Predatory Bird Monitoring Scheme

The Predatory Bird Monitoring Scheme (PBMS) Report 2006-7

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Contents

1. Executive Summary

The Predatory Bird Monitoring Scheme (PBMS) examines the levels of certain pollutants in selected wildlife species in Britain. It started in the 1960s to assess the impact of organochlorine pesticides on raptor populations, and the scheme is now the longest-running of its kind in the world. The aims of the PBMS are to monitor the levels of contaminants to determine how and why they vary between species and regions, how they are changing over time, and the risks they may have on individual birds and on their populations. Dead predatory birds are submitted to the PBMS by the public and by wildlife hospitals, veterinarian and zoological organisations. Eggs are collected, under licence, from a range of nests. The majority of these eggs are addled or deserted, although for some species, e.g. northern gannets, fresh egg are sampled.

Second generation anticoagulant rodenticides (SGARs) are potentially toxic to all mammals and birds, and predators that feed upon rodents are particularly likely to be exposed to these compounds. Since 1983 the PBMS has monitored SGAR residues in barn owls, while kestrels have been monitored since 2001. The proportion of barn owls which have one or more SGARs in their liver increased from less than 10% in the 1980s to approximately 40% in the early 2000s. However, there has been a small decrease in this percentage in the last few years. A higher proportion of kestrels have detectable residues of SGARs in their liver than barn owls with 60% of birds received in the years 2001 to 2006 having one or more SGAR in their liver. There is no evidence of a change over time in the proportion ok kestrels with detectable liver SGAR residues. Overall, the high incidence of exposure amongst monitored species remains of concern.

Sparrowhawk livers are analysed for a range of persistent organic pollutants (POPs) and heavy metals. Sparrowhawks are studied because they have a wide distribution across the Britain and can be used as a sentinel species for the terrestrial environment. Following restrictions on its use as an agricultural pesticide, mercury concentrations have declined in sparrowhawks. However, despite PCBs being banned in 1981, there has not been any long-term change in polychlorinated biphenyl (PCB) liver concentrations in sparrowhawks during the period 1968-2006. In herons, used as a sentinel species for freshwater habitats, both PCB and mercury concentrations have declined. In 2006, mean PCB and mercury concentrations in both species were below those thought to have an adverse effect on individual birds.

Pollutants, such as mercury and PCBs, can affect development and hatchability.. Therefore, the PBMS monitors the levels of contaminants in the eggs of a range of species including those of conservation concern such as golden eagle and the re-introduced white-tailed sea eagle. Other species that are monitored are the northern gannet, which are used as a monitor of the marine environment, and merlin that hunt in upland habitats. In general, and specifically in 2006, the residues measured in the eggs of golden eagle and gannets are below those thought to have an adverse effect on bird eggs, but some residues in individual merlin eggs were at concentrations associated with effects in other species. Few white-tailed see eagle eggs are received for analysis by the PBMS but a large proportion of those eggs that have been analysed, including the egg collected in 2006, have DDE, PCB and mercury concentrations above levels associated with adverse effects on bird embryos and the hatching success of eggs.

Despite the withdrawal of PCBs from manufacturing over 20 years ago, the evidence for declining PCB concentrations in predatory birds is equivocal, with declines in liver or egg residues in some species but not in others. Mercury concentrations in most species have not significantly changed during the monitoring period.

2. The Predatory Bird Monitoring Scheme

2.1. Background

The Predatory Bird Monitoring Scheme (PBMS) is the umbrella project that encompasses the long-term contaminant monitoring and surveillance work in avian predators carried out by the Centre for Ecology & Hydrology and its predecessor organisations (Institute of Terrestrial Ecology, Nature Conservancy). The PBMS monitors the concentrations of contaminants in the livers and eggs of selected species of predatory and fish-eating birds in Britain. Predatory birds and their eggs are good environmental sentinels of contamination because lipophilic compounds in particular bioconcentrate along food chains and can be accumulated in high concentrations by top predators. Furthermore, predatory birds have large foraging areas and so assimilate diffuse contaminants from across relatively wide geographical areas.

The PBMS originates from studies in the early 1960s when there were major concerns over the impacts of organochlorine (OC) insecticides and organomercury fungicides on wild birds and mammals. Early monitoring, accompanied by experimental and ecological studies, demonstrated the adverse effects of OC insecticides, particularly dieldrin and DDT, on predatory bird populations in Britain. This early work contributed to the scientific evidence that led to the bans on the agricultural use of these insecticides in Britain and elsewhere.

The PBMS has subsequently expanded in its range of monitoring to encompass other compounds, thereby reflecting contemporary conservation and regulatory concerns. Monitoring of the assimilation of industrial polychlorinated biphenyls (PCBs) was begun in 1966 after these contaminants were identified as pollutants that were potentially toxic to birds, and mercury (Hg), which can derive from past agricultural and from both past and current industrial sources, has been monitored since approximately 1970. Second-generation anticoagulant rodenticides (SGARs) have been monitored in British barn owls (*Tyto alba*) since 1982 and the range of species monitored for these biocides was expanded in 2001. Since 2005, the scheme has also submitted sparrowhawk (*Accipiter nisus*) egg contents for analysis as part of a European monitoring scheme of decabromodiphenyl ether (deca-BDE) concentrations in biotic and abiotic matrices.

2.2. Aims

Currently, the PBMS has two key objectives:

(i) to detect temporal and spatial variation in exposure, assimilation and risk for selected pesticides and pollutants of current concern in sentinel UK predatory bird species and in species of high conservation value

(ii) in conjunction with allied studies, to elucidate the fundamental processes and factors that govern food-chain transfer and assimilation of contaminants by top predators.

Through its monitoring, the PBMS can identify and quantify current and emerging chemical threats to vertebrate wildlife, determine how chemical risk varies between species, food chains and ecosystems, and assess whether the measured tissue and egg concentrations are likely to be associated with adverse effects in individuals and populations. By conducting such assessments, it is possible to determine whether mitigation of exposure is required, what measures might be effective, and track whether mitigation has been successful.

2.3. Collection of carcasses and eggs for monitoring

The PBMS monitors contaminants principally in liver tissues and usually in addled or deserted eggs. The choice of sample depends on the likely site of toxicological significance for any particular compound and/or the species of bird monitored. For example, SGAR concentrations are measured in the liver because it is the target organ for these compounds (where they interfere with the production of clotting factors) and contains high-affinity binding sites to which SGARs bind. Conversely some contaminants are embryotoxins and monitoring residues of these compounds in eggs is more appropriate. Furthermore, the populations of some species, such as golden eagle (*Aquila chrysaetos*) and merlin (*Falco columbarius*), are at low densities in Britain and it is not possible to collect sufficient carcasses each year to obtain a statistically robust sample for monitoring liver concentrations. However, it is possible to collect reasonably large numbers of failed eggs for these species. Thus, monitoring contaminant levels in eggs allows us to study the impacts of chemicals on these rarer species.

The PBMS analyses the carcasses of birds that have died from natural causes. The collection of carcasses relies on members of the public who, in response to advertisements, send in dead predatory birds that they find. Taxidermists and wildlife rehabilitation centres also contribute significant numbers of specimens. However, only birds that have been free-living prior to death, or at most have been in captivity for 7 days, are used by the PBMS. Volunteers submit the carcasses through the post using approved, biohazard-safe packaging. Typically, most submissions are in autumn (September and October), and early spring (February to April inclusive) and, together, these five months account for approximately 60% of the birds submitted per year. Most of the birds submitted at this time are juveniles (birds that have hatched in the current or previous calendar year). Overall, approximately twice as many juvenile birds as adults (where adults are defined as individuals that have hatched before the previous calendar year) are submitted to the PBMS. On receipt, the details of each predatory bird is given a unique identifying code and the carcass is stored at -20°C until a macroscopic post-mortem examination is carried out.

Only individuals that are licensed by the relevant regulatory statutory body can collect bird eggs in the UK. Licensed collectors visit nests as part of other studies, predominantly ringing exercises, and send the PBMS eggs known to be addled or deserted.

