductive performance in Germany, Hauer *et al.* (2002b) found that body condition of females was lowest in spring, and highest in winter, but the authors do not show a monthly breakdown. In the current study, condition appears reasonably constant throughout the year, but shows a sudden 'crash' in May, particularly for males where sample size is greater and therefore the trend more reliable than for females. Although this might relate to food limitation, it seems unlikely given the sudden nature of the decline. An alternative explanation is that there might be an influx of sub-adult individuals (typically in lower condition than adults) to the road kill samples at this time of year. Although not conclusive, this might indicate seasonal reproduction, reflecting a seasonal increase in newly independent animals seeking territories and therefore susceptible to road traffic accidents. Given that cubs remain dependent on the mother for an estimated 10 months (Kruuk *et al.* 1987), this suggests an increase in birth rates during July. A July peak in birth rate was found in Germany (Hauer *et al.* 2002b), and summer peaks have also been recorded in Denmark (Elmeros and Madsen 1999), Shetland (Kruuk *et al.* 1991) and Norway (Heggberget and Christensen 1994). This is a time of year when road traffic mortalities are infrequent, so direct evidence of reproduction (such as current lactation, recent placental scarring and pregnancy) would be difficult to obtain. Re-analysis of these data is necessary following further assessment of aging criteria, to find out whether the decrease in condition is related to a change in the age structure of the sample.

9.11 Methodological problems with chemical data

During the statistical analysis of chemical data from liver samples, a number of problems became apparent, which detract from the comparability of data over time. However, while comparisons with previous data are difficult, the improvements in analytical methodology will make detection of current levels and future change more accurate and should enhance the analysis of health impacts of the pollutants considered.

In addition to the differences observed between analytical batches, isolated anomalies occurred with samples that had been submitted in a decomposed state. Post mortem procedures have since been modified, so samples from decomposed animals will no longer be submitted.

Although levels of contaminants were expressed as wet weight due to inaccuracies in lipid content data, these problems need to be addressed in future. Contaminant concentrations expressed as wet weight rise as lipid concentrations fall, due to release of contaminants when fat stores are metabolised, and because liver weight falls during starvation (Malcolm *et al.* 2003). If problems in measurement of lipid content can be overcome, future analyses should examine lipid concentrations as well as wet weights.

9.12 Pollutants found in otters

Of the organochlorine pesticides measured, only three occurred relatively frequently both before and after changes in methodology. These were the para-para isomers of DDE and TDE (derivatives of DDT) and dieldrin. As well as being among the most frequently found determinands, pp'DDE and dieldrin were present in higher concentrations than any others. The other determinands occurred in less than ten per cent of samples and in most cases, high values could be explained by either decomposition of samples or poor body condition (k) of the animal. There were no samples for which pp'DDT was present at higher levels than pp'DDE, which indicates that there were no incidents of recent ingestion of DDT. Isodrin and beta-HCH were found frequently in samples analysed following the change in analytical procedures, but at levels that were below the detection limits prior to the laboratory move.

It should be noted that beta-HCH is degraded rapidly in animal tissues after death even when samples are frozen at -20°C (Jefferies and Hanson 2000). Results for HCH are therefore questionable, as time from death to analysis varied considerably between samples. Some were submitted several years after the animal's death.

The most commonly occurring PCBs were congeners 105, 118, 128, 138, 153, 156, 170, 180 and 187, found in more than 95 per cent of samples since 2001, at varying concentrations. In terms of concentration, congener 153 was dominant, followed by congeners 187, 138, 180, 170 and 118 in decreasing order. The same dominant congeners were observed in a study of seabirds found dead around Britain in the 1990s, with the exception of congener 187 which was not looked for in the seabird study (Malcolm *et al.* 2003). The same order of concentrations was found, except that in seabirds, congener 118 occurred at higher concentrations than congener 170.

The only other pollutant found frequently in the samples submitted was hexachlorobenzene.

9.13 Differences in pollutant burden with sex and age

For OCs, PCBs and HCB, levels of pollutants were higher in males than in females, and juveniles showed higher levels than adults or sub-adults. This pattern probably reflects the excretion of pollutants that occurs when females reproduce, which has been described for a number of species, including birds (Bargar *et al.* 2001), amphibians (Kadokami *et al.* 2004) and mammals (Dip *et al.* 2003, Neale *et al.* 2005). In mammals that nurse their young, a high proportion of the mother's pollutant burden is shed in the fat portion of milk and colostrum. In humans, breast feeding for only 6 months contributes 12 to14 per cent of the 25 year total PCB intake (Patandin *et al.* 1999).

In the absence of accurate age data, age classes can be used to assess accumulation with age, but they provide little resolution. Length can be used as an indicator of age and provides an improved assessment of the accumulation of pollutants with growth. Length is a continuous variable, so length classes can be assigned according to the distribution of the data. This enables the allocation of approximately equal group sizes, which are better suited for statistical comparison than unevenly distributed groups (few juveniles, large numbers of adults).

When animals were classified according to length, there was clear evidence for accumulation of PCBs and dieldrin with increasing size in males, the degree of accumulation differing between PCB congeners. In females, there was evidence for initial accumulation, followed by decreases with increasing size.

In a study of urban foxes, differences in PCB levels between age classes were particularly marked for congener 153 (Dip *et al.* 2003). This was the congener to show the most marked differences between length classes in the current study. Levels in female foxes also increased initially with age and then declined (Dip *et al*. 2003).

Kruuk and Conroy (1996) concluded from analyses of Scottish otters that there was no significant accumulation of PCBs with age. However, they described a mixture of positive and negative correlations with age for females, while for males, all ages showed positive correlation (although most were not statistically significant). In the light of the differences in accumulation between sexes shown in the current study, it seems likely that similar relationships may have been present in their sampled population, leading to their finding of no obvious trends in females but positive trends in males. It is possible that correlation with growth may give a clearer indication of accumulation patterns than correlation with age.

9.14 Differences in pollutant burden between Regions

For the commonly occurring organochlorines (DDE, TDE, beta-HCH and dieldrin), PCBs and HCB, regional differences and trends over time were compared. Of the five Environment Agency Regions compared (Anglian, EA Wales, Midlands, North East and North West), levels of organochlorine pesticides were highest in Midlands Region. Other rankings varied between pollutants, but were generally low in Welsh Regions and the North East. PCBs and HCB were highest in the North East and North West Regions.

Previous data (Jefferies and Hanson 2000) show that the highest levels of OC pollution were found in England, moderate levels in Wales and the lowest levels in Scotland. No further regional breakdown was attempted. For PCBs, the authors give a regional breakdown and compare their data with a contradictory study (Mason and MacDonald 1993, cited by Jefferies and Hanson, 2000). In the cited study, PCB contamination was highest in East Anglia, and declined to the west, south west and north. Jefferies and Hanson (2000) found the reverse, with the lowest PCB levels in East Anglia, followed by northern England, while concentrations in the south west were the highest. Our findings, of relatively high concentrations in the north and generally lower concentrations in East Anglia partially support Jefferies and Hanson's (2000) finding. However, our data showed variation between congeners and did not include data from the South West Region.

Regional comparisons such as these may also be flawed in that they assess differences across boundaries that are arbitrarily assigned (Environment Agency management areas in this study). A better approach would be to use analytical packages such as GIS (Geographical Information Systems) to look for spatial patterns without any prior assumptions, or to attempt to correlate the data with underlying factors such as pesticide usage, land-use, industrial intensity and climate data. Such data are not available to the author at present and the analyses would be extremely complex, given the spatial patchiness of the otter chemistry data and the interaction of factors such as each animal's sex, age, and condition, and changes in pollutant burden over time. The addition of further data in future years should enhance interpretation.

9.15 Changes in pollutant burden over time

Trends over time are not apparent between 1994 and 2003 (1992-3 were excluded from analyses due to low sample size). Values fluctuate and it seems likely that a large part of the observed differences are due to analytical differences between batches rather than genuine changes in levels. However, when the latter part of the series is taken in isolation, excluding data prior to the changes in methodology, there is a decline in OCs, PCBs and HCB. Levels in these years are probably indicative of a real change, since methods are now more consistent, with fixed rather than variable detection limits. The short time-span of this analysis prevents us drawing definite conclusions, but further monitoring will show whether the trend is continued.

Jefferies and Hanson (2000) give concentrations of OCs and PCBs in otters from the late 1960s to the late 1980s. Comparisons suggest that previous, steeper declines in OCs had started to level off by the end of their study in the late 1980s and the start of our study in the early 1990s. For example, Jefferies and Hanson (2000) show a steep decline in dieldrin, from arithmetic mean values of over 1,000 µg/kg wet weight in the late 1960s, to around 250 µg/kg in the late 1980s. The arithmetic mean for dieldrin in this study (1992-2003) was 150 µg/kg (males and females pooled), suggesting some further decrease since the 1980s, despite the lack of obvious trends within the 1992-2003 dataset (Figure 9.1). Similarly, Jefferies and Hanson's data show a steep decline in DDE from values up to 1600 µg/kg in the early 1970s, to 640 µg/kg in the late 1980s. In this study, although no significant decline is seen within the dataset, the mean value is 277 µg/kg, suggesting that for this determinand also, levels have dropped since the conclusion of their work (Figure 9.2). A study of OCs and PCBs in Northern European fish also shows steep declines since the late 1960s, levelling off towards the mid 1990s, at multiple sites and in multiple fish species (Bignert *et al.* 1998). Because our data are highly variable and declines are now more subtle, a longer time period may be needed to confirm whether declines are still occurring.

Unfortunately, Jefferies and Hanson's data for PCB concentrations are not comparable with the data used in this study, due to a different range of congeners having been used. However, in their study, levels of PCB contamination were rising in otters between the late 1960s and late 1980s. In a study of seabirds found dead around the British coast during the 1990s, Malcolm *et al.* (2003) found concentrations similar to those detected in the 1970s and 1980s, suggesting that declines are slow despite restrictions in PCB use. In our study, PCB concentrations appear to peak in 1994. Although values since then are generally lower, there is no obvious decline in subsequent years.

9.16 Health implications of chemical pollutants

Health implications of the level of PCBs and OCs now present are difficult to ascertain from this study. Condition (k) was not correlated with levels of either OCs or PCBs, although other studies have shown evidence for a decrease in otter condition with increasing PCB contamination (Kruuk and Conroy 1996, Gutleb 2000).

Neither bacteriology or histopathology were undertaken due to time constraints and the generally poor and frozen condition of carcasses submitted, so we cannot be compare our results with the studies carried out by Simpson (1998, 2000) or the assessment of disease prevalence used by Gutleb (2000). Although gross signs of disease were observed occasionally during this study, there was no apparent link with high levels of contamination, with the possible exception of renal calculi. Renal calculi were observed more frequently in animals with high levels of OCs, particularly dieldrin. However, this may be coincidental, since both the incidence of renal calculi and the levels of OCs increase with age.

Links between adrenal weight and PCB concentration were shown by Simpson (1998, 2000) and Bradshaw (2002). However, measurement of adrenal weight was infrequent in the latter years of the present study and new analyses incorporating additional data could not be conducted. Since 2004, adrenal weight has been measured during all post mortem examinations.

Further additions to the standard post mortem procedure include the recording of a larger range of organ weights, parasite loading and more detailed examination of the uterus for placental scarring or abnormalities. These will be presented in future reports. Examination of reproductive factors such as placental scarring will add to our knowledge of breeding seasonality (or its absence). It is of considerable interest because the principle effects of OCs and PCBs are likely to be on reproduction (Brunstrom *et al.* 2001, Fossi and Marsili 2003, Kihlstrom *et al.* 1992, Wren 1991). When the baculum length data are re-examined (see section 10.9), they will also be analysed in conjunction with contaminant data, to test whether baculum length correlates with PCB contamination, as has been shown in studies of juvenile mink (Harding *et al.* 1999).

The question of whether PCBs, or dieldrin and related compounds, were responsible for the otter decline or are slowing their recovery, remains unresolved. Within continental Europe there is a widely held view that PCBs were the primary factor limiting otter populations, supported by a variety of evidence. For example, PCB concentrations in otter tissues have been shown to be positively correlated with increasing prevalence of disease in otters and decreases in PCB levels across mainland Europe seem to be correlated with increasing otter populations (Gutleb 2000). The presence and absence of otter populations within countries of south western Europe also reflects PCB levels (Ruiz-Olmo *et al*. 2000). However, evidence suggests that in Britain, dieldrin and related compounds were more significant. Particularly compelling and comprehensive evidence is presented by Jefferies and Hanson (2000). Some of the more striking points include the observation that PCB contamination in Britain was increasing during a time when the otter population was recovering. There is a close link in time between the introduction of dieldrin in 1955 and the onset of the dramatic otter decline in 1957. Levels of PCBs were high in a thriving population of otters in Shetland and there are clear spatial and temporal correlations between otter declines and agricultural practices (Jefferies and Hanson, 2000). A more detailed overview of these issues can be found in Chanin (2003).

Several authors have questioned whether the known sensitivity of mink to PCBs can be extrapolated to otters (Jefferies and Hanson 2000, Kruuk and Conroy 1996). Without direct toxicity trials on otters, this question cannot be fully resolved. However, a comparison of bioaccumulation and biotransformation for otter, weasel, stoat and polecat (Leonards *et al.* 1998) suggests that while polecats are likely to be less sensitive (they can metabolise a larger range of congeners), the other three species are likely to be at least as sensitive to PCBs as mink. The authors concluded that the toxic threat to otters was greater than for either of the other species examined, due to greater dietary exposure. Although it seems likely that dieldrin and related compounds were the cause of the major crash in otter populations in Britain, PCBs may also be affecting otter health.

From this study, it appears that declines in both OCs and PCBs have levelled off. However, it seems likely that small declines are continuing but are difficult to detect given the variability within the chemical data, the spatial spread of the data and the large number of complicating factors. Changes in methodology have rendered comparisons over time difficult. Continued monitoring with consistent methodology and more comprehensive analysis are necessary to find out whether slight declines in OCs and PCBs are continuing and whether these chemicals are affecting otter health.

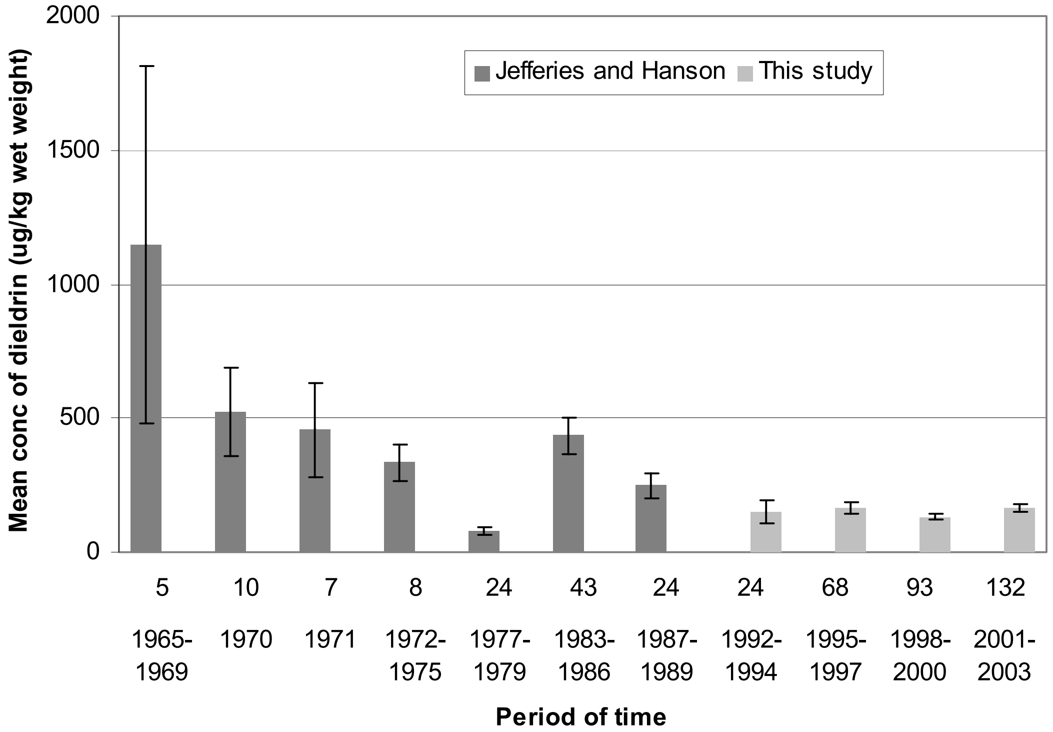

Figure 9.1 Decline in dieldrin levels since the late 1960s. 1965-1989 data are taken from Jefferies and Hanson (2000).

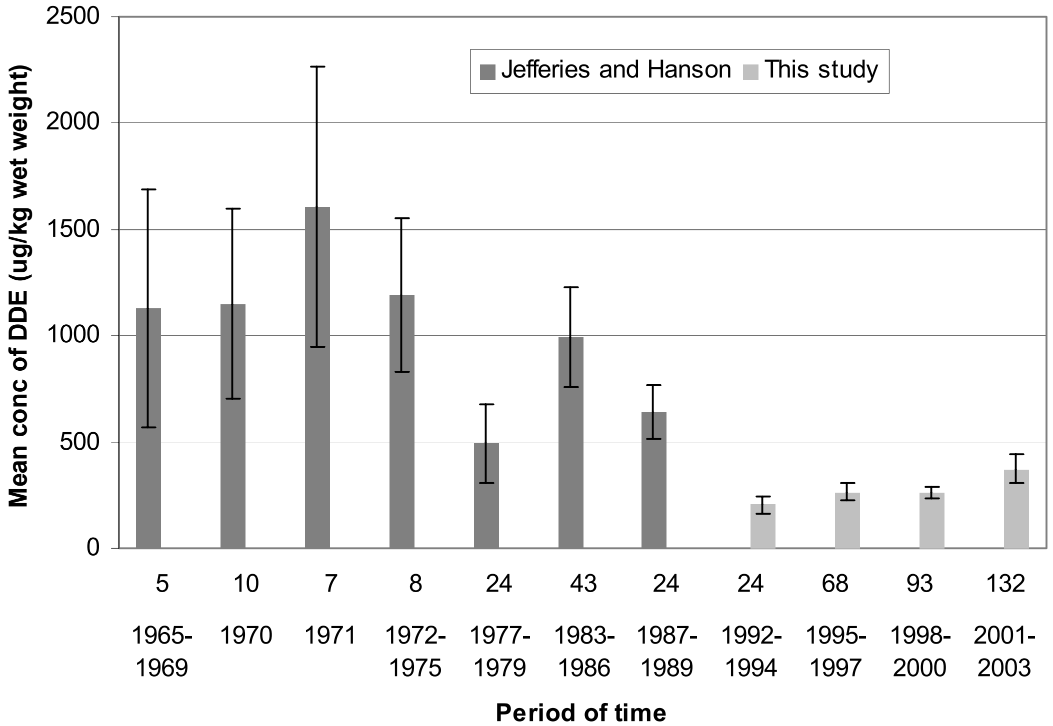

Figure 9.2 Decline in DDE levels since the late 1960s. 1965-1989 data are taken from Jefferies and Hanson (2000).

10 Further research and collaborations

Since the middle of 2004, the management of the Cardiff University Otter Project has passed from Dr Adeline Bradshaw to Dr Elizabeth Chadwick. In addition to continuing post mortem analysis and monitoring of chemical pollution, a number of new research projects are underway.

10.1 Genetic analysis

A PhD study by G Hobbs, supervised by Professor M Bruford at Cardiff University, using samples from Southern and South West Regions provided by V Simpson in addition to samples from all other Regions archived at Cardiff University.

Following successful preliminary analyses during summer 2005, the PhD began in October 2005. DNA is being extracted from archived muscle samples to assess microsatellite variability. Initial analyses will focus on samples from Wales and surrounding catchments, followed by samples from the rest of England in years two and three.

The project has three aims.

- To compare spatial genetic patterns with environmental and landscape features, to gain a better understanding of barriers to dispersal and gene flow.
- To genetically identify the source populations and dispersal routes of otters that have recolonised areas of central England.
- To identify the genetic contribution and the spread of introduced animals.

10.2 Analysis of lead levels in otter bone

A BSc dissertation by A Nicholls with E Chadwick supervising.

Initial results were presented as a poster at the Ninth International Mammalogical Congress, in Sapporo, Japan (the poster is presented as Appendix 4). A publication is being prepared.

Levels of lead were determined using ICP-MS (Inductively Coupled Plasma Mass Spectrometry), following nitric acid digestion of ashed rib samples. In total, 347 samples were used, supplied by V Simpson. A marked decline in lead levels was measured between 1992 and 2004, which reflects the decline in airborne concentration following emissions legislation (Figure 10.1).

10.3 Dietary analysis

A PhD study by G Parry, supervised by Dr D Forman at Swansea University.

All stomach and gastro-intestinal tracts are retained and sent for analysis in this collaborative study between Cardiff and Swansea Universities. All prey remains will be identified.

While only a small number (14) have been examined thus far, preliminary analyses have identified eel, salmonid, stickleback and a variety of marine species. In addition, avian prey includes species such as mallard, coot, pied wagtail and crow and mammalian prey includes brown rat, bank vole and rabbit (D Forman, personal communication). In one instance domestic refuse (including a rubber balloon) was recovered from an emaciated juvenile. Further analyses over the next two years will enable regional trends to be assessed.

10.4 Endoparasite identification

A collaborative study with Dr D Forman at Swansea University

During examination of the digestive tract for prey remains, it is also possible to remove endoparasites for identification. In a parallel investigation to the dietary analysis described above, intestinal parasites have so far been recovered from all animals examined. This contrasts strongly with a study in Denmark, where endoparasites were found in less than four per cent of animals examined and it was concluded that the otter is infrequently parasitized (Madsen *et al.* 2000). Parasite loading (number of specimens recovered) has been highly variable with some animals having in excess of 200 individual specimens whilst others have less than 10. A wide diversity of helminths (of both marine and freshwater origin) has been recovered, predominately from the small intestine. In addition, animals are screened for *Angiostrongylus vasorum* (canine heart worm). So far this has not been found.

In light of the recent finding of the fluke *Pseudamphistomum truncatum* (not previously recorded in Britain) in the gall bladders of otters and mink from Somerset (Simpson *et al.* 2005), gall bladders are now also retained for further examination.

10.5 Ectoparasite identification

A collaborative study with Dr D Forman at Swansea University.

The pelt of each animal is thoroughly searched for ectoparasites, which are retained for identification in a further collaboration between Cardiff and Swansea Universities. Ticks collected have been identified predominantly as *Ixodes trianguliceps* and *I. ricinus*. Several hedgehog ticks (*I. hexagonus*) have also been recovered (D Forman, personal communication).

10.6 Skull morphometrics study

A BSc dissertation by J Bishop, with E Chadwick supervising. Skulls were cleaned by the National Museum of Scotland and will be held in the mammals and birds collection there, curated by Dr A Kitchener.

Craniometric data were obtained from a total of 125 intact skulls. Measurements used included condylobasal length, basilar length, palatal length, zygomatic breadth, mastoid breadth, inter-orbital breadth, post-orbital breadth, post-orbital constriction, upper molar breadth, rostral breadth, maxillary tooth row length (as defined in Lynch and O'Sullivan (1993)) and canine length.

The results indicated sexual and age dimorphism, particularly around the jaw, with males showing significantly larger canines and rostral breadth (breadth of the muzzle), after allowing for differences in skull size (see Figure 10.2, for example). Further work on skull morphometrics is planned, in collaboration with D Forman of Swansea University, and a publication is being prepared.

10.7 Stable isotope analysis

This is a proposed research collaboration with Dr R Luxton of Cardiff University. An application for funding is in preparation.

Coastal feeding is widely documented in many European otter populations, but traditional opinion suggests that in England and Wales otters feed mainly in fresh water (Chanin 2003).

The development of stable isotope (SI) technology enables the investigation of feeding habits over long periods of time (seasonal or lifetime consumption). This differs from stomach contents or spraint analyses, which only reveal diet immediately prior to death or defecation. Foraging locations can be inferred from the characteristic signature assimilated from isotopically distinct food-webs. Turnover rates differ between tissues and this can be exploited by selecting tissues to represent particular periods over which SIs were integrated (Rubenstein and Hobson 2004). To date, no such studies have been carried out using tissue of the European otter. Using our archive of bone and muscle, we propose to identify spatial and temporal variation in the importance of marine derived nutrients to the otter, through coastal feeding and feeding on anadromous fish inland.

10.8 Aging

We are currently awaiting export permissions to send all our otter teeth for analysis at Matson's laboratory in North America (www.matsonslab.com/). Import permits were granted in May 2006.

Aging will be carried out wherever possible, using cementum analysis of the teeth. This will enable clarification of the age structure of the population and the new information will be used to analyse the bioaccumulation of pollutants and the morphometric data.

10.9 Re-analysis of baculum length

Baculae are currently being cleaned by the National Museum of Scotland, to be held in their collection following morphometric analysis at Cardiff University.

Baculum length measurements taken at post-mortem are inaccurate due to the adhesion of tissue. An agreement has been made with the National Museum of Scotland that all baculae archived at Cardiff University will be cleaned and returned for morphometric analysis, before being held permanently in the collection at Edinburgh. In conjunction with age data from teeth and observations of skull sutures, this will enable more accurate assessment of baculum length as an indicator of age.

10.10 Brominated flame retardants (PBDEs)

Angela Pountney at Exeter University is carrying out a PhD study on brominated flame retardants (PBDEs), using samples contributed by Cardiff University and by V Simpson.

This study will measure the levels of PBDEs within otter tissue and investigate whether these compounds are having specific adverse effects on the individual otters.

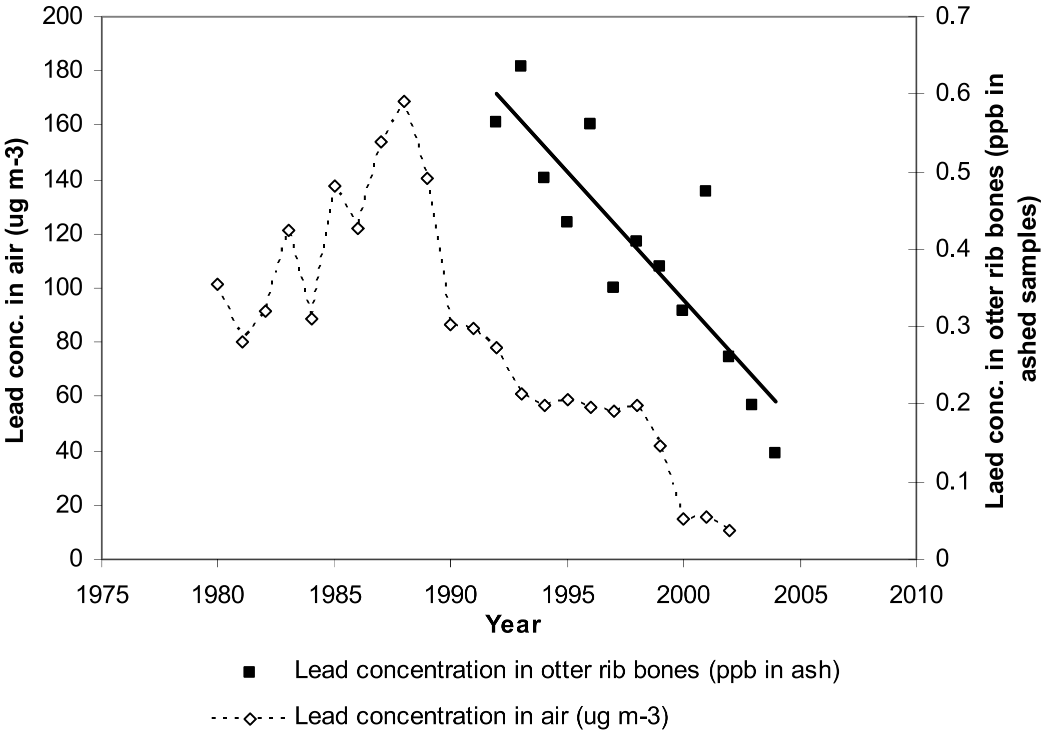

Figure 10.1 Declining lead levels measured in otter bone and in air

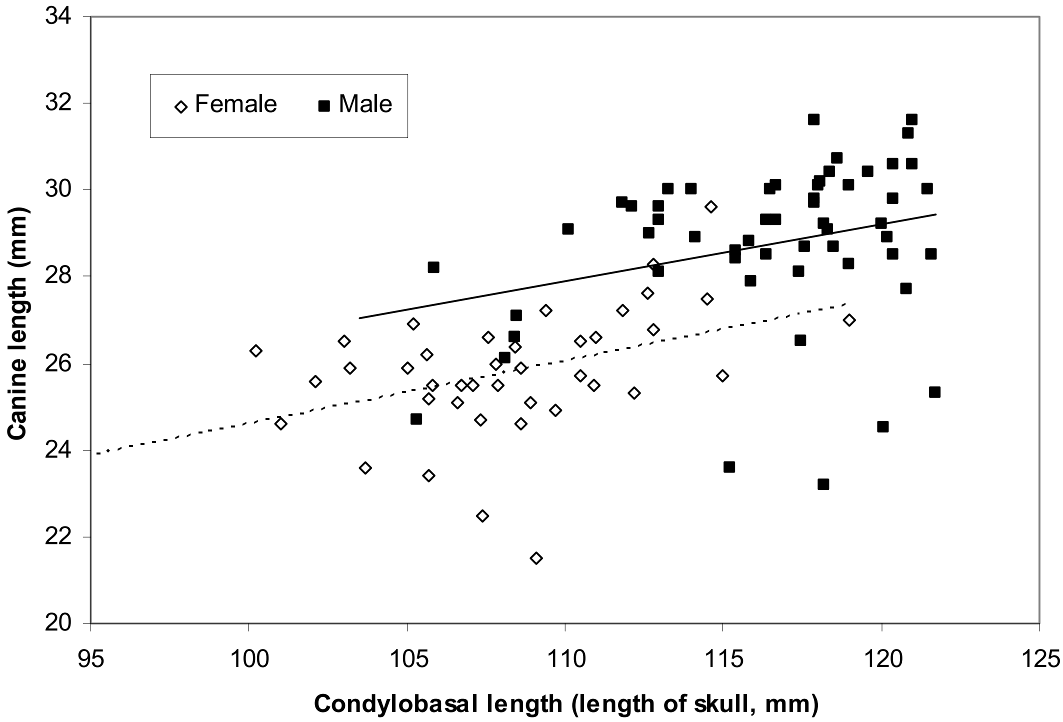

Figure 10.2 Sexual dimorphism in otter jaw structure

11 Conclusions

- Both the distribution and the number of otter carcasses being submitted have increased during the period covered by this report. The increases support the conclusions of the national otter surveys, which have clearly shown that otter distribution in Britain is expanding and otter numbers are increasing.