The numbers of samples submitted to the PBMS vary year on year. This is because the samples are collected through volunteers and not through a standardized sampling protocol. Furthermore, it can be difficult to obtain samples, especially from remote areas. Usually, some 250 to 400 bird carcasses and 50-100 eggs are submitted to the PBMS each year. In 2006, the PBMS received 387 birds and 162 eggs (Tables 2.1).

Table 2.1. Summary of birds and eggs submitted by volunteers to the PBMS in 2006.

			Number of	
			Carcasses[1]	**Eggs[2]**
Owls	Barn Owl	*Tyto alba*	156*	5
	Eagle Owl	*Bubo bubo*	2	1
	Tawny Owl	*Strix aluco*	55	9
	Little Owl	*Athene noctua*	11	0
	Long-eared Owl	*Asio otus*	11	0
	Short-eared Owl	*Asio flammeus*	1	0
Falcons	Kestrel	*Falco tinnunculus*	26*	38
	Merlin	*Falco columbarius*	3	13*
	Peregrine falcon	*Falco peregrinus*	3	35
	Hobby	*Falco subbuteo*	2	5
Eagles	Golden Eagle	*Aquila chrysaetos*	0	10*
	White-tailed Sea Eagle	*Haliaeetus albicilla*	0	1*
Hawks & Vultures	Sparrowhawk	*Accipiter nisus*	65*	1
	Goshawk	*Accipiter gentilis*	0	1
	Buzzard	*Buteo buteo*	30	3
	Marsh Harrier	*Circus aeruginosus*	0	1
	Hen Harrier	*Circus cyaneus*	1	11
	Montague's Harrier	*Circus pygargus*	1	1
	Marsh Harrier	*Circus aeruginosus*	3	1
	Red Kite	*Milvus milvus*	3*	12
Others	Heron	*Ardea cinerea*	5*	0
	Kingfisher	*Alcedo atthis*	5	0
	Bittern	*Botaurus stellaris*	2	0
	Little Egret	*Egretta garzetta*	1	0
	Water Rail	*Rallus aquaticus*	1	0
	Gannet	*Morus bassanus*		10*
	Chough	*P. pyrrhocorax*		5
		Total	387	162

[1]It is not always possible to take a liver sample from a bird and so the number of samples analysed may differ from the values in this table.
[2] Egg numbers may include more than one egg from a single clutch.
* indicates core species for which samples are taken for chemical analysis each year.

2.4. Post mortems of carcasses and processing of eggs

The post-mortem examination is conducted to determine age, using the European Union for Bird Ringing (EURING) classification (Speek et al., 2001), sex, body weight and putative cause of death. The most common causes of death (>70% of submissions) are road traffic accidents, other types of collision, and starvation. Additional observations made on the carcasses include an assessment of the amount of fat reserves in the body, moult score (primaries, secondaries, tail and body feathers (Redfern and Clark, 2001)) and the presence of hemorrhaging in the body organs. Where possible, whole organs are excised, weighed, and various tissues (liver, brain, kidneys, pectoral muscle, sub-cutaneous fat) are archived in glass jars at and retained in the PBMS tissue and egg archive at -20°C.

Eggs that are submitted to the PBMS are measured (length, breadth, intact weight and weight of contents) and information on date of collection and provenance is also recorded. Each egg is cracked using a scalpel, the contents removed, an approximate degree of development assessed, and the contents are homogenised prior to archiving at -20°C in glass jars in the PBMS tissue and egg archive. The egg shell is rinsed, left to dry for 4 weeks at ambient temperature, then weighed. An egg shell thickness index (Ratcliffe, 1970)is calculated as shell weight (mg)/length (mm) * breadth (mm).

2.5. The PBMS tissue and egg archive

The PBMS frozen (-20°C) archive contains samples dating back to 1968. It consists of approximately 17,500 tissue samples from 6,000 individual birds and 9000 egg contents; the majority (82%) of tissue samples are from 1980 onwards. This archive constitutes a valuable resource for a range of environmental toxicology studies and other conservation-orientated research work. The archive facilitates assessment of the exposure to and effects of chemicals in predatory birds that is wider in scope than the core PBMS activities (Jagannath et al., 2008, Pain et al., 2007) and can be used for piloting and refining new monitoring. It also provides a resource for projects that aim to assess the impacts of a range of non-chemical threats. In the past, these have included illegal trading and hunting (Natural Research, 2007) and quantifying the fine scale genetic structure of golden eagle populations (Bourke and Dawson, 2006).

2.6. Description of samples that undergo chemical analysis

At present, the core monitoring programme involves analysing contaminant concentrations in a sub-set of the livers and eggs that are archived each year. The numbers of samples available for analysis vary year on year. This is because samples are provided by amateur naturalists and other interested parties and not through a standardized sampling protocol. Furthermore, it can be difficult to obtain samples, especially from remote areas

The livers of a stratified sample of barn owls, and the livers of all kestrels (*Falco tinnunculus*) and red kites (*Milvus milvus*) received each year are analysed for four SGARs, difenacoum, bromadiolone, brodifacoum and flocoumafen. The monitoring data are presented in section Section 3.

The livers from a stratified sample of sparrowhawks received each year and the livers of all herons (*Ardea cinerea*) submitted to the PBMS are monitored for PCBs (35 individual congeners, total PCBs and sum PCB Toxic Equivalencies—PCB-TEQs) and for a suite of non-essential and essential trace metals (mercury (Hg), arsenic (As), lead (Pb), cadmium (Cd), copper (Cu) and zinc (Zn)). The results of this monitoring are reported in Section 4.

The eggs contents of one egg from each clutch of merlin, golden eagle and white-tailed sea eagle (*Haliaeetus albicilla*) eggs that have been received each year are analysed for the same compounds and the results of the monitoring are reported in sections 5, 6, and 7, respectively of this report.
Approximately 10 gannet (*Morus bassanus*) eggs are collected biennially from colonies on Bass Rock (North Sea) and Ailsa Craig (Irish Sea). These eggs are also analysed for PCBs and metals and the results are reported in section 8.

2.7. Summary of analysis methods

This is the first year that rodenticides were determined by liquid chromatography-mass spectrometry (LC-MS). Approximately 0.25 grams of fresh liver was ground with sodium sulphate in a pestle and mortar to form a dry free flowing powder. This was extracted twice into a mixture of acetone and chloroform using a mechanical wrist shaker, the solvent being collected by centrifugation after each extraction. The combined solvent extract was exchanged into a chloroform/acetonitrile mixture and cleaned up by solid phase extraction; the final residue was dissolved in 1 ml of LCMSMS mobile phase. The extract was determined by LCMSMS using negative atmospheric pressure chemical ionisation and multiple reaction monitoring. The instrument was calibrated using certified rodenticides standards prepared in mobile phase. The liver samples were run in batches of sixteen which incorporated a blank prepared with chicken liver, and a spiked recovery standard prepared with chicken liver. For most compounds, recoveries were between 60% and 85% and the limit of detection was approximately 1 -2 ng/g wet wt. for each compound.

The analytical methods used to quantify PCBs and Hg are described in detail by (Pereira et al., 2009, Wienburg and Shore, 2004). Limits of detection for the different PCB congeners range typically between 10 pg and 70 pg in the sample and limits of detection for Hg are typically between 1 and 2 ug/g dry wt. In addition to PCBs, contaminants originating from historic organochlorine insecticide use were also quantified as they are determined using the same analysis as that used for PCBs. The compounds quantified include DDE (from the insecticide dichlorodiphenyltrichloroethane (DDT)), HEOD (from the insecticides aldrin and dieldrin) and g-HCH (gamma-hexachlorocyclohexane). These compounds are no longer a focus for PBMS monitoring and the data are reported here only in the Appendix.

Metal concentrations were measured in approximately 1 g sub-samples that were dried to constant weight at 80°C for 24 h, solubilised at room temperature overnight in 2 ml of (Analar) nitric acid, then heated at 90°C for 20 min followed by 120°C for 1 h. To further digest the organic matter, 0.5 ml of 30% hydrogen peroxide were added to the sample which was then heated at 120°C for 15 min. Samples were diluted with double-deionised water to known volume and a 10% acid strength. The resulting digests were analysed for a suite of trace metals and mercury by Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) using a Perkin Elmer DRCII ICP-MS with standard conditions.