- Road traffic accidents (RTAs) are clearly a significant cause of death, particularly in the winter months. However, due to the unavoidable bias in collection methods, the importance of RTAs relative to other causes of mortality is overestimated. It is not possible to tell from this study how much RTAs affect otter population growth.

- No major change to the structure of the population has occurred over the course of the study. Some evidence, such as decreasing body size and incidence of renal calculi, suggests a shift towards a younger population.

- Although indirect evidence suggests that reproduction may be seasonal, there is no conclusive evidence for this. Non-seasonal reproduction has potential animal welfare implications, since cubs may be left at any time of year following the death of an adult female.

- Slight but non-significant declines in OCs, PCBs and HCB are apparent in recent years. Comparison with data from previous studies suggests that declines have, to a great extent, levelled off. However, pp'DDE, dieldrin and PCBs are still present in virtually all samples examined, despite legislative exclusion.

- Clear differences in pollutant loading are apparent between sexes and age groups. There is strong evidence for bioaccumulation in males and maternal transfer from females to juveniles. Although overall levels are low, the transfer of accumulated pollutant loads to young at a crucial stage of their development could have serious consequences.

12 Recommendations

- The collection and necropsy of otters found dead in England and Wales has provided a wealth of information. It should be continued, to monitor future changes in the health and population structure of this key indicator species.

- The chemical analysis of otter tissue collected post mortem has been established as a tool for monitoring the freshwater environment. Chemical analyses of samples have already provided evidence of contamination, bioaccumulation and maternal transfer. These analyses should be continued, to monitor change and to increase the size of the existing dataset, enabling more comprehensive spatio-temporal analyses.

- Some of the archived material should be chemically analysed again, using the improved analytical techniques, to enable comparison of past and present data. For example, since changes in methodology there seems to be a dramatic decline in isodrin, but there are no comparable data prior to 1999. Re-analysis of archived samples for isodrin would be of particular interest, since the compound is highly toxic.

- Samples should be archived, to enable retrospective analyses for contaminants of as yet unknown significance. Interpretation of the impact of OCs and PCBs would have been far easier if samples had been archived prior to population crashes. Archiving present samples for the future could prove invaluable.

- We recommend statistical analysis of all the available data for England and Wales in combination. This might be extremely informative and give a clearer understanding of some issues than the separate analyses carried out at present for southern England and the rest of England and Wales.

- Other organisations and research bodies should be consulted to discuss testing for additional substances, such as synthetic pyrethroids. These have been reported to have toxic effects on mammals, causing the development of motor and sensory disorders and have been shown to cause inhibition of mitochondrial activity in rats (Gassner *et al.* 1997).

- Problems with measurement of lipid content of samples should be addressed and resolved, to enable this to be taken into account in analyses of contamination.

- Accurate assessment of the age of sampled animals is critical to measuring the potential change in age structure over time and is an important factor in assessing bioaccumulation of contaminants. We have taken steps to have archived teeth aged at a specialist laboratory in the United States. This should be supported.

- A recent study of *Toxoplasma gondii* showed high levels of infection of Californian sea otters, particularly associated with human habitation (Conrad *et al.* 2005). Assessment of the prevalence of this parasite in UK otters would be of interest.

Abbreviations and acronyms

DDE	dichlorodiphenyldichlorethylene, a breakdown product of DDT
DDT	dichlorodiphenyltrichloroethane
EDCs	endocrine disrupting chemicals
HC Benz	hexachlorobenzene
HC Buta	hexachlorobutadiene
HCH	hexachlorocyclohexane
NGR	national grid reference
OCs	organochlorine pesticides
PCBs	polychlorinated biphenyls
TCB	tetrachlorobenzene
TDE	trichlorodiphenyltrichloroethylene, a breakdown product of DDT
RTA	road traffic accident
UWC	University of Wales, Cardiff

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Appendices

Appendix 1 post mortem record sheet used by A bradshaw 1994 - 2003

POSTMORTEM REF NO.	/ /	DETAILS OF OTTER:	
CHEMICAL REF:		DATE FOUND:	
EXAMINED BY:		AGE:	
DATE:		SEX:	
COLLECTED BY:		LOCATION:	
CARCASS CONDITION:		NGR:	
EA CONTACT:		CATCHMENT:	

THIS REPORT CONTAINS UNPUBLISHED INFORMATION WHICH MUST NOT BE RELEASED WITHOUT THE AUTHORS PERMISSION AND IN THAT CASE ITS SOURCE MUST BE FULLY ACKNOWLEDGED
NOTES/MAILING LIST

BODY MEASUREMENTS			
BODY LENGTH	mm	TOTAL LENGTH (NOSE-TO-TAIL)	mm
TAIL	mm	WEIGHT	Kg
		CONDITION INDEX (K)	

SUMMARY OF PATHOLOGICAL FINDINGS	
REPRODUCTIVE STATUS	
RENAL CALCULI	
MALIGNANCY	
ADRENAL ENLARGEMENT	
PERITONITIS/SEPTICAEMIA	
PARASITES	
FIGHTING INJURIES	
PROPOSED CAUSE OF DEATH	

REFERENCE:

GROSS POSTMORTEM EXAMINATION:

SKIN & SUBCUTIS	
BODY CAVITIES	
MUSCULO-SKELETAL SYSTEM	
ALIMENTARY SYSTEM	
RESPIRATORY SYSTEM	
CARDIOVASCULAR SYSTEM	
LYMPHORETICULAR SYSTEM	
ENDOCRINE SYSTEM	
URINARY SYSTEM	
REPRODUCTIVE SYSTEM	
NERVOUS SYSTEM	

NOTES:

SAMPLES REMOVED:	BACULUM		LIVER		KIDNEYS		SPLEEN		OTHER	
					CALCULI		HEART			
	SKULL		MUSCLE				TESTES			
	(TEETH)		-20°C		GI TRACT		LUNGS			
			70% ETHANOL		CONTENTS		HAIR			
	TIB/FIB						UTERUS			
			SCENT				VIBRISSAE			