2.8. Data expression, format and analysis

Throughout this report, liver and/or egg anticoagulant rodenticide, PCB and OC concentrations are reported as µg/g wet weight (wet wt). Sum PCB-TEQ concentrations (see below for explanation) are expressed as pg/g wet wt. All metal concentrations in livers and eggs are expressed on a µg/g dry weight (dry wt) basis. All residue data for individual birds are given in the Appendix tables.

PCB concentrations in biological materials can be expressed in different ways.In the main body of the report, PCB concentrations are summarised as total PCBs, sum congener PCBs, Paris 10 congeners and sum PCB-TEQs.

Total PCB concentrations were calculated as the total concentration of all peaks (excluding peaks identified as OC insecticides) with retention times greater than that of dichlobenil. The concentration is calculated from the total response factor of all the peaks in the Aroclor 1254 standard.

The *sum congener PCB concentration* is the sum of the concentrations of each of the 35 PCB congeners that were individually measured. Data for individual congeners are given in the relevant Appendix tables.

The "*Paris 10 congeners*" are a selection of individual PCB congeners defined in the 1974 Paris Commission and are congeners 28, 31, 52, 101, 105, 118, 138, 153, 156, 180. The concentration of these congeners are summed to give the Paris 10 congener concentration.

The *sum PCB-TEQ concentrations* have been calculated using the appropriate Toxic Equivalence Factors (TEFs) as given in the 1997 World Health Organisation values that apply to birds (Van den Berg et al., 1998). TEFs have been assigned to the "dioxin-like" PCB congeners. Each individual PCB-TEQ is calculated by multiplying the wet weight concentration of the congener by the TEF for that congener. The PCB congeners for which TEQs have been calculated are congeners 77, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189. The sum PCB-TEQ concentration is the sum of the TEQs for these 11 congeners.

Total PCB concentrations are likely to over-estimate the true level of PCB contamination because the measures are derived from a large number of peaks, some of which may not actually represent PCBs. Congener specific parameters such as congener sum and Paris 10 sum concentrations are more precise measures but are likely to underestimate the true total PCB contamination, because not all 209 PCB congeners are quantified. Furthermore, it is still unclear what the toxicological significance of these parameters are. PCB-TEQ concentrations give a relatively more accurate assessment of the potential effects of coplanar PCB residues.

For all summed PCB and PCB-TEQ concentrations, individual congener concentrations that were below the limit of detection (non-detected) were assigned a zero value.

Contaminant concentrations for birds that died in 2006 are summarized as geometric means and geometric standard errors based on data for all birds, including non-detected residues. The number of birds or eggs analysed and reported in the Appendix tables may be greater than the number for which summary data are presented in the main sections of the report. This is because some carcasses or eggs may have been collected in earlier years but only submitted to the PBMS in 2006.

Long-term temporal trends in contaminant concentrations were assessed using linear regression analysis of annual median values weighted for the number of birds analysed in each year (Minitab 15.1; Minitab Inc.).

2.9. Outputs from the PBMS

The results of the monitoring work are published in annual reports and scientific papers (for example(Jagannath et al., 2008, Knopper et al., 2007, Pereira et al., 2009, Pereira et al., 2008, Shore et al., 2006a, Walker et al., 2007a, Walker et al., 2007b, Walker et al., 2008a, Walker et al., 2008b, Wienburg and Shore, 2004) and on a dedicated PBMS website.

Volunteer collectors are sent a post mortem report (carcasses) or biometric data (egg) for each sample they submit and a summary of the contaminant levels for those samples that are analysed chemically. This level of feedback to collectors is essential in maintaining a strong relationship between the PBMS and the volunteer base that supports it.

3. Anticoagulant rodenticides (SGARs) in barn owls (*Tyto alba*), kestrels (*Falco tinnunculus*) and red kites (*Milvus milvus*)

3.1. Background

The aim of this work is to monitor the exposure of barn owls (*Tyto alba*), kestrels (*Falco tinnunculus*) and red kites (*Milvus milvus*) to anticoagulant rodenticides by measuring liver residues in carcasses submitted to the PBMS by members of the public. The birds have died from various causes, but mainly from road traffic collisions and from starvation.

The PBMS has monitored SGAR residues in barn owls since 1983 and the findings from barn owls analysed in previous years have been reported by Newton et al. (1990b, 1999b) and long-term trends were last reviewed in this report series by Shore et al. (2005b). This is the sixth year in which the PBMS has monitored kestrels for SGARs. Kestrels were incorporated into the scheme because a study of birds that died between 1997 and 2000 indicated a high proportion (24/36 individuals of the sample) had detectable concentrations of one or more SGAR in the liver (Shore et al., 2001). A small number of red kites are received by the PBMS each year and these are analysed for rodenticides because previous studies also demonstrated that a high proportion of individuals are exposed to these biocides (Shore et al., 2000).

To date, monitoring of rodenticides has been restricted to the second generation anticoagulant rodenticides (SGARs) difenacoum, bromadiolone, brodifacoum and flocoumafen. This year, the concentrations of warfarin and coumatetralyl (first generation hydroxycoumarins) and of diphacinone and chlorophacinone (indandione derivatives) were also been quantified. This was possible because the analytical method used by the PBMS has changed to a liquid chromatography-mass spectrometry (LC-MS) approach, which has facilitated the simultaneous measurement of all the compounds. In addition to expanding the range of rodenticides that can be quantified, this method is also more sensitive and can detect lower concentrations of these compounds than was possible previously. This has implications for interpretation of long-term monitoring data which are considered below.

3.2. Rodenticide concentrations in birds submitted to the PBMS in 2006

Results for individual birds are presented in the appendix.

Sixty two barn owls were submitted to the PBMS in 2006; all had died that year. Thirty-nine (62.9% of the sample) contained detectable liver concentrations of one or more SGAR (Table 3.1). This was the highest proportion reported since monitoring started in 1983 and was significantly higher (Fisher's Exact test, $P<0.005$) than the proportion for the previous five years combined (127 out of 301 birds; 42%). This was to be expected because of the lower limits of detection achieved by the new LC-MS analysis. As in previous years, the majority of exposure in barn owls was due to bromadiolone and difenacoum and residues of these compounds occurred in 59.7% of the livers analysed. Brodifacoum was detected less frequently (Table 3.1) and flocoumafen not at all. Multiple SGAR residues were detected in approximately one fifth of the livers analysed.

Of the other anticoagulant rodenticides, coumatetralyl was detected in one barn owl and chlorophacinone in two (4.3%); residues were all below 0.04 µg/g wet wt. Warfarin and diphacinone were not detected in any of the barn owls tested.

Table 3.1. Number and % of barn owls and kestrels analysed that contained detectable liver residues of anticoagulant rodenticides. Total number of barn owls and kestrels analysed was 62 and 18, respectively.

	barn owls		Kestrels	
	with detectable residues			
	number	%	number	% hits
2nd Generation (SGAR)				
bromadiolone	26	41.9	11	61.1
difenacoum	21	33.9	11	61.1
flocoumafen	0	0.0	0	0.0
brodifacoum	11	17.7	6	33.3
Any SGAR	39	62.9	14	77.8
Multiple SGARs	13	21.0	10	55.6
1st Generation (FGAR)				
warfarin	0	0.0	0	0.0
coumatetralyl	1	2.1	0	0.0
chlorophacinone	2	4.3	1	5.6
diphacinone	0	0.0	0	0.0
Any FGAR.	3	6.4	1	5.6
Multiple FGARs	0	0.0	0	0.0
Any rodenticide	39	62.9	14	77.8
Multiple rodenticides	16	25.8	11	61.1