Appendix 2: Basic information recorded for each otter

Appendix 2: Basic information recorded for each otter

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
1	17 February 1994	SN547195	South West - Welsh	Male	Sub-adult	1070	5.6	
2	17 August 1992	SM812246	South West - Welsh	Female	Adult	1120	5.8	
3	05 February 1994	SM959240	South West - Welsh	Male	Adult	1112	8.3	
4	05 January 1994	SN037228	South West - Welsh	Male	Adult	1175	5.9	
5	1994		EA Wales	Male	Sub-adult	920	5.3	
6	1994		EA Wales	Female	Adult	1130	6.5	
7	07 April 1994	SN961547	South East - Welsh	Male	Adult	1095	8.7	
8	21 July 1994	SO0428	South East - Welsh	Female	Juvenile	680	1.3	
9	1994		EA Wales	Male	Sub-adult	1185	6.9	
10	27 October 1992	SN590776	South West - Welsh	Female	Adult	1060	5.8	Lactating
11	31 March 1994	SH530395	Northern - Welsh	Female	Adult	1060	7.7	Lactating
12	1994		EA Wales	Female	Adult	1075	8.0	Pregnant
13	27 February 1994	SM940160	South West - Welsh	Female	Adult	1050	6.1	Lactating
14	01 March 1994	SM944322	South West - Welsh	Female	Adult	1120	7.0	Lactating
15	24 April 1994	SN427222	South West - Welsh	Female	Adult	1045	5.9	
16	21 July 1994	SO135377	South East - Welsh	Female	Adult	1020	5.3	
17	19 August 1994	SJ293031	Upper Severn - Midlands	Female	Sub-adult	1000	5.1	
18	21 September 1994	SO110843	South East - Welsh	Male	Sub-adult	1000	5.4	
19	11 August 1994	SO870397	Lower Severn - Midlands	Female	Adult	1025	5.7	
20	9 October 1994	SN232435	South West - Welsh	Male	Sub-adult	965	4.9	
21	01 August 1994	SN0100	South West - Welsh	Male	Adult	1060	8.4	
22	24 November 1994	SO094259	South East - Welsh	Male	Sub-adult	1060	5.9	
23	31 December 1994	NT975250	Northumbria - North East	Male	Adult	1070	5.8	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
24	5 January 1995	SN577896	Northern - Welsh	Male	Sub-adult	1000	8.4	
25	4 November 1994	SS9386	South West - Welsh	Female	Adult	1015	7.1	
26	July 1994	SN864058	South West - Welsh	Male	Adult	1101	8.3	
27	25 February 1995	SO272921	Upper Severn - Midlands	Male	Adult	1075	7.3	
28	30 August 1995	SK386564	Lower Trent - Midlands	Male	Sub-adult	980		
29	July 1995	SK7857	Lower Trent - Midlands	Male	Adult	1063	8.5	
30	10 December 1992	SO0428	South East - Welsh	Male	Adult	1010	6.2	
31	16 December 1994	SO130220	South East - Welsh	Female	Sub-adult	900	4.4	
32	06 February 1995	SN133249	South West - Welsh	Male	Adult	1180	8.4	
33	15 February 1995	SH580380	Northern - Welsh	Male	Adult	1100	9.2	
34	25 July 1993	SN378335	South West - Welsh	Female	Sub-adult	1000	5.3	
35	10 October 1995	SN060353	South West - Welsh	Male	Sub-adult	1090	6.6	
36	22 February 1995	SM955201	South West - Welsh	Female	Sub-adult	970	4.5	
37	8 November 1994	SN870300	South West - Welsh	Female	Adult	990	5.3	
38	21 November 1994	SM811082	South West - Welsh	Female	Adult	1085	7.2	
39	1 April 1995	SN634339	South West - Welsh	Male	Adult	1115	8.0	
40	November 1994	SN5000	South West - Welsh	Male	Adult	1090	9.0	
41	16 May 1995	SN3245	South West - Welsh	Male	Adult	1020	4.5	
42	8 December 1994	SM999009	South West - Welsh	Female	Adult	1000	6.2	
43	19 March 1995	SN539698	South West - Welsh	Male	Sub-adult	850	4.6	
44	1 September 1995	SN3731	South West - Welsh	Male	Adult	1020	6.0	
45	1 October 1995	ST1285	South East - Welsh	Male	Adult	1114	8.5	
46	28 January 1992	SM955147	South West - Welsh	Female	Adult	990	6.7	Pregnant
47	September 1993	SN0215	South West - Welsh	Male	Sub-adult	930	4.7	
48	21 November 1993	SN013006	South West - Welsh	Male	Adult	1070	8.4	
49	8 October 1995	SN128022	South West - Welsh	Male	Sub-adult	1030	5.4	
50	October 1995	SN303414	South West - Welsh	Female	Adult	990	5.9	
51	October 1995	SN426028	South West - Welsh	Male	Adult	1150	10.0	
52	December 1995		EA Wales	Male	Sub-adult	910	3.9	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
53	24 November 1995	TG202117	Eastern - Anglian	Male	Sub-adult	910	3.9	
55	May 1994	SH586386	Northern - Welsh	Male	Adult	1230	7.2	
56	23 December 1995	SN994628	South East - Welsh	Male	Adult	1060	8.6	
57	21 January 1996	SO0428	South East - Welsh	Male	Adult	1100	7.7	
58	February 1996	SN170459	South West - Welsh	Male	Adult	1185	9.5	
59	9 February 1996	SN532153	South West - Welsh	Male	Adult	1000	4.9	
60	23 December 1995	SN432279	South West - Welsh	Female	Adult	1030	6.6	Pregnant
61	13 February 1996	SN515117	South West - Welsh	Female	Adult	1024	5.7	Lactating
62	January 1996	SJ413074	Upper Severn - Midlands	Male	Adult	1142	8.4	
63	March 1996	SO2682	Upper Severn - Midlands	Female	Adult	1050	7.5	Lactating
64	14 February 1996	TM039790	Eastern - Anglian	Male	Adult	1010	7.5	
65	1 March 1996	TF936264	Eastern - Anglian	Male	Adult	1080	9.3	
66	3 April 1996	TL925819	Central - Anglian	Male	Adult	1120	11.7	
67	31 March 1996	TL9969	Central - Anglian	Female	Sub-adult	900	4.5	
68	31 March 1996	TL9969	Central - Anglian	Female	Sub-adult	1000	5.6	
69	February 1996		North East	Female	Juvenile	750	2.0	
70	February 1996		EA Wales	Female	Adult	1000	5.5	
71	2 March 1996	SN979286	South East - Welsh	Male	Adult	1090	9.0	
72	March 1996	SO181978	Upper Severn - Midlands	Female	Adult	1020	6.1	
73	March 1996	SO3750	South East - Welsh	Female	Sub-adult	900	4.9	
74	1996		Welsh	Female	Sub-adult	900	5.0	
75	27 August 1996	SN607024	South West - Welsh	Male	Adult	1160	10.4	
76	March 1996	ST0888	South East - Welsh	Male	Adult	1100	9.8	
77	21 April 1996	SN615809	South West - Welsh	Male	Sub-adult	1000	4.7	
78	1996	SN5000	South West - Welsh	Female	Adult	1020	5.5	
79	21 June 1996	SN2010	South West - Welsh	Female	Sub-adult	920	5.0	
80	3 October 1996	SN760076	South West - Welsh	Male	Adult	1180	8.7	
81	15 May 1996	SO362302	South East - Welsh	Male	Sub-adult	890	4.3	
82	February 1996		EA Wales	Female	Sub-adult	960	3.9	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
83	29 September 1996	SN658918	Northern - Welsh	Male	Adult	1070	8.0	
84	07 October 1996	SO079604	South East - Welsh	Female	Sub-adult	980	4.7	
85	September 1996	SO175973	Upper Severn - Midlands	Male	Adult	1086	9.4	
86	14 September 1996	TG421186	Eastern - Anglian	Male	Adult	1180	10.5	
87	22 October 1996	SK990035	Northern - Anglian	Male	Adult	1170	12.0	
88	10 October 1996	SO1173	South East - Welsh	Male	Sub-adult	980	5.0	
89	29 October 1996	SO202196	South East - Welsh	Female	Adult	1030	7.0	Lactating
90	November 1996		EA Wales	Male	Adult	1080	6.3	
91	15 November 1996	SO0558	South East - Welsh	Female	Sub-adult	920	5.0	
92	November 1996	SJ177192	Upper Severn - Midlands	Female	Adult	1085	6.6	
93	2 December 1996	SN634343	South West - Welsh	Male	Adult	1080	8.5	
94	December 1996		EA Wales	Female	Adult	1030	7.0	Lactating
95	2 December 1996	SO115245	South East - Welsh	Male	Adult	1070	8.5	
96	September 1996	SJ658579	Southern - North West	Male	Adult	1100	7.4	
97	12 March 1993	NY420585	Northern - North West	Male	Adult	1140	10.4	
98	03 November 1992	SD445614	Central - North West	Female	Adult	1090	6.0	
99	26 November 1996	TL698478	Eastern - Anglian	Female	Adult	1030	6.5	
100	16 December 1996	TL865288	Eastern - Anglian	Male	Adult	1170	9.6	
101	5 December 1996	NZ0371	Northumbria - North East	Male	Adult	1190	6.4	
102	November 1996	SJ5220	Upper Severn - Midlands	Male	Adult	1075	7.0	
103	December 1996	SH564398	Northern - Welsh	Male	Adult	1120	9.1	
104	05 January 1997	SJ2304	Upper Severn - Midlands	Female	Sub-adult	980	4.0	
105	16 January 1997	SN382455	South West - Welsh	Male	Sub-adult	950	6.2	
106	17 January 1997	SN434125	South West - Welsh	Female	Adult	1020	5.1	
107	9 February 1997	SN902292	South East - Welsh	Male	Juvenile	640	1.7	
108	January 1997	SJ639319	Upper Severn - Midlands	Female	Adult	1000	3.9	
109	25 February 1997	SN495219	South West - Welsh	Male	Sub-adult	960	4.9	
110	17 February 1997	SN117046	South West - Welsh	Female	Adult	1050	6.4	
111	February 1997	SO263582	South East - Welsh	Male	Adult	1090	9.0	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
112	6 March 1997	SO034278	South East - Welsh	Female	Adult	1020	6.6	Lactating
113	12 March 1997	SO245757	Upper Severn - Midlands	Female	Sub-adult	810	3.5	
114	16 March 1997	SS569902	South West - Welsh	Male	Adult	1130	9.2	
115	1997		EA Wales	Female				
116	11 April 1997	SN44	South West - Welsh	Male	Adult	1140	6.5	
117	12 May 1997	SO066504	South East - Welsh	Male	Sub-adult	940	3.6	
118	May 1997	SN014389	South West - Welsh	Female	Adult	1030	6.0	
119	June 1997	SN1015	South West - Welsh	Male	Juvenile	685	1.5	
120	13 June 1997	SO2647	South East - Welsh	Male	Adult	1190	8.5	
121	June 1997		North East	Male	Adult			
122	4 June 1997	SP779924	Northern - Anglian	Male	Sub-adult	1090	6.8	
123	27 June 1997	SN619837	South West - Welsh	Male	Adult	1130	8.0	
124	27 June 1997	SN412056	South West - Welsh	Male	Adult	1170	8.9	
125	11 July 1997	SM9535	South West - Welsh	Male	Adult	1150	4.5	
126	20 July 1997	SR9795	South West - Welsh	Male	Juvenile	700	1.2	
127	1 October 1997	SO1635	South East - Welsh	Female	Sub-adult	1000	5.6	
128	July 1997	SN2555	South West - Welsh	Male	Sub-adult	1080	5.1	
129	5 October 1997	SN610824	South West - Welsh	Male	Sub-adult	1090	5.4	
130	4 November 1997	SN7515	South West - Welsh	Female	Sub-adult	1020	5.8	
131	July 1997	SO799145	Lower Severn - Midlands	Male	Adult	1190	10.0	
132	December 1997	SK228666	Lower Trent - Midlands	Male	Juvenile	680	2.2	
133	11 November 1997	SO335637	South East - Welsh	Female	Adult	1030	5.6	
134	December 1997		EA Wales	Male	Adult	1100	9.9	
135	20 December 1997	ST269835	South East - Welsh	Male	Adult	1164	10.2	
136	19 December 1997	SN604963	Northern - Welsh	Male	Adult	1030	7.0	
137	02 November 1997	NT922370	Northumbria - North East	Male	Adult	1010	7.5	
138	02 November 1997	NT922370	Northumbria - North East	Male	Adult	1100	9.9	
139	14 August 1997	TM455765	Eastern - Anglian	Female	Adult	1050	7.4	
140	22 September 1997	TG346248	Eastern - Anglian	Female	Sub-adult	860	3.6	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
141	5 November 1997	TF999203	Eastern - Anglian	Female	Adult	1050	6.5	
142	30 November 1997	TF999203	Eastern - Anglian	Male	Adult	1110	9.4	
143	January 1998	SN189368	South West - Welsh	Male	Sub-adult	1080	7.6	
144	10 January 1998	SM90	South West - Welsh	Male	Adult	1165	7.8	
145	January 1998	SN626813	South West - Welsh	Female	Adult	1000	6.2	Lactating
146	19 November 1997	SN364126	South West - Welsh	Male	Adult		8.1	
147	31 January 1998	SN647304	South West - Welsh	Male	Adult	1140	9.5	
148	2 February 1998	SN545107	South West - Welsh	Female	Sub-adult	780	3.3	
149	February 1998	SN62	South West - Welsh	Male	Adult		5.0	
150	1998		North West	Male	Adult			
151	13 February 1998	SH780644	Northern - Welsh	Male	Adult	1080	8.3	
152	25 February 1998	SO259143	South East - Welsh	Female	Adult		5.5	Lactating
153	March 1998		EA Wales	Female	Sub-adult	760	2.9	
154	11 March 1998	SE87	Dales - North East	Male	Sub-adult	1005	6.6	
155	1 March 1998	SN384379	South West - Welsh	Female	Sub-adult	970	5.0	
156	13 February 1998	SM966198	South West - Welsh	Male	Sub-adult	1000	5.7	
157	March 1998		EA Wales	Male	Adult	1020	8.4	
158	1998		Thames	Male	Adult	1070	7.7	
159	1998		Thames	Female	Adult	964	5.4	
160	1998		Thames	Female	Sub-adult	983	5.6	
161	1998		Thames	Female	Adult	900	5.2	
162	1998		Thames	Female	Adult	955	4.8	
163	23 March 1998	SN65	South West - Welsh	Male	Adult	1045	7.0	
165	7 April 1998		EA Wales	Male	Adult	1070	7.0	
166	13 April 1998	SN735663	South West - Welsh	Male	Juvenile	845	2.3	
167	20 April 1998	SN224595	South West - Welsh	Male	Adult	1120	10.4	
168	20 April 1998	TL035867	Northern - Anglian	Male	Sub-adult		8.4	
169	24 April 1998	SO1868	South East - Welsh	Female	Sub-adult	960	5.0	
170	01 August 1998	SN623214	South West - Welsh	Female	Sub-adult	965	5.5	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
171	October 1998	SM92	South West - Welsh	Female	Adult	950	6.5	Lactating
172	3 February 1998	SH614388	Northern - Welsh	Male	Adult	1180	9.5	
173	19 October 1998	TF634121	Central - Anglian	Male	Adult	1085	8.0	
174	1998		Anglian	Male	Adult	1135	7.5	
175	November 1998	TF098087	Northern - Anglian	Male	Adult	1140		
176	20 December 1998	TM248444	Eastern - Anglian	Male	Sub-adult	1010	5.8	
177	1998	SE610834	Dales - North East	Male	Adult	1020	5.3	
178	18 October 1998	SE949807	Dales - North East	Male	Adult	1205	9.8	
179	1998	SE705859	Dales - North East	Male	Adult	1300	9.3	
180	December 1998	TF1108	Northern - Anglian	Male	Adult		5.6	
181	6 November 1998		Thames	Female	Adult	1020	4.4	
182	5 November 1998		Thames	Female	Adult	980	6.8	Lactating
183	December 1997	TL507425	Central - Anglian	Female	Sub-adult			
184	December 1998	TG043437	Eastern - Anglian	Male	Adult	1120	9.0	
185	7 May 1998	SN374275	South West - Welsh	Male	Juvenile	710	1.8	
186	1998		EA Wales	Male	Juvenile	760	2.5	
187	27 May 1998	SO325588	South East - Welsh	Female	Sub-adult	935	3.4	
188	10 September 1998	SN979287	South East - Welsh	Female	Sub-adult	840	3.4	
189	3 October 1998	SO080440	South East - Welsh	Female	Sub-adult	990	4.8	
190	October 1998		EA Wales	Male	Adult	1170	8.7	
191	18 November 1998		EA Wales	Female	Adult	1000	7.2	Lactating
192	November 1998	SO276612	South East - Welsh	Female	Adult	1030	6.0	
193	November 1998	SM82	South West - Welsh	Female	Adult	1010	5.2	
194	30 November 1998	SM959241	South West - Welsh	Male	Adult	1160	7.8	
195	2 December 1998	SN465204	South West - Welsh	Male	Adult	1100	8.6	
196	October 1998		EA Wales	Male	Adult	1130	9.0	
197	March 1998		EA Wales	Male	Sub-adult	950	5.2	
198	1998		EA Wales	Male	Adult	1080	8.8	
199	1998		EA Wales	Male	Adult	1150	9.5	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
200	17 January 1999	SO88	Upper Severn - Midlands	Male	Adult	1185	5.6	
201	9 April 1999	TL934581	Eastern - Anglian	Male	Sub-adult	845	4.3	
202	21 January 1999	SN265155	South West - Welsh	Male	Adult	1175	8.5	
203	7 February 1999	SN981288	South East - Welsh	Male	Adult	1060	6.5	
204	January 1999	SN242490	South West - Welsh	Male	Adult	1290	10.9	
205	1 February 1999	SH608284	Northern - Welsh	Male	Juvenile	635	1.6	
206	5 February 1999	SN591454	South West - Welsh	Male	Adult	1200	8.5	
207	18 February 1999	SN618809	South West - Welsh	Male	Adult			
208	25 February 1999	SO032632	South East - Welsh	Male	Adult	1110	8.5	
209	4 March 1999	SN4055	South West - Welsh	Male	Adult	1135	8.8	
210	12 March 1999	SN643682	South West - Welsh	Male	Adult	1110	9.2	
211	11 March 1999	SN497168	South West - Welsh	Male	Adult	1040	6.0	
212	1999		EA Wales	Male	Adult	1100	6.5	
213	1999		EA Wales	Female	Adult	1060	7.0	
214	June 1998	SH449549	Northern - Welsh	Male	Adult	1200	10.5	
215	June 1998	SN525684	South West - Welsh	Female	Sub-adult	940	3.2	
216	10 November 1998	SN81	South West - Welsh	Male	Sub-adult	1050	6.5	
217	2 October 1998		EA Wales	Female	Sub-adult	950	4.5	
218	23 February 1999	SS501865	South West - Welsh	Male	Adult	1060	7.0	
219	1999		EA Wales	Male	Adult	1170	9.5	
220	4 May 1999	SO027595	South East - Welsh	Male	Sub-adult	950	4.3	
221	1 May 1997	SD500046	Central - North West	Female	Adult	1040	6.0	Pregnant
222	8 June 1999	TM327887	Eastern - Anglian		Juvenile		2.0	
223	5 July 1999	NY393166	Northern - North West	Female	Sub-adult	1000	6.5	
224	10 November 1997	NY389704	Northern - North West	Female	Sub-adult	1000	5.5	
225	October 1999	SO0967	South East - Welsh	Male	Adult	1070	7.5	
226	27 April 1999	SJ312309	Upper Severn - Midlands	Female	Adult	1000	6.3	
227	1999	SE6577	Dales - North East	Female	Sub-adult	900	4.5	
229	4 September 1999	SN979287	South East - Welsh	Female	Sub-adult	830	2.2	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
230	11 October 1999	SP204035	West - Thames	Male	Adult	1150	8.7	
231	September 1999	TG343098	Eastern - Anglian	Male	Adult	1145	9.0	
232	27 August 1999		EA Wales	Male	Sub-adult	970	5.0	
233	13 October 1999	NY368588	Northern - North West	Male	Adult	1110	7.2	
234	10 November 1999	SP254049	West - Thames	Female	Adult	1010	5.0	Lactating
235	14 October 1999	NY36	Northern - North West	Male	Adult	1040	7.0	
236	01 August 1997	NY5461	Northern - North West	Female	Adult	1000	6.5	Pregnant
237	13 June 1998	NY339509	Northern - North West	Male	Sub-adult	1060	6.4	
238	October 1999	NY539591	Northern - North West	Male	Sub-adult	935	4.5	
239	05 August 1999	NY4376	Northern - North West	Male	Sub-adult	920	4.3	
240	19 July 1999		EA Wales	Male	Sub-adult	1160	5.1	
241	24 October 1999	SO1363	South East - Welsh	Female	Adult	960	5.2	Lactating
242	30 October 1999	SH288402	Northern - Welsh	Male	Sub-adult	985	5.4	
243	10 November 1999	SN568196	South West - Welsh	Male	Adult	1150	9.0	
244	23 December 1994	SM943321	South West - Welsh	Male	Adult	1080	8.5	
245	October 1999	SM90	South West - Welsh	Male	Adult	1070	7.8	
246	01 August 1995	NY45	Northern - North West	Male	Adult	1165	9.5	
247	9 November 1999	NY597286	Northern - North West	Male	Adult		8.5	
248	25 October 1999	SJ299316	Upper Severn - Midlands	Male	Adult	1070	7.4	
249	1999		Midlands	Male	Sub-adult	915	4.5	
250	1999		Midlands	Male	Sub-adult	890	4.2	
251	7 December 1999		Midlands	Male	Adult	1045	8.5	
252	7 December 1999		Midlands	Male	Sub-adult	930	4.3	
253	December 1999	SO777236	Lower Severn - Midlands	Male	Adult	1100	5.4	
254	1 January 2000	SO41980482	South East - Welsh	Male	Adult	1190	10.5	
255	12 December 1999	TG249076	Eastern - Anglian	Female	Adult	1060	3.6	
256	December 1999	SN188404	South West - Welsh	Male	Adult	1170	9.5	
257	17 January 2000	SU171818	West - Thames	Female	Adult	1000	6.1	
258	31 March 2000	SO676581	South East - Welsh	Male	Adult	1150	7.5	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
259	28 October 1995	SO25	South East - Welsh	Female	Sub-adult	1060	6.4	
260	22 January 2000	SO167903	Upper Severn - Midlands	Male	Adult	1090	7.9	
261	24 January 2000	SO103485	South East - Welsh	Female	Adult	1060	6.5	Lactating
273	January 1997	NY3545	Northern - North West	Female	Sub-adult	800	2.5	
284	3 February 2000	NY427577	Northern - North West	Male	Adult	1156	9.7	
285	30 January 2000	NZ607187	Dales - North East	Female	Adult	1055	6.1	Lactating
286	13 March 2000	NZ544092	Dales - North East	Female	Adult	1050	5.8	
287	25 October 1999	SO00	South East - Welsh	Female	Sub-adult	930	4.8	
288	25 October 1999	SO00	South East - Welsh	Female	Sub-adult		4.6	
289	January 2000		EA Wales	Male	Sub-adult		5.8	
290	January 2000		EA Wales	Male	Adult		5.8	
291	January 2000		EA Wales	Male	Sub-adult	1010	6.3	
292	15 February 2000	SN635243	South West - Welsh	Male	Adult	1060	5.7	
293	17 February 2000	TM008936	Central - Anglian	Male	Adult	1210	7.3	
294	24 February 2000	ST292887	South East - Welsh	Male	Adult			
295	March 2000	SO996754	Lower Severn - Midlands	Female	Adult	1000		
296	4 March 2000	SK712188	Lower Trent - Midlands	Male	Juvenile			
297	2000		EA Wales	Female	Juvenile	630	1.0	
298	26 February 2000	SO028597	South East - Welsh	Female	Sub-adult	1000	5.5	
299	26 March 2000	NY659585	Northumbria - North East	Male	Sub-adult	930	4.3	
300	30 March 2000	NY665586	Northumbria - North East	Male	Sub-adult	925	4.6	
301	28 April 2000	SO426656	South East - Welsh	Male	Adult	1135	7.0	
302	February 2000	SO0765	South East - Welsh	Male	Adult	1130	9.0	
303	April 2000	SO42656568	South East - Welsh	Male	Adult	1140	10.2	
304	29 April 2000	SN904290	South East - Welsh	Male	Adult	1090	7.7	
305	14 May 2000	SN643872	Northern - Welsh	Male	Adult	1120	6.2	
306	April 2000	TA013574	Ridings - North East	Female	Sub-adult	860	5.0	
307	14 February 2000	SS69	South West - Welsh	Female	Sub-adult	980	4.4	
308	17 May 2000	SO088328	South East - Welsh	Male	Sub-adult	1050	5.4	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
309	7 March 2000	SH651298	Northern - Welsh	Female	Adult	1040	5.7	
310	4 June 2000	SO228172	South East - Welsh	Male	Adult	1200	9.5	
311	25 February 2000	SN14	South West - Welsh	Female	Adult	1020	5.6	
312	February 2000	SN14	South West - Welsh	Female	Sub-adult	820	3.4	
313	March 2000		Midlands	Male	Adult	1180	9.7	
314	April 2000	SP439653	Lower Severn - Midlands	Male	Adult	1000	7.3	
315	26 May 2000	SJ52	Upper Severn - Midlands	Male	Adult	1110	9.0	
316	11 June 2000	SO618149	South East - Welsh	Male	Adult	1130	8.2	
317	26 June 2000	SO342856	Upper Severn - Midlands	Male	Adult	1014	6.6	
318	13 June 2000	SN605929	Northern - Welsh	Female	Sub-adult	960	4.0	
319	25 May 2000	SN695629	South West - Welsh	Male	Adult	1030	5.2	
320	01 August 2000	SJ00	Upper Severn - Midlands	Male	Sub-adult	1070	5.6	
321	2 July 2000	SE413762	Dales - North East	Male	Adult	1175	9.5	
322	27 April 2000	NY34	Northern - North West	Male	Adult	1175	9.7	
323	5 April 2000	TM273258	Eastern - Anglian	Male	Sub-adult	1038	6.3	
324	17 August 2000	SJ343723	Northern - Welsh	Male	Adult	1140	9.0	
325	20 August 2000	TG145123	Eastern - Anglian	Male	Adult	1210	9.0	
326	13 July 2000	SS595946	South West - Welsh	Male	Adult	1110	9.6	
327	June 2000	SO004072	South East - Welsh	Male	Adult	1070	8.0	
328	25 September 2000	TM019590	Eastern - Anglian	Female	Adult	1080	6.0	
329	29 September 2000	SN200459	South West - Welsh	Male	Adult	1190	9.6	
330	27 September 2000	SN995373	South East - Welsh	Female	Sub-adult	945	4.5	
331	6 October 2000	TM296566	Eastern - Anglian	Male	Adult	1020	9.5	
332	29 September 2000	SO075530	South East - Welsh	Female	Sub-adult	1000	4.6	
333	2000	SN00	South West - Welsh	Male	Sub-adult	1130	5.0	
334	20 October 2000	SO173972	Upper Severn - Midlands	Male	Adult	1160	9.0	
335	23 October 2000	SO612129	Lower Severn - Midlands	Male	Adult	1170	10.5	
336	29 August 2000	NZ162728	Northumbria - North East	Male	Adult	1050	5.5	
337	01 August 2000	SE78	Dales - North East	Male	Adult		6.5	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
338	December 1999	SE88	Dales - North East	Male	Adult	1120		
339	May 2000		North East	Female	Juvenile	590	1.4	
340	3 July 2000	SE76	Dales - North East	Male	Sub-adult	1120	7.7	
341	8 September 1999	TA09	Dales - North East	Female	Adult	1000	5.5	
342	2 November 2000	SO10	South East - Welsh	Male	Adult	1140	9.0	
343	2000	NZ235874	Northumbria - North East	Female	Adult	1050	5.6	
344	2000	NZ216714	Northumbria - North East				4.0	
345	10 November 2000	SE715518	Dales - North East	Female	Adult	1020	6.2	
346	14 November 2000	SU117864	West - Thames	Female	Adult	1000	7.0	Pregnant
347	14 November 2000	SO478994	Upper Severn - Midlands	Female	Adult	965	5.2	
348	20 November 2000	SJ210377	Northern - Welsh	Female	Sub-adult	1010	4.7	
349	4 November 2000	SE837034	Lower Trent - Midlands	Male	Adult	1260	10.0	
350	November 2000	SO607544	South East - Welsh	Male	Adult	1180	5.1	
351	December 2000	SO507568	South East - Welsh	Male	Adult	1090	9.0	
352	December 2000	SK231191	Upper Trent - Midlands	Male	Adult		9.0	
353	01 August 2000	SO518689	Upper Severn - Midlands					
354	4 November 2000	SO058300	South East - Welsh	Female	Adult	1030	6.7	
355	26 November 2000	SO228602	South East - Welsh	Male	Adult	1030	6.6	
356	29 November 2000	SN546473	South West - Welsh	Female	Adult	1050	6.5	Lactating
357	7 December 2000	SO019573	South East - Welsh	Female	Adult	1080	7.4	Lactating
358	8 March 2000	SH504687	Northern - Welsh	Male	Adult	1220	8.7	
359	2000	SH531398	Northern - Welsh	Female	Sub-adult	970	4.7	
360	25 June 2000	SH631718	Northern - Welsh	Male	Adult	1120	8.7	
361	November 2000	SU208984	West - Thames	Male	Adult	1010	9.8	
362	19 October 2000	ST326985	South East - Wales	Female	Adult	1025	5.7	
363	30 November 2000	SM9985002950	South West - Welsh	Male	Adult	1150	7.5	
364	11 December 2000	TM099326	Eastern - Anglian	Male	Sub-adult	980	5.0	
365	13 December 2000	SN546473	South West - Welsh	Male	Adult	1140	7.2	
366	14 December 2000	SN531215	South West - Welsh	Male	Juvenile		2.6	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
367	20 December 2000	SP177006	West - Thames	Male	Adult		8.0	
368	05 January 2001	SO26	South East - Welsh	Female	Sub-adult	790		
369	05 January 2000	SO26	South East - Welsh	Female	Sub-adult	970		
370	08 January 2000	TM095547	Eastern - Anglian	Male	Juvenile	600	1.5	
371	01 January 2001		EA Wales	Male	Adult	1000	5.7	
372	07 December 2000	SM977347	South West - Welsh	Female	Sub-adult	1020	4.8	
373	26 January 2001	ST007807	South East - Welsh	Male	Sub-adult	970	4.8	
374	14 January 2001	ST104745	South East - Welsh	Male	Adult	1225	10.5	
375	01 January 2001	SN23	South West - Welsh	Male	Adult	1120	9.2	
376	14 August 2000	NY5674	Northern - North West	Female	Juvenile	550	0.9	
377	07 February 2001	NY248238	Northern - North West	Female	Sub-adult	800	2.7	
378	13 December 2000	NY792119	Northern - North West	Male	Sub-adult	940	5.6	
379	19 May 2000	NY303460	Northern - North West	Male	Sub-adult	910	4.5	
380	24 April 2001	NY241235	Northern - North West	Male	Adult	1060	7.0	
381	14 February 2001	TG217098	Eastern - Anglian	Female	Juvenile	616	1.1	
382	08 February 2001	TM145741	Eastern - Anglian	Female	Juvenile	560		
383	08 February 2001	TM145741	Eastern - Anglian	Male	Juvenile	610		
384	11 August 2000	TL824873	Central - Anglian	Female	Sub-adult	1000	6.0	
385	01 June 2000	TL048881	Northern - Anglian	Female	Adult	1030	6.8	
386	19 December 1999	TL035880	Northern - Anglian	Male	Adult	1020	7.9	
387	24 April 2000	SP798875	Northern - Anglian	Female	Adult		4.2	
390	15 December 2000	SH467500	Northern - Welsh	Male	Adult	1240	10.0	
391	2001		EA Wales	Female	Adult	1000	5.9	
392	20 February 2001	SO048577	South East - Welsh	Female	Adult	1040	5.3	Lactating
393	13 February 2001	SO30	South East - Welsh	Female	Adult	1060	7.7	
394	12 February 2001	NU197106	Northumbria - North East	Female	Adult	1050	6.2	
397	07 February 2001	SO765600	Upper Severn - Midlands	Female	Sub-adult	1030	5.5	
398	06 April 2001	TM053765	Central - Anglian	Female	Sub-adult	1000	5.0	
399	28 March 2001	SO546407	South East - Welsh	Female	Adult	1000	6.0	Pregnant