The potentially lethal range for SGAR residues in birds of prey has variously been described as > 0.1 µg/g wet wt (Newton et al., 1998) and > 0.2 µg/g wet wt (Newton et al., 1999b) and is so classed on the basis of two sets of observations. These first was that owls diagnosed at post-mortem of having died from rodenticide poisoning (because they had characteristic signs of haemorrhaging from such organs as the heart, lungs, liver, brain and/or subcutaneous areas) almost all had liver residues >0.1 µg/g wet wt. The second was that owls that had been experimentally poisoned had residues of the range 0.2-1.72 µg/g wet wt (Newton et al., 1999b). Most barn owls with detectable residues in the liver had concentrations below this proposed lethal range (Figure 3.1), but six (9.7% of the sample) had residues (summed values for all four SGARS) greater than 0.1 µg/g wet wt; three of these exceeded 0.2 µg/g wet wt. The maximum concentration detected was 0.912 ug/g wet wt of

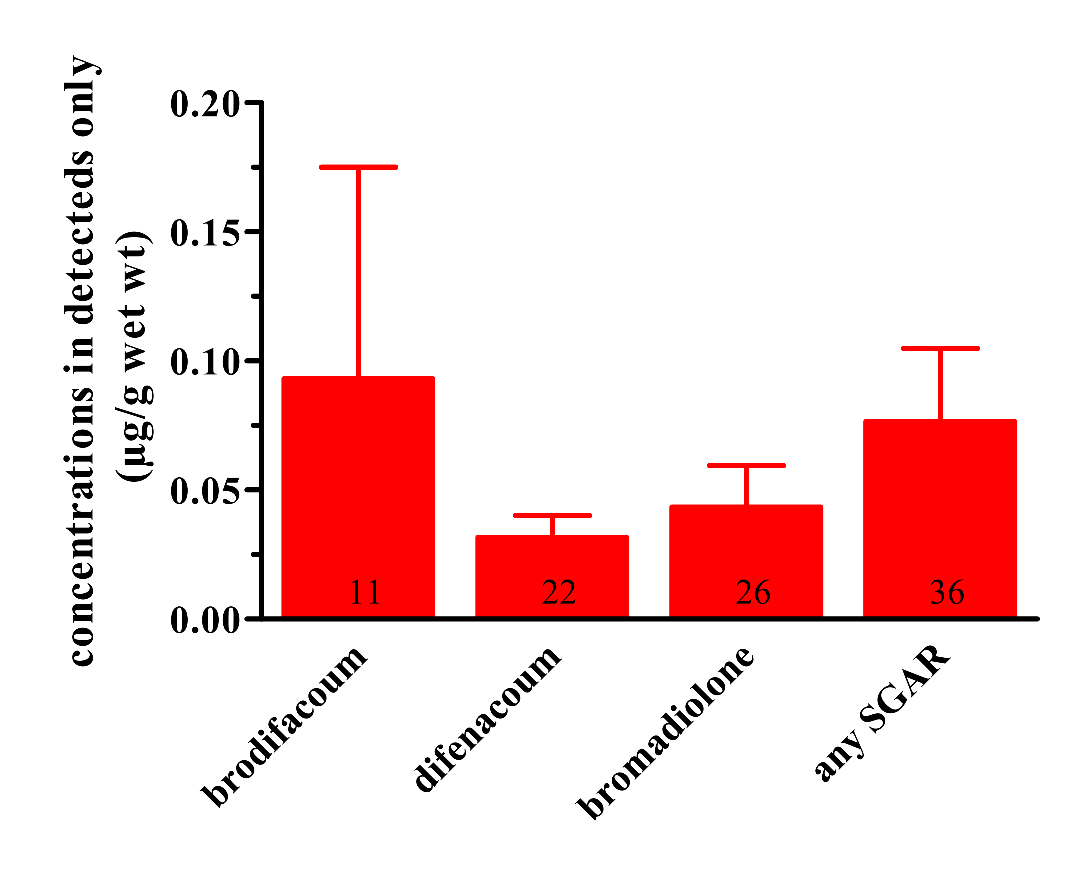

Figure 3.1. The mean (+SEM) concentration of SGARs in the livers of barn owls received in 2006. Only detected values were included (number indicated for each compound). Flocoumafen was not detected in any of the livers analysed.

brodifacoum (bird number 15434). This bird had extensive haemorrhaging but died as a result of a road traffic collision and it is not possible to determine if rodenticides contributed to the extent and severity of haemorrhaging. The second highest liver residue was 0.409 ug/g wet wt (0.396 µg/g wet wt. bromadiolone and 0.013 µg/g wet wt. brodifacoum) in a bird (number 15284) diagnosed to have died from unknown trauma. There was hemorrhaging at one or more sites within the body and rodenticides may have contributed to the death of this bird. In the other four birds, summed SGAR liver residues were below 0.21 µg/g wet wt. and at post mortem examination, there were either no signs of hemorrhage or the circumstances in which the bird was found suggested a physical trauma had caused the hemorrhaging.

Eighteen kestrels were received in 2006. Thirteen had died during that year, one died in 2005, three in 2004, and one in 2002. Fourteen kestrels (77.8% of sample) contained detectable levels of one or more SGAR in their livers and 10 (55.6%) contained multiple SGAR residues (Table 2.1). As with barn owls, more kestrels contained detectable residues than in previous analyses, reflecting the enhanced sensitivity of the LC-MS analysis. Eleven kestrels (61.1% of sample) each had detectable concentrations of difenacoum and bromadiolone in their liver; brodifacoum was detected in 6 birds and flocoumafen was not detected in any birds (Table 2.1).

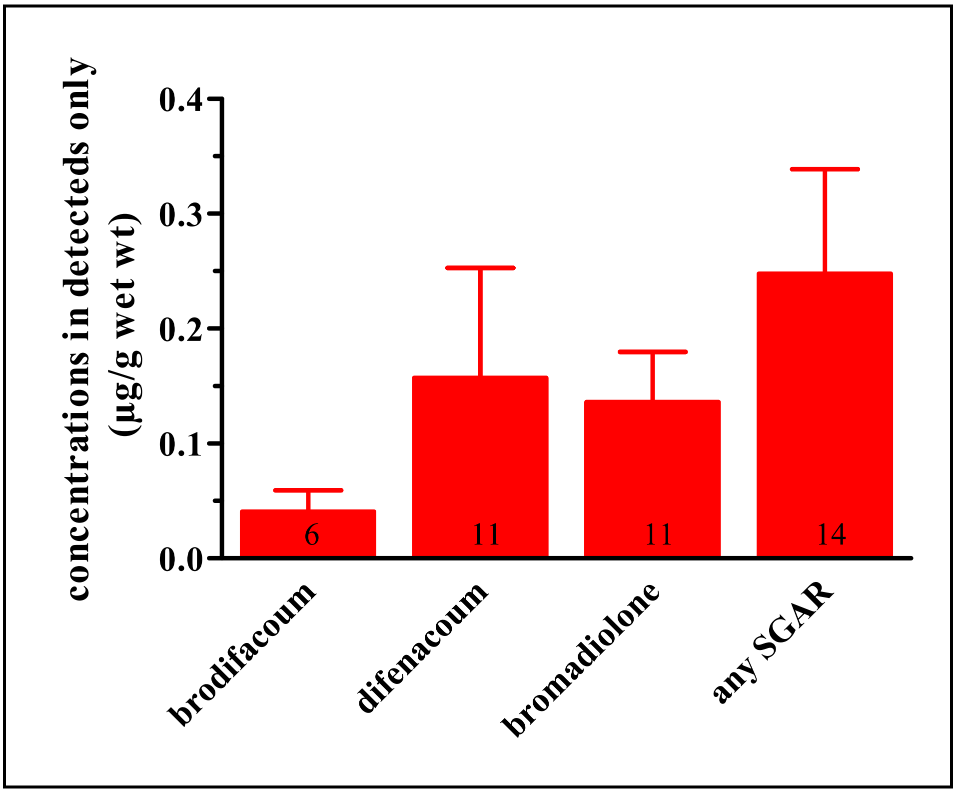

Figure 3.2 The mean (+SEM) concentration of SGARs in the livers of kestrels received in 2006. Only detected values were included, the number of which are indicated for each compound. Flocoumafen was not detected in any of the livers analysed.