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
401	04 April 2001		EA Wales	Male	Sub-adult	920	4.0	
402	19 March 2001	TL076485	Central - Anglian	Male	Adult	1195	9.0	
403	06 January 2001	SO548252	South East - Welsh	Female	Adult	1000	5.5	
404	08 April 2001	NZ087527	Northumbria - North East	Male	Sub-adult	1040	6.0	
405	12 April 2001	NZ888092	Dales - North East	Male	Sub-adult	1040	5.5	
406	16 April 2001	NU282015	Northumbria - North East	Female	Adult	1070	6.7	Lactating
407	2001		North East	Male	Adult	1130	7.1	
408	21 May 2001	SO2271	South East - Welsh	Male	Adult	1180	5.6	
409	31 May 2001	SJ304602	Northern - Welsh	Male	Adult	1230	9.2	
410	06 June 2001	SR975944	South West - Welsh	Male	Adult	1090	4.6	
411	17 November 2000		Midlands	Male	Sub-adult	1070	7.2	
412	21 July 2000	SJ5317	Upper Severn - Midlands	Female	Sub-adult	960	4.8	
413	16 June 2001	SN638756	South West - Welsh	Female	Sub-adult	900	3.8	
414	June 2001	Wales	South East - Welsh	Male	Adult	1160	9.0	
415	24 April 2001	SO843029	Lower Severn - Midlands	Female	Adult	1020	5.9	
416	10 December 2000	SH618417	Northern - Welsh	Male	Sub-adult	950	4.2	
417	2001	SH356344	Northern - Welsh	Female	Adult	1080	7.2	
418	17 May 2001	SH695187	Northern - Welsh	Male	Sub-adult	1050	5.2	
419	12 December 2000	SN296417	South West - Welsh	Female	Adult	1020	7.2	
420	05 May 2001	SE7152	Dales - North East	Male	Sub-adult			
421	05 May 2001	SE7152	Dales - North East	Male	Adult			
422	11 April 2001	SJ355767	Southern - North West	Male	Adult	1240	8.7	
423	04 May 2001	SJ544193	Upper Severn - Midlands	Male	Adult	1010	6.2	
424	19 July 2001	SE779566	Dales - North East	Female	Adult	1000	5.9	Lactating
425	22 August 2001	SN179436	South West - Welsh	Female	Sub-adult	1030	5.8	
426	18 August 2001	SK8409	Northern - Anglian	Female	Adult	1050	5.0	
427	29 April 2001	SO17	South East - Welsh	Male	Adult	1140	9.0	
428	18 April 2001	SO1758	South East - Welsh	Female	Adult	1035	6.2	
429	07 August 2001	TA163097	Northern - Anglian	Male	Adult	1170	9.0	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
430	25 May 2001	SJ173172	Upper Severn - Midlands	Male	Sub-adult	1040	5.8	
431	30 May 2001	SN200388	South West - Welsh	Male	Adult	1140	4.5	
432	02 August 2001	NY562334	Northern - North West	Female	Sub-adult	1030	6.8	
433	04 September 2001	SO993198	Lower Severn - Midlands	Female	Sub-adult	1020	5.8	
434	14 September 2001	SO027662	South East - Welsh	Male	Adult	1070	6.6	
435	27 September 2001	TG418186	Eastern - Anglian	Female	Sub-adult	1090	6.4	
436	September 2001	SN83	South West - Welsh	Female	Adult		4.6	
437	27 September 2001		North East	Male	Adult	1070	9.2	
438	16 October 2001	NY888883	Northumbria - North East		Sub-adult		4.2	
439	06 July 2001	TG278269	Eastern - Anglian					
440	05 July 2001	TG498008	Eastern - Anglian	Female	Adult	1080	6.6	Pregnant
441	29 October 2001	SO017511	South East - Welsh		Adult		3.3	
442	2 November 2001	SN664256	South West - Welsh		Adult		7.6	
443	06 November 2001	SJ020650	Northern - Welsh	Male	Adult	1140	8.7	
444	29 October 2001	SJ096068	Upper Severn - Midlands	Male	Adult	1130	7.0	
445	04 June 2001		EA Wales	Male	Sub-adult	880	3.4	
446	14 November 2001	SH752053	Northern - Welsh	Female	Adult	1020	5.7	
447	25 October 2001	SH029760	unknown - incorrect NGR	Male	Adult		10.2	
448	20 November 2001	TG191109	Eastern - Anglian	Male	Adult	1130	7.8	
449	25 November 2001	SO19060 20569	South East - Welsh	Male	Adult	1120	8.0	
450	07 November 2001		EA Wales				3.8	
451	05 December 2001	SO13256309	South East - Welsh	Male	Adult	1100	8.6	
452	04 December 2001	SN478639	South West - Welsh	Male	Juvenile	945	2.9	
453	18 October 2001	SN412056	South West - Welsh	Male	Sub-adult	1080	6.8	
454	07 December 2001	SP987587	Central - Anglian	Female	Adult			
455	10 December 2001	NZ180634	Northumbria - North East	Male	Sub-adult	1115	6.5	
456	26 December 2001	SO326472	South East - Welsh	Male	Adult		9.4	
457	02 January 2002	SO84	Lower Severn - Midlands	Male	Adult	1180	9.0	
458	31 December 2001	SN054404	South West - Welsh	Male	Adult	1210	8.5	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
459	23 December 2001	SJ299619	Northern - Welsh	Male	Adult	1150	8.5	
460	2002	SN179437	South West - Welsh	Male	Adult		9.0	
461	02 August 2001	SM946339	South West - Welsh	Male	Adult	1100	7.3	
462	2002		EA Wales	Male	Adult	1150	7.4	
463	11 January 2001	SN292297	South West - Welsh	Female	Adult	1055	6.3	Lactating
464	2002		EA Wales	Female	Adult	1050	6.7	
465	17 July 2001	SH558626	Northern - Welsh	Male	Adult	1060	6.5	
466	05 January 2002	SH713298	Northern - Welsh	Male	Sub-adult	955	5.3	
467	13 January 2001	SH758198	Northern - Welsh	Female	Sub-adult	1020	4.8	
468	06 December 2001	SH466521	Northern - Welsh	Female	Sub-adult	800	2.4	
469	05 January 2002	SH625148	Northern - Welsh	Female	Adult	1020	6.2	Lactating
470	13 January 2002	SH636635	Northern - Welsh	Female	Adult	1030	6.5	
471	18 January 2002	TM038333	Eastern - Anglian	Female	Adult	1030	6.3	
472	31 January 2002	SJ498104	Upper Severn - Midlands	Male	Adult	1060	6.9	
473	11 February 2002	SE81	Lower Trent - Midlands	Male	Adult			
474	18 February 2002	SJ290265	Upper Severn - Midlands	Female	Adult	1080	7.0	Lactating
475	18 February 2002	SJ290265	Upper Severn - Midlands	Female	Sub-adult	890	4.1	
476	18 February 2002	SO538047	South East - Welsh	Male	Adult		4.6	
477	21 February 2002	SJ759277	Upper Severn - Midlands	Female	Adult	1045		
478	23 February 2002	TG335003	Eastern - Anglian	Male	Adult	1130	7.9	
479	05 March 2002	SO848409	Lower Severn - Midlands	Male	Adult	1120	9.0	
480	12 March 2002	SO394757	Upper Severn - Midlands	Female	Adult	1040	4.0	
481	22 February 2002	SH575715	Northern - Welsh	Female	Sub-adult	1000	5.0	
482	15 March 2002	SH621371	Northern - Welsh	Female	Adult		5.5	
483	13 February 2002	SH547700	Northern - Welsh	Female	Adult		7.5	
484	03 February 2002	SH958564	Northern - Welsh	Female	Sub-adult	880	3.7	
485	13 December 2001	SH190282	Northern - Welsh	Female	Sub-adult	970	4.6	
486	23 February 2002	NT764030	Northumbria - North East	Female	Sub-adult	750	2.2	
487	25 March 2002	TG153143	Eastern - Anglian	Male	Sub-adult	920	4.8	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
488	06 March 2002	NZ883094	Dales - North East	Female	Adult		7.0	Lactating
489	13 March 2002	SE968897	Dales - North East	Male	Sub-adult	900	3.8	
490	01 March 2002	NT944341	Northumbria - North East	Male	Adult	1160	8.4	
491	06 April 2002	NZ235735	Northumbria - North East	Female	Sub-adult	910	4.0	
492	14 April 2002	SO100279	South East - Welsh	Female	Adult	1020	5.2	
493	March 2002		EA Wales	Male	Sub-adult	1043	5.3	
494	25 March 2002		EA Wales	Female	Sub-adult	1000	3.0	
495	20 November 2001	NY972690	Northumbria - North East	Female	Sub-adult	950	3.9	
496	23 April 2002	SE603484	Dales - North East	Male	Adult		4.4	
497	17 July 2001	SH558626	Northern - Welsh					
498	25 April 2002	SE569846	Dales - North East	Male	Sub-adult	980	3.4	
499	16 May 2002	NT953337	Northumbria - North East	Male	Juvenile	880	2.4	
500	May 2002	SH80	Northern - Welsh	Male	Juvenile		1.3	
501	2002		North East	Female	Adult	1020	6.5	
502	28 April 1999	NT995268	Northumbria - North East	Male	Adult	1080	5.9	
503	27 April 1999	NZ1156	Northumbria - North East	Male	Sub-adult	1000	5.2	
504	2002		North East	Female	Sub-adult	800	2.9	
505	11 February 1999	NY8383	Northumbria - North East	Female	Adult	1030	6.7	
506	02 December 2001	NY986668	Northumbria - North East	Male	Adult	1010	6.3	
507	22 June 2002	SH648555	Northern - Welsh	Female	Adult	1070	6.4	
508	11 April 2002	SN759075	South West - Welsh	Female	Adult	990	6.4	
509	2002	SN545106	South West - Welsh	Female	Sub-adult	780	3.3	
510	01 May 2002	SN757072	South West - Welsh	Female	Adult	1050	6.7	
511	27 June 2002	SN384498	South West - Welsh	Male	Adult	1120	7.7	
512	06 March 2002	SN552147	South West - Welsh	Female	Sub-adult	970	4.0	
513	09 July 2002	SJ363004	Upper Severn - Midlands	Female	Sub-adult	990	4.2	
514	25 July 2002		EA Wales	Male	Adult	1052	6.7	
515	28 July 2002	SO484666	Upper Severn - Midlands	Male	Adult	1090	8.0	
516	18 July 2002	SN672956	Northern - Welsh	Female	Juvenile	580	0.7	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
517	03 July 2002	SH563405	Northern - Welsh	Female	Sub-adult	970	4.3	
518	12 April 2002	SH618386	Northern - Welsh	Female	Sub-adult	1054	5.2	
519	29 April 2002	SH362348	Northern - Welsh	Female	Adult	1010	6.1	
520	11 August 2002	TL163559	Central - Anglian	Female	Adult	950	4.7	
521	19 March 2002		Anglian	Male	Adult	1030	7.8	
522	23 August 2002	SN933734	South East - Welsh	Male	Adult	1174	7.3	
523	24 August 2002	SO347913	Upper Severn - Midlands	Female	Adult		5.8	
524	10 October 2002		Midlands	Male	Adult	1125	9.2	
525	16 October 2002	TM157580	Eastern - Anglian	Male	Adult		5.6	
526	17 October 2002	SD567109	Central - North West	Male	Adult	1220	9.6	
527	21 October 2002	TL729759	Central - Anglian	Male	Sub-adult	1060	6.0	
528	14 November 2002	SO086815	South East - Welsh	Female	Adult		6.0	Pregnant
529	19 November 2002	SO245474	South East - Welsh	Male	Adult	1110	6.8	
530	15 October 2002	SO45822022	South East - Welsh	Male	Sub-adult	1000	5.2	
531	11 September 2002	ST313903	South East - Welsh	Male	Adult		8.4	
532	19 November 2002	TM038604	Eastern - Anglian	Male	Adult		6.2	
533	19 November 2002	SP665826	Lower Severn - Midlands	Male	Adult	1170	9.2	
534	13 October 2002	SH524415	Northern - Welsh	Male	Sub-adult	860	3.9	
535	09 August 2002	SJ04824867	Northern - Welsh	Female	Adult	1070	6.2	
536	2002	SJ0448	Northern - Welsh	Female	Sub-adult	934	4.4	
537	26 November 2002	SK364280	Lower Trent - Midlands	Male	Adult	1023	10.0	
538	19 October 2002	SJ176192	Upper Severn - Midlands	Male	Adult	1100	8.3	
539	26 November 2002	SE706513	Dales - North East	Male	Adult		8.8	
540	16 December 2002	SJ201626	Northern - Welsh	Male	Adult		9.2	
541	2002	SJ2062	Northern - Welsh	Female	Adult		2.1	
542	29 November 2002	SH507625	Northern - Welsh	Male	Adult	1080	9.4	
543	2002	SN0709215198	South West - Welsh	Male	Adult	1120	8.4	
544	2002	SO045087	South East - Welsh	Male	Adult	1150	8.5	
545	2002	SN3700313491	South West - Welsh	Female	Sub-adult	1040	5.9	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
546	2002	SN3713	South West - Welsh	Male	Adult	1020	7.4	
547	20 December 2002	TM038326	Eastern - Anglian	Female	Sub-adult	860	3.3	
548	05 January 2003	SO801464	Lower Severn - Midlands	Male	Sub-adult	1050	7.4	
549	15 January 2003	SO773223	Lower Severn - Midlands	Male	Sub-adult	1070	6.7	
550	21 January 2003	SO799192	Lower Severn - Midlands	Female	Adult	1015	6.2	
551	31 December 2002	SP227032	West - Thames	Female	Adult	1020	6.5	
552	21 January 2003	SN178418	South West - Welsh	Male	Adult	1200	10.3	
553	25 January 2003	TL933659	Central - Anglian	Female	Sub-adult	900	3.9	
554	09 November 2002	SS508877	South West - Welsh	Female	Juvenile		0.9	
555	27 January 2003	SO29	Upper Severn - Midlands	Female	Adult	1000	5.5	
556	03 February 2003	TG149094	Eastern - Anglian	Male	Adult	1025	6.2	
557	09 February 2003	SN608824	South West - Welsh	Female	Adult	880	6.2	Pregnant
558	30 December 2002	SE732512	Dales - North East	Male	Adult	1020	10.5	
559	14 February 2003	SE894833	Dales - North East	Male	Adult	1080	7.2	
560	26 February 2003	SO 45	South East - Welsh	Female	Sub-adult		5.0	
561	22 February 2003	TM788717	unknown - incorrect NGR	Male	Adult		7.5	
562	03 March 2003	SO274965	Upper Severn - Midlands	Male	Sub-adult	925	5.3	
563	28 December 2002	SH585415	Northern - Welsh	Male	Sub-adult	1000	5.0	
564	10 February 2003	SH383353	Northern - Welsh	Female	Adult	1075	7.4	Pregnant
565	20 February 2003	SH688396	Northern - Welsh	Male	Sub-adult	1050	6.7	
566	11 January 2003	SH709505	Northern - Welsh	Female	Sub-adult	1000	5.8	
567	06 February 2003	SH619418	Northern - Welsh	Male	Adult		7.3	
568	2003		Anglian	Female	Sub-adult	820	2.3	
569	11 March 2003	SO250706	South East - Welsh	Male	Sub-adult		5.5	
570	12 March 2003	SO27	South East - Welsh	Male	Adult		8.0	
571	24 March 2003	SO722559	Upper Severn - Midlands	Female	Adult	1000	5.9	
572	25 March 2003	SO522419	South East - Welsh	Female	Sub-adult	1015	5.0	
573	04 April 2003	SN67559430	Northern - Welsh	Male	Adult	1050	5.8	
574	2003	SO300807	Upper Severn - Midlands	Male	Adult	1110	8.9	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
575	12 February 2003	SO300807	Upper Severn - Midlands	Male	Adult	1090	7.6	
576	08 January 2003		Midlands	Male	Adult		6.8	
577	10 December 2003	SJ488134	Upper Severn - Midlands	Female	Adult	1030	6.4	
578	2003		Midlands	Male	Adult	1150	9.5	
579	21 April 2003	TM274524	Eastern - Anglian	Female	Sub-adult	960	4.6	
580	26 April 2003	SN9718028513	South East - Welsh	Female	Sub-adult			
581	18 May 2003	SN622884	Northern - Welsh	Female	Adult	1080	5.2	
582	9 June 2003	SO105918	Upper Severn - Midlands	Male	Adult	1080	5.6	
583	2003		Anglian	Male	Adult			
584	10 July 2003	SO502441	South East - Welsh					
585	29 April 2003	SP9770972794	Northern - Anglian	Male	Juvenile	835		
586	2 July 2003	TL268668	Central - Anglian	Male	Adult	1085	8.0	
587	29 July 2003	TM102330	Eastern - Anglian	Female	Adult	1015	6.5	
588	26 May 2003	TL115995	Northern - Anglian	Male	Adult	1130	8.3	
589	01 September 2003	SP90276644	Northern - Anglian	Male	Sub-adult		5.8	
590	10 July 2003	TA05	Ridings - North East	Female	Sub-adult	710	2.3	
591	01 August 2003	SO819197	Lower Severn - Midlands	Female	Adult	1000	5.5	
592	31 July 2003	SP990412	Central - Anglian	Male	Sub-adult	1030	7.1	
593	4 May 2003	SN126052	South West - Welsh	Female	Sub-adult	780	2.8	
594	10 March 2003	SN16270703	South West - Welsh	Male	Adult	1100	5.5	
595	29 June 2003	SM959241	South West - Welsh	Female	Sub-adult	960	4.8	
596	2003		EA Wales	Female	Adult	970	4.1	
597	5 July 2003	SN57177508	South West - Welsh	Female	Adult	1035	4.8	
598	2003		EA Wales	Male	Sub-adult			
599	02 August 2003	SO32096778	South East - Welsh	Male	Adult			
600	2003		Anglian	Male	Adult			
601	8 September 2003	SN62018105	South West - Welsh	Male	Adult	1150	7.3	
602	10 September 2003	SH725248	Northern - Welsh	Male	Adult	1150	7.5	
603	21 March 2003	SJ131715	Northern - Welsh	Male	Adult		5.7	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
604	21 June 2003	SH652515	Northern - Welsh	Female	Sub-adult	940	4.5	
605	02 August 2003	SH875312	Northern - Welsh	Male	Sub-adult	980	5.1	
606	22 November 2002	SD502878	Northern - North West	Male	Sub-adult		5.7	
607	23 January 2002	NY407008	Northern - North West	Male	Adult	1120		
608	23 October 2002	NY456577	Northern - North West	Female	Sub-adult	1000	6.4	
609	01 October 2002	SD472853	Northern - North West	Male	Adult			
610	10 October 2003	SJ612054	Upper Severn - Midlands	Male	Adult	1100	7.7	
611	4 November 2003	SN6877	South West - Welsh	Male	Adult	1070	7.7	
612	11 November 2003	SO200122	South East - Welsh	Male	Adult	1100	7.2	
613	8 October 2003	NY71804635	Northumbria - North East	Male	Adult	1140	4.5	
614	22 November 2003	SO673227	Lower Severn - Midlands	Female	Adult	1100	6.0	
615	21 November 2003	TL974272	Eastern - Anglian	Male	Adult	1075	9.0	
616	27 November 2003	SH577285	Northern - Welsh	Male	Sub-adult	995	5.4	
617	23 October 2003	SE223058	Ridings - North East	Male	Sub-adult	1030	5.5	
618	23 October 2003		EA Wales	Male	Adult	1120	8.2	
619	19 October 2003	SN66003862	South West - Welsh	Female	Adult	1020	6.2	Lactating
620	2003		EA Wales					
621	4 November 2003	SP93496218	Northern - Anglian	Male	Sub-adult	1080	7.4	
622	3 December 2003	SU196847	West - Thames	Female	Sub-adult	1000		
623	15 December 2003	NU05851709	Northumbria - North East	Male	Adult		5.5	
624	18 December 2003	TG366203	Eastern - Anglian	Female	Adult	1020	5.0	
632	2004		EA Wales	Male	Sub-adult	1000	5.9	
637	16 September 2003	SO165357	South East - Welsh	Male	Sub-adult	1075	6.5	
638	May 2003		EA Wales	Male	Adult	1140	4.9	
639	2003	SO159335	South East - Welsh					
640	2002		EA Wales	Female	Sub-adult	860	2.3	
643	30 December 2003	NY40710058	Northern - North West	Female	Adult			
644	20 November 2003	ST52599143	South East - Welsh	Male	Sub-adult	980	5.3	
645	3 September 2003	SO404020	South East - Welsh	Male	Adult		7.4	

UWC Ref	Date found, or year of receipt	National grid reference	Area name	Sex	Age class	Total length (mm)	Weight (kg)	Lactating or pregnant
646	30 December 2003	SO40855400	South East - Welsh	Male	Adult	1170	7.6	
648	8 December 2003	SO3045420539	South East - Welsh	Male	Adult	1085	7.0	
649	26 January 2003	SO41220325	South East - Welsh	Male	Sub-adult	975	5.0	
651	11 January 2003		EA Wales	Male	Adult	1090	7.5	
652	8 March 2003		EA Wales	Male	Adult	1308	9.0	
657	3 November 2003	SP64519573	Lower Trent - Midlands	Female	Adult	990	6.3	

Notes: Where the date found is not known, the year of receipt has been entered.

Appendix 3: Distribution of otters found 2001-2003

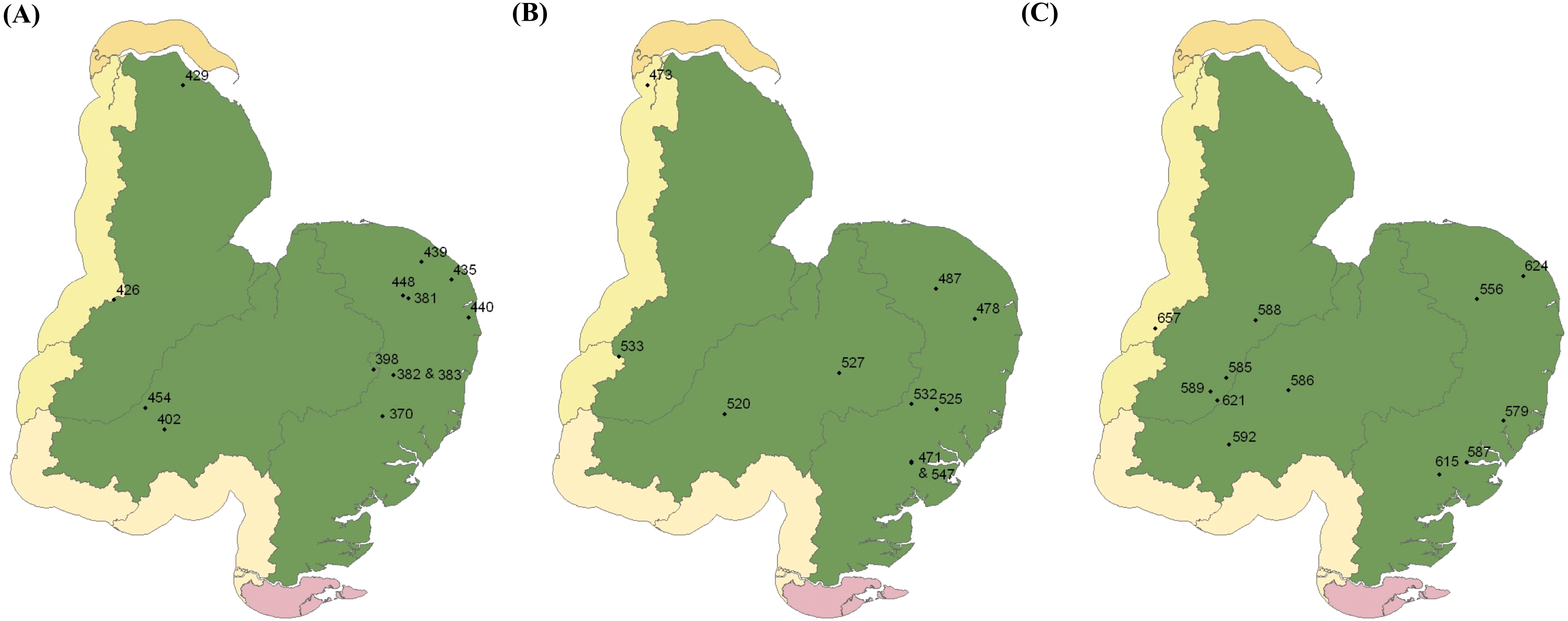
All otter casualties that were found from 2001 to 2003 and received at UWC are mapped by year and by Environment Agency Region. They are labelled by UWC reference number. Otters found during this period for which no precise date was given are included separately.

Key to maps

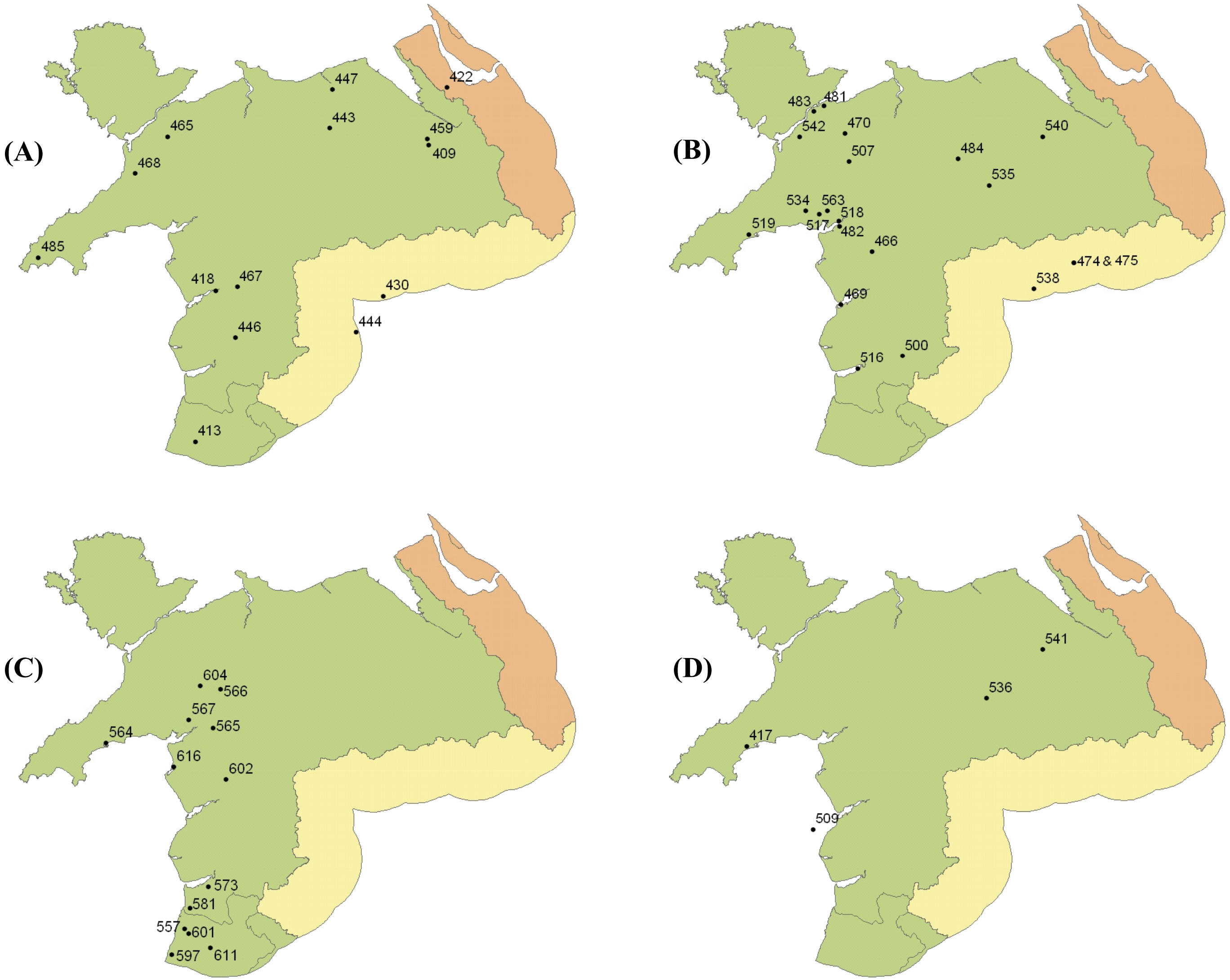
Anglian Region	North West Region
EA Wales	South West Region
Midlands Region	Southern Region
North East Region	Thames

●430 Otter casualty, with UWC reference

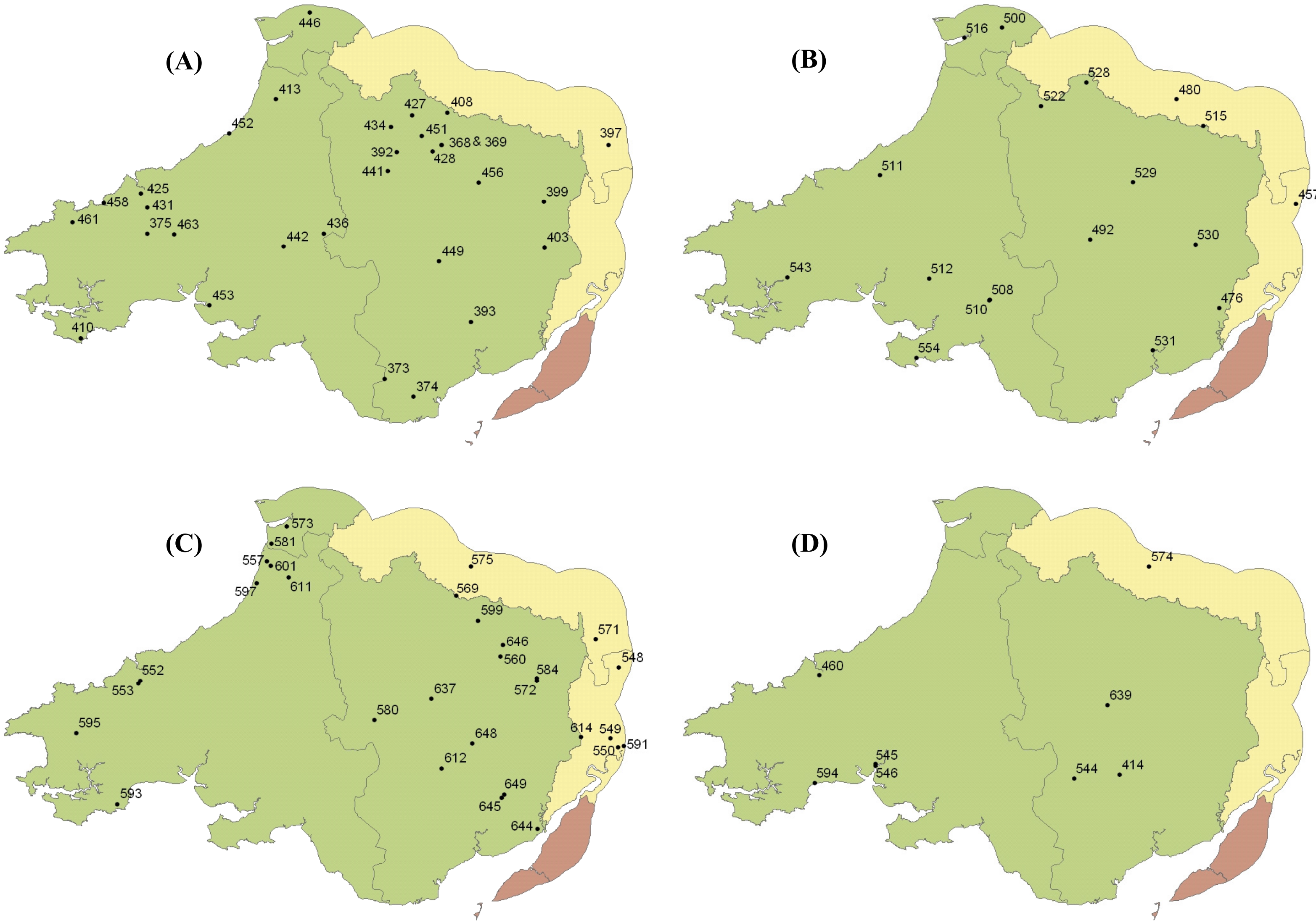
(A) (B) (C)



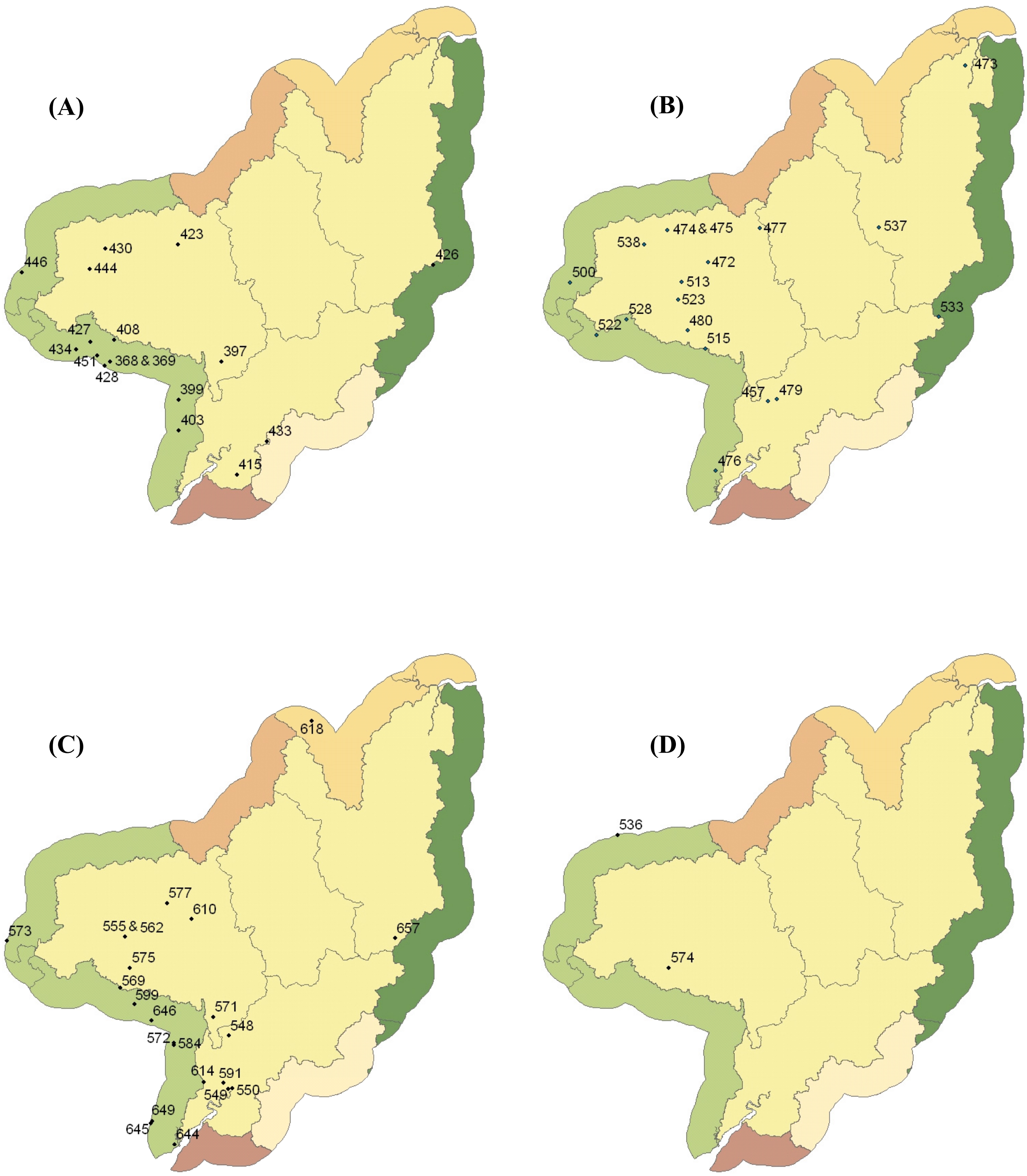
Anglian Region: casualties found in 2001 (A), 2002 (B), and 2003 (C).