Nine kestrels had sum SGAR concentrations above 0.1µg/g wet wt., five of which exceeded 0.2 µg/g wet weight. None of these birds showed hemorrhaging that wasn't associated with physical trauma. The median sum concentrations of SGARs in kestrel livers was significantly higher than that in barn owls (Mann-Whitney U-test, U=104.0, P=0.039). As in previous years, the results reported here suggest that kestrels are either exposed to SGARs more frequently and to a greater magnitude than barn owls, or that the residues are retained within the liver for a longer period in kestrels.

Only one kestrel had a detectable liver concentration of chlorophacinone (0.029µg/g wet wt.). Warfarin, coumatetralyl and diphacinone were not detected in any of the kestrels.

Three red kite livers were analysed for birds that died in 2006. Two contained detectable concentrations of anticoagulant rodenticides. One bird (number 15029) had hemorrhaging at multiple sites but had relatively low liver SGAR residues (bromadiolone and difenacoum concentrations of 0.055 µg/g wet wt. and 0.084 µg/g wet wt., respectively). The other (number 15672) was from a chick that had no signs of hemorrhaging and a liver bromadiolone concentration of 0.115 µg/g wet wt.

3.3. Long term trends in liver SGAR concentrations in barn owls and kestrels

A common limit of quantification (LoQ) was applied to the long-term dataset for SGARs. This was 0.01 µg/g wet wt. and was applied to each of the four compounds. The LoQ was based on the least sensitive analytical capability in the earliest years of monitoring which was for difenacoum. Any detected values below this LoQ were re-assigned as a non-detected values and the percentage occurrence of SGARs were then recalculated for each year—these are termed "adjusted % detected" values. The use of adjusted % detected values under-estimates the true occurrence of liver SGAR residues for compounds and years where the limit of quantification was substantially lower, but it eliminates biases in the long-term data due to improvement in the sensitivity of analysis over time. The adjusted % detected values therefore provide a measure of temporal changes but do not necessarily indicate the actual scale of exposure. Adoption of a common limit of detection between SGARs also eliminates detection biases when comparing % detection values for different rodenticides.

The adjusted % detected values for one or more SGAR in barn owl livers has changed over the course of monitoring from approximately 5% in 1984 to a maximum of 53% in 2003 (Figure 3.3). In the last three years (2004-2006), this value has been lower at between 30% and 35%. The increase in detection of SGARs in owls between 1984 and 2003 was driven by a rise in exposure to difenacoum and bromadiolone (Figure 3.4). Similarly, in the period 2004-2006 the exposure to both these compound was reduced compared with recent preceding years, except for bromadiolone in 2006 (Figure 3.4). Brodifacoum, and to a lesser extent flocoumafen, has been detected in barn owls during the course of the monitoring period but there is no evidence of any significant progressive change in exposure over time (Figure 3.4).

The scale of exposure of barns owls in England, Scotland and Wales has also been examined using the data available pooled for the last five years to provide sufficient sample size for analysis (Table 3.2). The adjusted % of owls with detected residues was higher in England than in Scotland and Wales, although the differences between countries were not statistically significant.

Table 3.2. Adjusted number (%) Percentage occurrence of second generation anticoagulant rodenticides (SGARs) in livers of barn owls found in England, Scotland and Wales collected between 2002 and 2006. A common limit of quantification of 0.01 µg/g wet wt. was applied to all compounds and samples.

	England (n=263)		Scotland (n=18)		Wales (n=18)		Chi Squared
	adjusted number (%) of owls with detected residues						(χ^2) statistic
Bromadiolone	62	(24%)	3	(17%)	1	(6%)	3.51
Difenacoum	59	(22%)	1	(6%)	4	(22%)	2.86
Flocoumafen	1	(0.4%)	0	(0%)	0	(0%)	0.14
Brodifacoum	21	(8%)	0	(0%)	0	(0%)	3.10
Any SGAR	108	(41%)	3	(17%)	5	(28%)	5.20
Multiple SGAR	28	(11%)	1	(6%)	0	(0%)	2.56

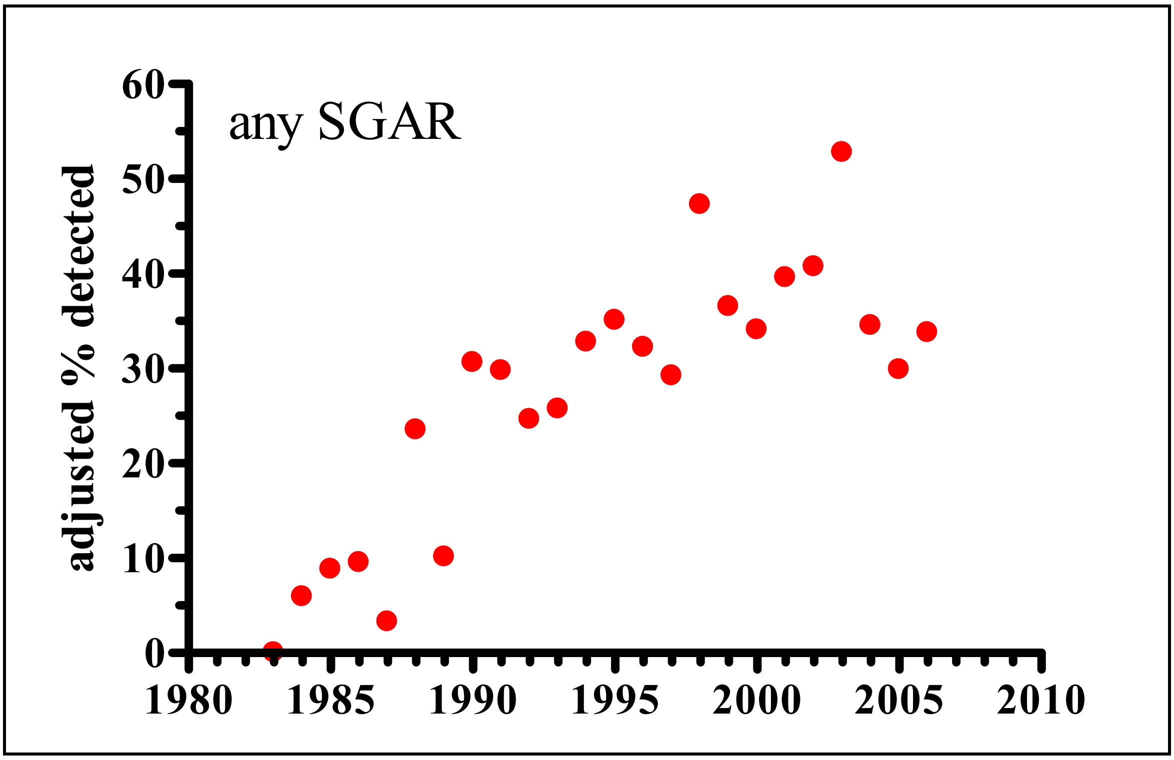

Figure 3.3. Variation over time in the adjusted % of barn owls with detectable liver residue of any SGAR (minimum concentrations for any individual compound of ≥ 0.010 µg/g wet wt).