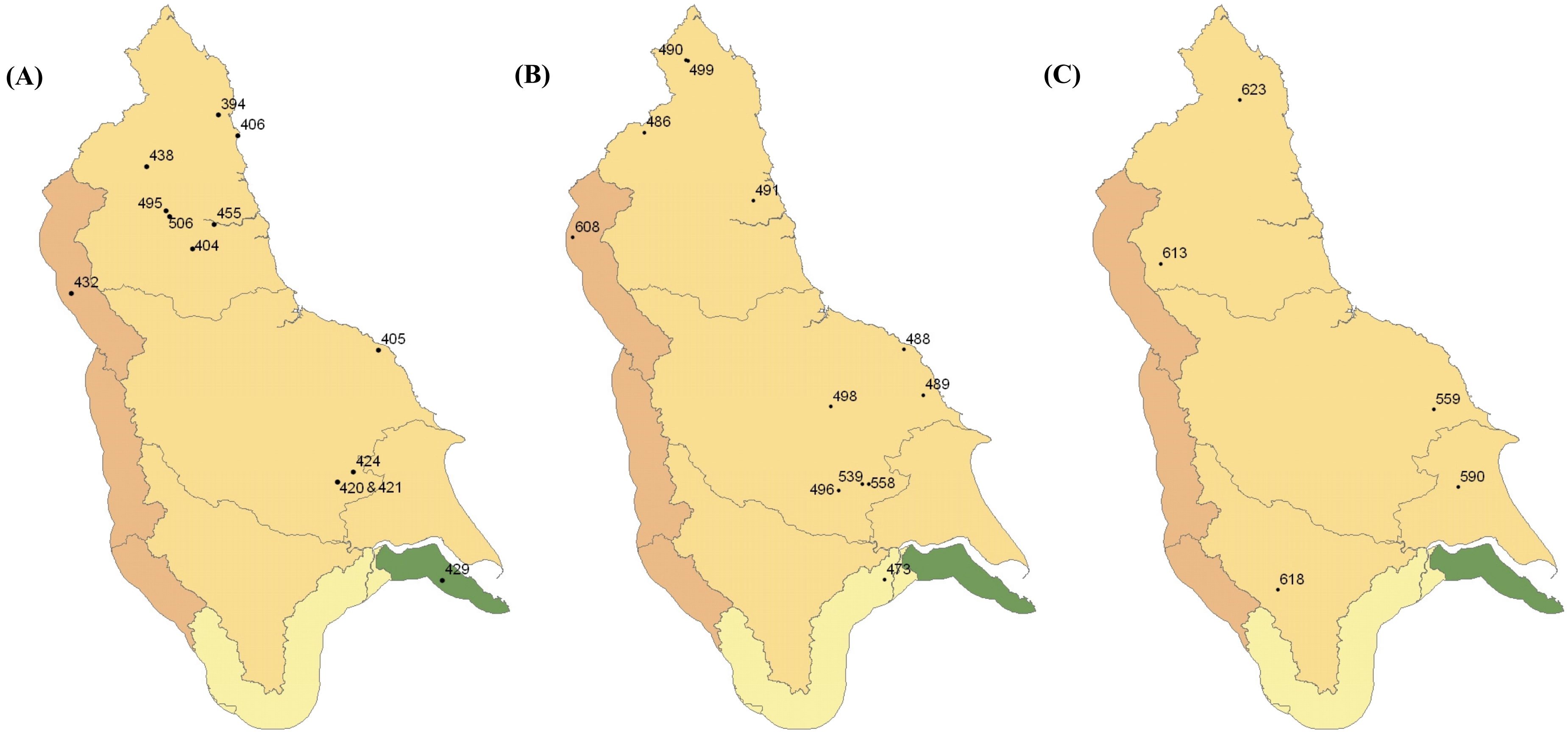
North Wales: casualties found in 2001 (A), 2002 (B), 2003 (C) and unspecified year (D).



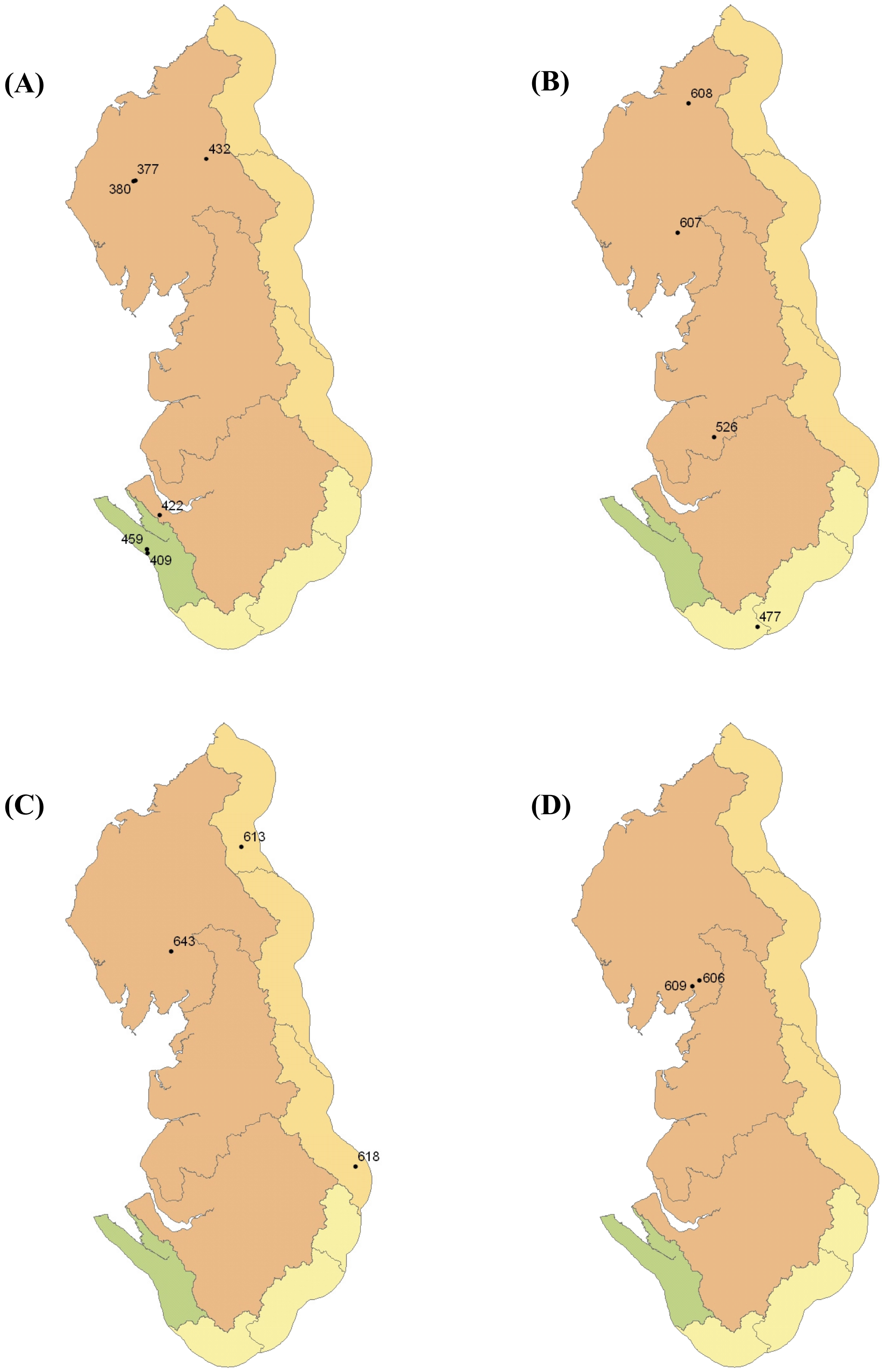
South Wales: casualties found in 2001 (A), 2002 (B), 2003 (C) and unspecified year (D).



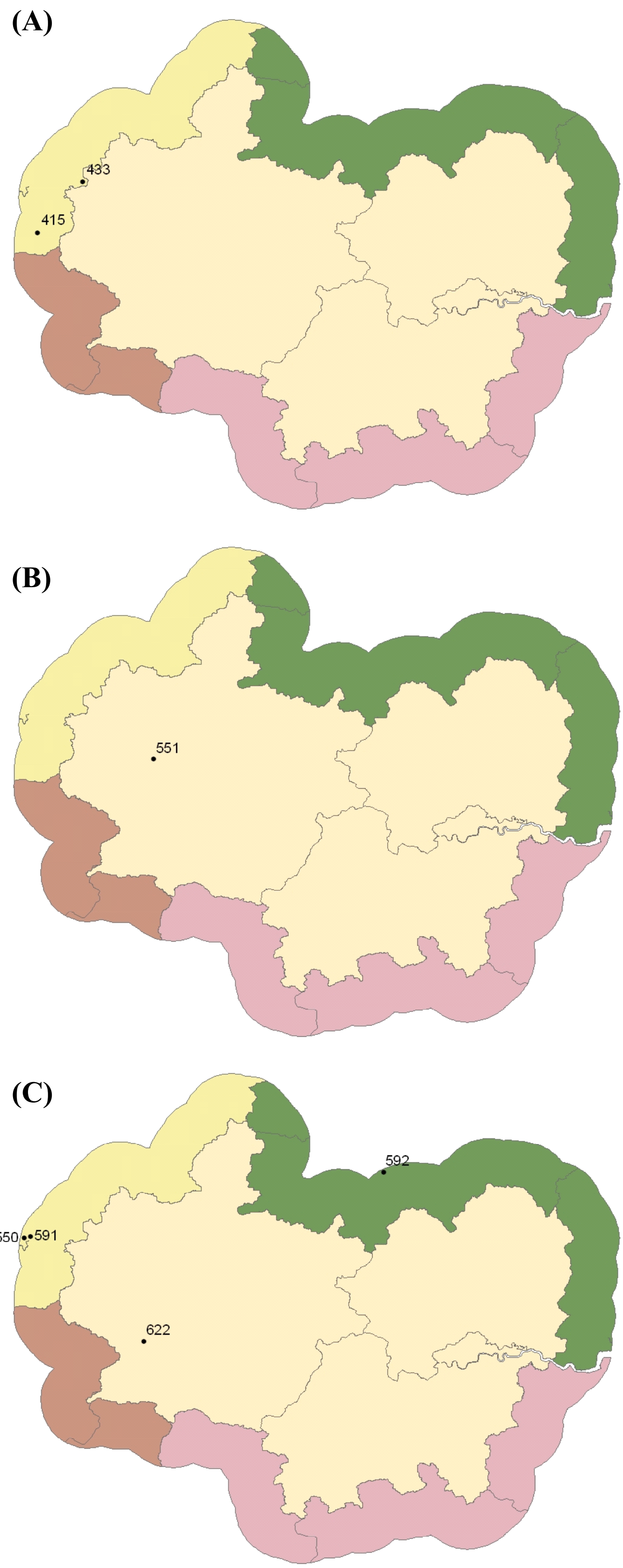
Midlands: casualties found in 2001 (A), 2002 (B), 2003 (C) and unspecified year (D).



North East: casualties found in 2001 (A), 2002 (B) and 2003 (C).



North West: casualties found in 2001 (A), 2002 (B), 2003 (C) and unspecified year (D).



Thames: casualties found in 2001 (A), 2002 (B) and 2003 (C).

Appendix 4: Poster presentation, Ninth International Mammalogical Congress

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

Heavy metals in otters *Lutra lutra*: Dramatic decline in lead in the period 1992-2004

WILDLIFE VETERINARY INVESTIGATION CENTRE

E A Chadwick[1], V R Simpson[2], F M Slater[1] and A E Nicholls[1].

[1] Cardiff School of Biomedical Sciences, Biomedical Sciences Building, Museum Avenue, Cardiff, Wales, UK, CF10 3US (e-mail chadwickEA@cardiff.ac.uk) and [2] Wildlife Veterinary Investigation Centre, Chacewater, Truro, Cornwall, UK. TR4 8PB.

Introduction and background

Although PCBs and organochlorine pesticides are regarded as the primary pollutants implicated in otter (*Lutra lutra*) declines throughout Europe, heavy metals, such as lead, have the potential to cause additional toxic effects[1].

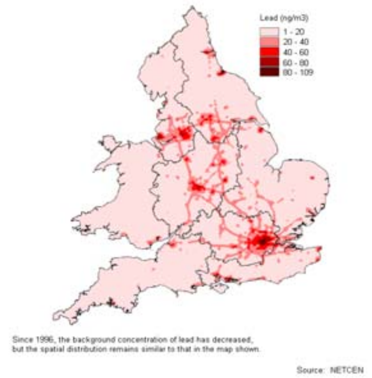
High concentrations of metals are found in aquatic biota originating from catchments with metal rich geology, particularly those that have been extensively mined[2]. In addition, levels of many metals are elevated along roadsides as a result of vehicle emissions and wear. Lead pollution can result from the combustion of leaded fuel[3], hence patterns of lead elevation follow heavily trafficked routes (Figure 1).

Combustion of leaded fuel is a major source of environmental lead contamination worldwide, but legislative change in many countries has caused a sharp decline in airborne concentrations. In the UK, legislation was introduced in 1986 halving the lead concentration in fuel, and in 1999 a ban on leaded fuel was put in place.

As otters are non-migratory aquatic predators which feed on resident prey species their tissues can be used to monitor environmental contamination. This study aimed to assess whether changes in legislation have affected lead levels found in the otter *Lutra lutra,* and by implication, in their habitat.

Figure 1. Concentration of lead in air in the UK

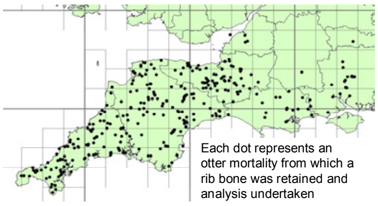
(from Environment Agency website http://www.environment-agency.gov.uk/)



Methodology

Since 1990, rib bones have been routinely collected during post mortem examinations of otters found dead in the southwest of England[4] (Figure 2). Levels of lead were determined using ICP-MS (Inductively Coupled Plasma Mass Spectrometry), following nitric acid digest of ashed rib samples. In total, 347 samples were used.

Figure 2. Sample distribution



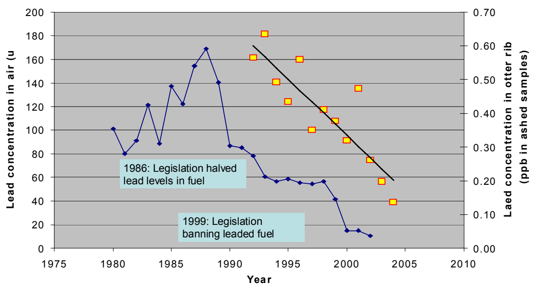
Each dot represents an otter mortality from which a rib bone was retained and analysis undertaken

Results

A marked decline in lead levels has been measured in otter rib bone between 1992 and 2004, which reflects the decline in airborne concentration following emissions legislation (Figure 3).

Concentrations in air are averaged from a network of continuous monitoring sites[5] while concentrations in bone are given as median values from ICP-MS analysis of all otter samples found dead in that year. Comparison with data on a county by county basis to test for effects of changing sample distribution showed closely correlated trends.

Figure 3. Lead concentration in air (blue) and in otter rib (yellow)



Discussion

Lead is extremely persistent in the environment, and while airborne lead concentrations have declined, there was no evidence previously to show whether this decline was reflected in aquatic food chains. This study provides that evidence.

Further analysis is planned, to examine spatial variation in the pattern of change, for example with traffic density and distance from roads. Health implications remain undetermined, but it is possible that reductions in lead levels may be a contributory factor to the increase in otter populations in the UK and elsewhere.

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5 Data taken from Environment Agency website http://www.environment-agency.gov.uk

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Environment Agency
Rio House
Waterside Drive, Aztec West
Almondsbury, Bristol BS32 4UD
Tel: 0870 8506506
Email: enquiries@environment-agency.gov.uk
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