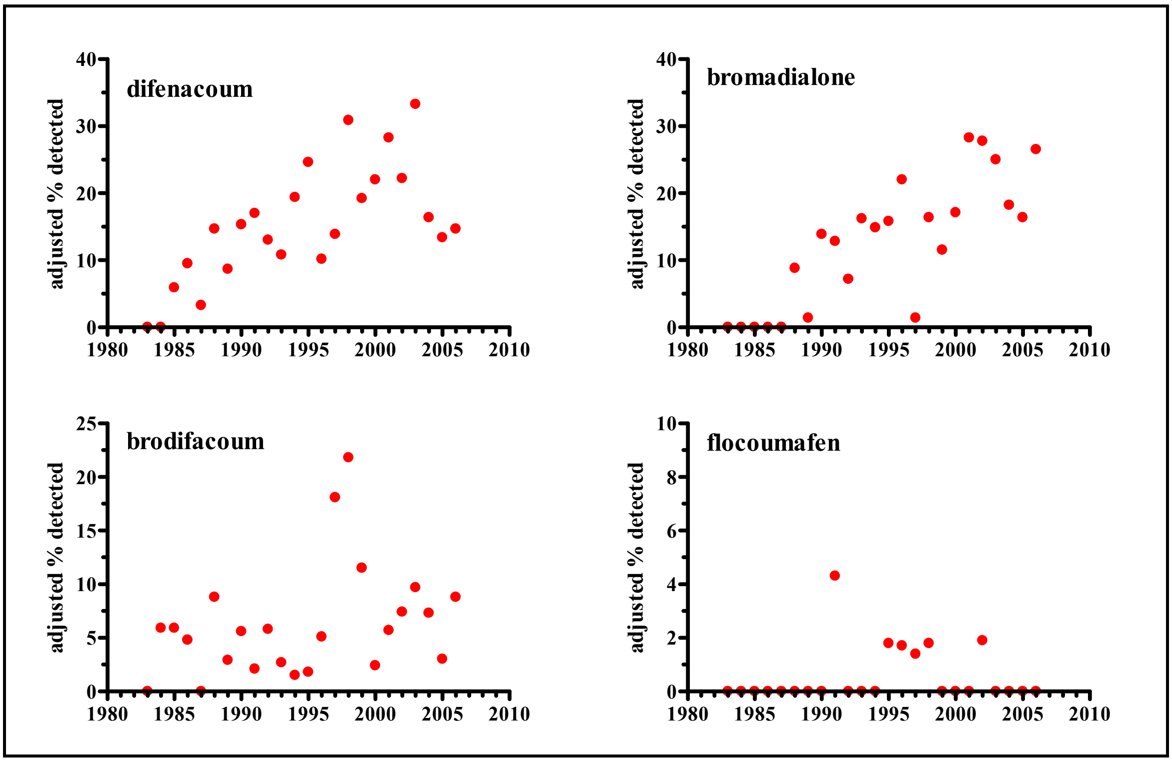

Figure 3.4. Variation over time in the adjusted % of barn owls with detectable liver residues (concentrations ≥ 0.010 µg/g wet wt.) of individual SGARs.

The same common limit of quantification as used for barn owls was applied to the whole of the dataset for kestrels to facilitate inter-year comparisons. Second generation anticoagulant rodenticides have been monitored in kestrels since 2001, with additional data available for a further 36 birds that had died between 1997 and 2000. However fewer kestrels are received each year than barn owls and so data have been collated into two-three year blocks. The adjusted % of birds with any detectable SGAR liver residue has been 50-70 %, with no apparent progressive increase or decrease over blocks of years (Figure 3.5). Much of this has been exposure to difenacoum and bromadiolone. The proportion of birds with detectable brodifacoum residue in the liver has increased from about 5%, in 1997-2000 to 17 in birds that died in 2005-2006 (Figure 3.5) but it is not yet possible to determine if this is a progressive trend or simply natural variation between sampling intervals. Continued monitoring is needed to determine the significance of any trend over time in exposure to brodifacoum.

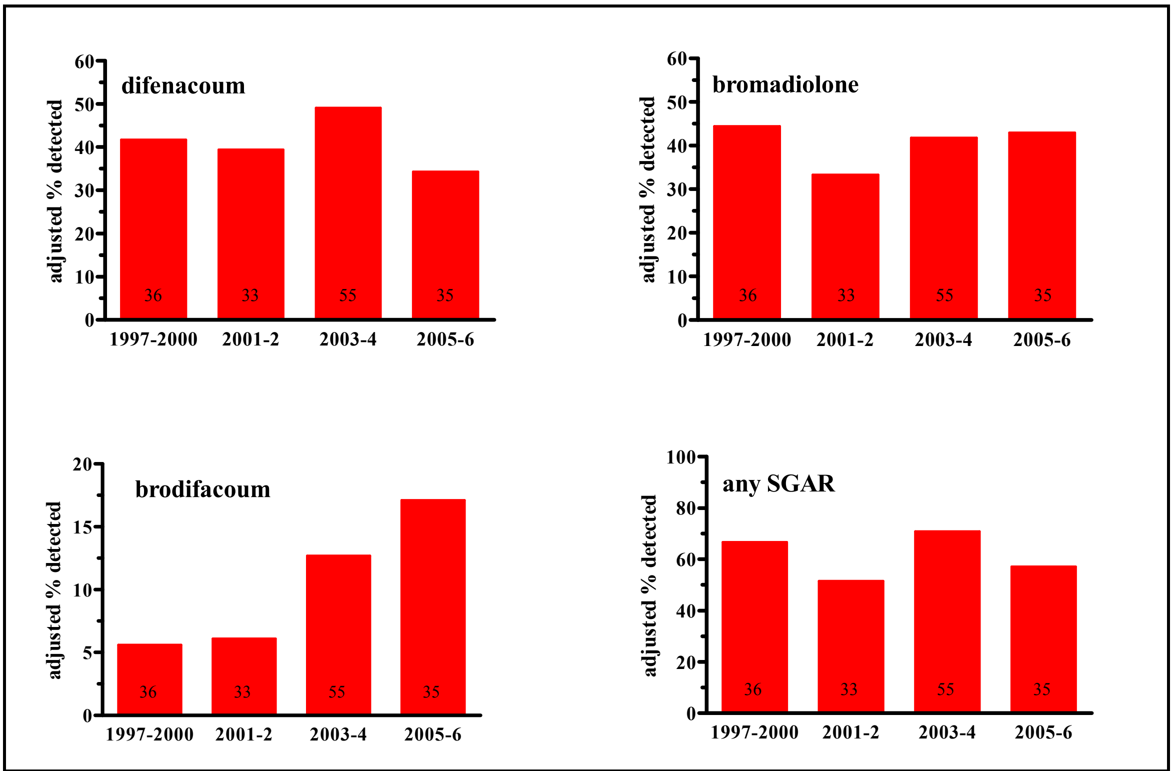

Figure 3.5. Variation over time in the adjusted % of kestrels with detectable liver residues of individual SGAR and of any SGAR (minimum concentrations for any individual compound of ≥ 0.010 µg/g wet wt).

4. Persistent organic pollutants and metals in the livers of sparrowhawks and herons

Sparrowhawks (a sentinel species of the terrestrial environment), and herons (which give an indication of contamination in the aquatic environment) have been monitored for PCBs and Hg since the mid 1960s but this is the first year in which a wider set of metals have been included in the monitoring. For birds collected in 2006, information on provenance, age, sex and condition is given in Table 10.3 in the Appendix. Details of analytical methods and data format are given in sections 2.6 and 2.7 respectively.

4.1. Contaminant concentrations in birds that died in 2006

The results for each individual liver is given in Tables 10.4 (PCB congeners), 10.5(PCB-TEQs), 10.6 (organochlorine insecticides) and 10.7 (inorganic elements) in the Appendix. The geometric median total PCB, sum congener PCB, sum PCB-TEQ concentrations and the concentrations of the Paris 10 congeners are presented in Table 4.1.

Table 4.1. Geometric mean (GM) concentrations of polychlorinated biphenyls (PCBs) in the livers of sparrowhawks and herons received in 2006.

	Species					
	Sparrowhawk			Heron		
Analyte	**GM**	**lower 95%CI**	**upper 95%CI**	**GM**	**lower 95%CI**	**upper 95%CI**
Total PCBs (µg/g ww)	1.061	0.570	1.976	0.602	0.018	20.50
Sum congener (µg/g ww)	0.508	0.268	0.964	0.298	0.007	12.70
Sum PCB-TEQ (pg/g ww)	1.508	0.775	2.938	0.990	0.005	193.2
Individual congeners (ng/g ww)						
PCB 28	0.045	0.016	0.130	0.824	0.005	151.0
PCB 31	0.018	0.013	0.024	ND	-	-
PCB 52	0.155	0.047	0.506	ND	-	-
PCB 101	31.61	12.68	78.77	2.823	0.006	1439
PCB 105	0.010	0.005	0.020	0.445	ND	1101
PCB 118	18.09	10.30	31.77	27.27	0.545	1363
PCB 138	41.22	21.98	77.28	40.34	0.937	1738
PCB 153	101.3	55.38	185.3	71.92	1.996	2592
PCB 156	11.24	5.075	24.90	3.181	0.004	2701
PCB 180	65.92	34.89	124.5	36.30	0.856	1540

ND indicates not detected

The geometric mean total and sum congener PCB concentrations in sparrowhawk livers were relatively low and indicated that, although exposure to PCBs is wide-spread the magnitude, is generally low and below that thought to cause adverse effects in individual birds.

Liver TEQ concentrations varied markedly between individual sparrowhawks with concentrations ranging from 0.02 to 21.5 pg/g wet wt. The geometric mean concentration was 1.51 pg/g wet wt, which is within the ranges reported in the livers of various predatory bird species from Europe, the USA and Japan (Kannan et al., 2003, Coady et al., 2001, Senthilkumar et al., 2002). The toxicological significance of liver TEQ concentrations is less well established for livers than for eggs (Hoffman et al., 1996), but 25 ng/g on a lipid weight (lipid wt) basis has been reported as the lowest observed effect concentration (LOEC) for induction of cytochrome P450 enzymes and for a 50% reduction in plasma thyroxine levels in common tern (*Sterna hirundo*) chicks (Bosveld et al., 2000). The geometric mean TEQ concentration for sparrowhawks that died in 2006 was 46.4 pg/g, when expressed on a lipid weight basis, approximately three orders of magnitude lower than the LOEC reported for tern chicks. The highest lipid weight TEQ concentration measured in the sparrowhawk livers (bird 15294, 718pg/g) was approximately two orders of magnitude below the LOEC for terns.

The concentrations of individual and summed PCBs in the four herons analysed were low and not considered to be toxicologically significant.. The TEQ concentrations were also low, ranging between 0.01 and 12 pg/g ww, and below those previously reported as having toxicological significance (Bosveld et al., 2000).

The hepatic metal concentrations in both sparrowhawks and herons were generally below those associated with adverse effects (Table 4.2) except for one sparrowhawk (bird 15201) which had a liver lead (Pb) concentration of 12.7 µg/g dry wt. Mercury concentrations in all sparrowhawks and herons that died in 2006 were below 30 µg/g wet wt (equivalent to approximately 105 µg/g dry wt.), which is associated with toxic effects in birds of prey (Thompson, 1996).

Table 4.2. Concentrations (µg/g dry wt.) of selected inorganic elements in the livers of sparrowhawks and herons received in 2006.

	Critical Concentration[1]	GM	95% CI	No. > Critical Concentration
Sparrowhawk (N=30)				
Hg	105	1.79	1.19 - 2.69	0
As	40	0.053	0.040 - 0.069	0
Pb	12[1]	0.057	0.021- 0.158	1
Cd	133	0.364	0.272 - 0.486	0
Cu	-	17.7	14.8 - 21.1	-
Zn	-	96.7	80.0 - 117	-
Heron (N=4)				
Hg	105	5.28	1.57 - 17.8	0
As	40	0.251	0.109 - 0.577	0
Pb	121	0.491	0.022 - 10.8	0
Cd	133	2.14	1.22 - 3.73	0
Cu	-	68.7	5.97 - 790	-
Zn	-	207	64.2 - 673	-

[1] based on a wet weight concentrations associated with adverse effects as suggested by (Thompson, 1996) for Hg, (Erry et al., 1999) for As, (Franson, 1996) for Pb and (Furness, 1996) for Cd and an average moisture content of 70%.

4.2. Long-term time trends

There has been no long-term change in total PCB liver concentrations in sparrowhawk livers during the period 1968-2006 (Figure 4.1; $F_{1,38}$=0.41, P=0.528). The summed liver concentrations of the Paris 10 congeners and the TEQs have been monitored since 1996 (Figure 4.1) and again neither have changed significantly over this period ($F_{1,9}$≤0.78, P≤0.017).

The mean mercury concentration did decline significantly in sparrowhawk livers between 1996 and 2006 (Figure 4.1; $F_{1,36}$=9.63, P=0.004). There are no time trend data for other metals as this is the first year that other metals have been quantified in livers.

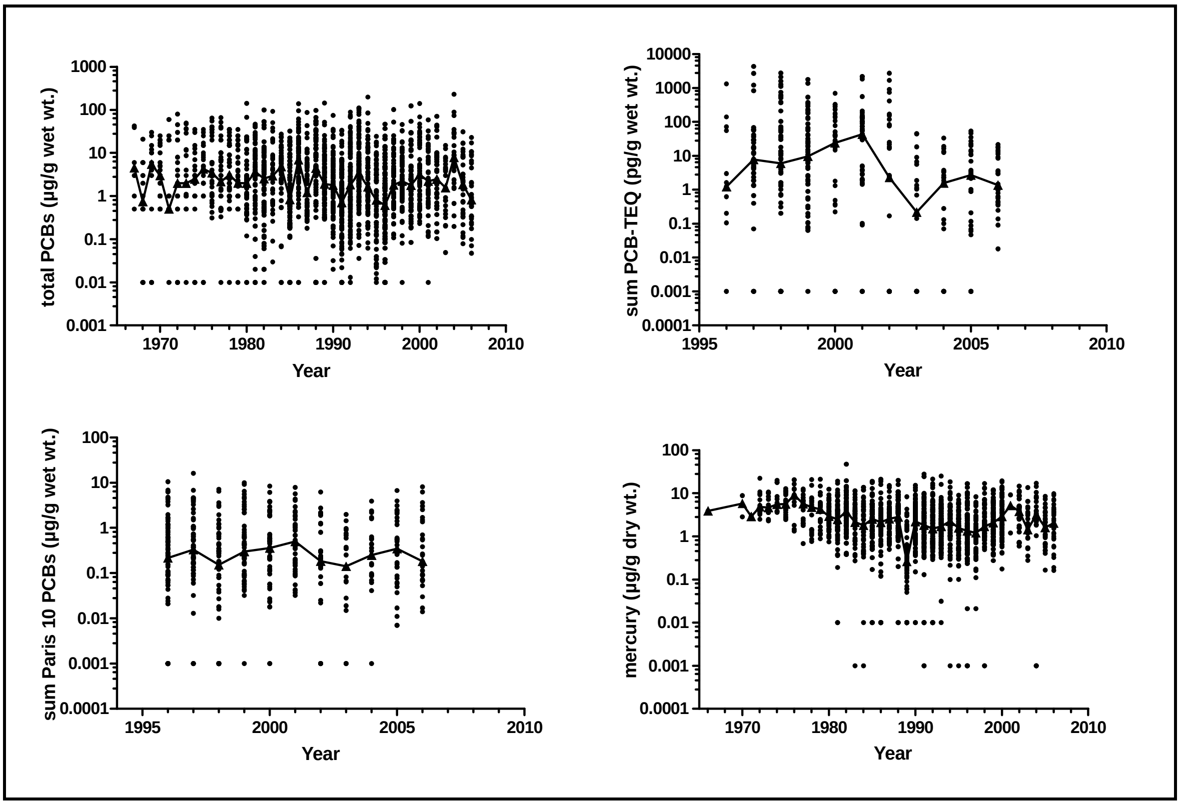

Figure 4.1 Long-term trends in liver total PCB, Paris 10 PCB, sum PCB-TEQ and Hg concentrations in Eurasian sparrowhawk (*Accipiter nisus*). Dots are concentrations in individual livers, and the triangles are annual median values with a connecting line

In herons (Figure 4.2), there is evidence of a significant long-term decline in total PCB concentrations ($F_{1,38}$=9.87, P=0.003) but no detectable significant decline in the Paris 10 congeners ($F_{1,7}$=2.92, P=0.131). However, PCB-TEQ concentrations have declined ($F_{1,7}$=9.10, P=0.020), and this appears to be due to PCB126 and PCB169 not being found in samples from 2002 onwards. In preceding years these two PCB congeners account for between 50 and 99% on the PCB TEQ concentration.

As in sparrowhawks, mercury concentrations in heron livers have significantly declined during the monitoring period 1969-2006 (Figure 3.10; $F_{1,35}$=19.56, P<0.001).

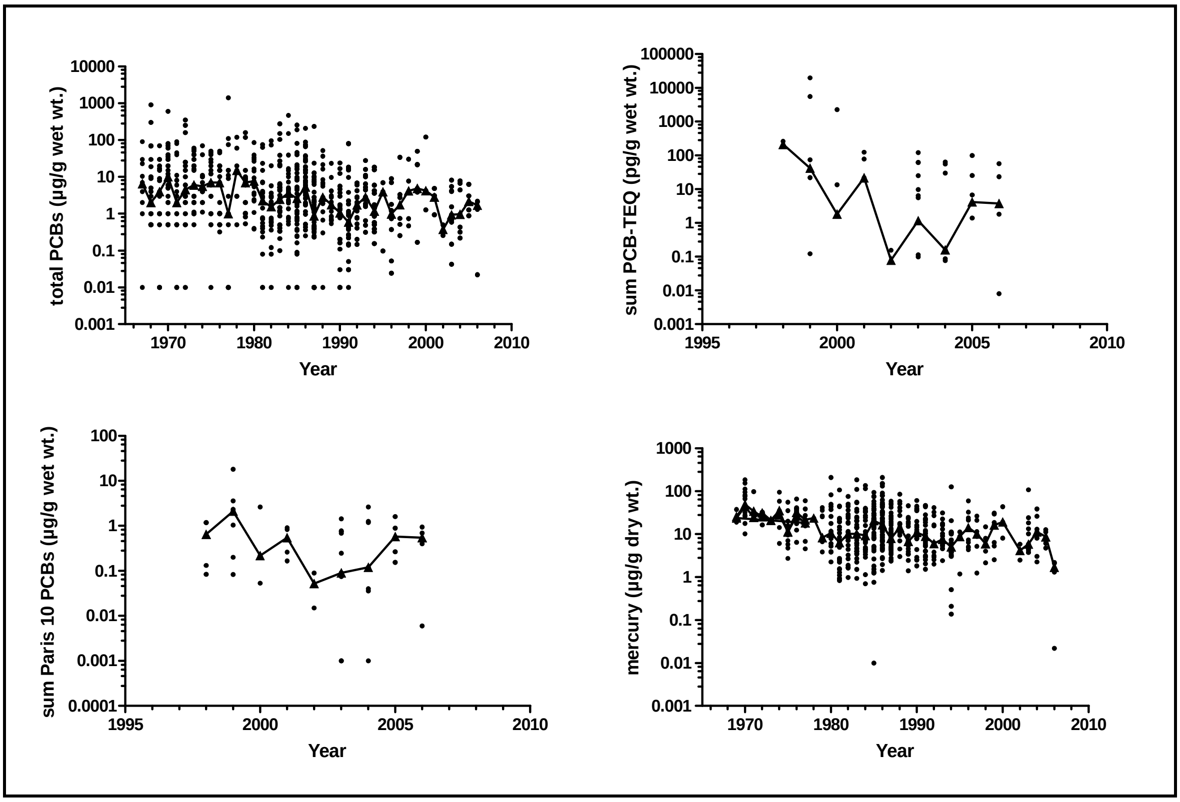

Figure 4.2. Long-term trends in liver total PCB, Paris 10 PCB, sum PCB-TEQ and Hg concentrations in grey heron (*Ardea cinerea*). Dots are concentrations in individual livers, and the triangles are annual median values with a connecting line

5. Persistent organic pollutants and metals in merlin (*Falco columbarius*) eggs

5.1. Contaminant concentrations in eggs collected in 2006

Merlin eggs have been monitored long-term for PCBs and organochlorine compounds. The findings from previous analyses are reported elsewhere (Newton et al., 1999a, Newton and Haas, 1988, Newton et al., 1982) and in previous recent reports in this series (Shore et al., 2005a, Shore et al., 2005b, Shore et al., 2006b). Those from 13 eggs (one per clutch) collected during 2006 and one egg collected in 2003 (but submitted in 2006) are given in Table 5.1.

Table 5.1: Summary of PCB concentrations in merlin eggs (n=13) received in 2006. Egg E8164 was excluded from this analysis as it was from a clutch laid in 2003

Analyte	GeoMean	lower 95%CI	upper 95%CI
Total PCBs (µg/g ww)	1.125	0.707	1.792
Sum TEQ (pg/g ww)	6.443	1.733	4.389
Congener sum (µg/g ww)	0.521	0.343	0.794
Selected congeners (ng/g ww):			
PCB 028	0.286	0.07	1.172
PCB 031	ND	ND	ND
PCB 052	ND	ND	ND
PCB 101	0.282	0.047	1.693
PCB 105	6.156	3.891	9.738
PCB 118	32.68	21.35	50.01
PCB 138	23.44	5.375	102.3
PCB 153	147.1	99.98	216.3
PCB 156	16.81	10.54	26.81
PCB 180	73.91	50.09	109.1

ND is not detected

The analyses of the eggs collected in 2006 confirm that merlins eggs in Britain are still generally contaminated with PCBs. Total PCB and TEQ residues were detected in all 14 eggs. The concentrations of total PCBs were generally low and are below concentrations that are thought to be toxicologically significant (Blus, 1996, Hoffman et al., 1996, Peakall, 1996, AMAP, 1998). No Observable Effect Concentrations (NOECs) for eggs of various experimental and wild bird species range between 1.5 and 200 pg TEQs/ g wet wt; LOECs range between 10 and 2200 pg/g wet wt and the LD_{50} for embryo mortality in white leghorn chickens, one of the more sensitive species, is 115-147 pg/g wet wt (AMAP, 1998). Thus, there is considerable overlap between NOEC, LOEC and LD_{50} TEQ values which, in part, reflects species variation in sensitivity. The geometric mean and the maximum calculated TEQ concentration associated with PCB contamination in the merlin eggs received in 2006 was 6.44 pg/g wet wt and 17.78 pg/g wet wt, respectively. Therefore it is likely that the TEQ concentrations measured in the merlin eggs collected in 2006 were not toxicologically significant. However, NOEC and LOEC concentrations have not been derived for merlins and it is possible that they are more sensitive to the effects of PCBs than some other species. Accumulation of further TEQ data for this and other species through the PBMS will assist in interpreting the long-term trends and toxicological significance of TEQ concentrations in merlins eggs in Britain.

Mercury was detected in all of the merlin eggs received in 2006 (Table 5.2). The geometric mean and the maximum concentration was 3.09 µg/g dry wt and 10.30 µg/g dry wt and was typical of concentrations recorded in previous years (Shore et al., 2005a).Total mercury concentrations greater than approximately 2 µg/g wet wt have been associated with impaired hatching in laboratory studies on some species, although the extent to which this effect level can be extrapolated to other species is uncertain as there appears to be considerable variation in sensitivity between species (Thompson, 1996). When expressed on a wet wt basis, the maximum mercury concentration in the merlin eggs received in 2006 was 2.26 µg/g wet wt (E8666), which exceeds the concentration associated with adverse effects on reproduction. Four eggs had mercury concentrations near to or exceeding 2 µg/g ww, with three from nests on Orkney and one egg from the Isle of Rum.

Both lead and cadmium are not thought to accumulate in avian eggs (Furness, 1996) and this is reflected in the low concentrations measured in the merlin eggs received in 2006 (Table 5.2). Studies in Spain on a range of raptor species have measured concentrations of none-detected to 4.54, and 0.001 to 1.12 µg/g ww for lead and cadmium concentration, respectively(Garcia-Fernandez et al., 2008). Therefore lead and cadmium concentrations in merlin eggs are consistent with those reported in raptor eggs from Spain. Both copper and zinc are essential metals and so their concentrations are expected to be homeostatically controlled.

Arsenic has not been widely studied in raptor eggs. Previous studies in Spain have measured wet weight arsenic concentrations in raptor egg contents of up to 0.032 µg/g, measured in black kite (*Milvus migrans*) eggs, which are thought to be low and not related to reproductive effects. As the maximum concentration in the merlin eggs received in 2006 was 0.029 $\mu g/g^{-1}$ ww, it is unlikely that arsenic would have an adverse effect on these merlin eggs.

Table 5.2. Summary of metal concentrations in merlin eggs (n=13) received in 2006. Egg E8164 was excluded from this analysis as it was from a clutch laid in 2003.

	Concentration (µg/g dry weight)		
Analyte	**GeoMean**	**lower 95%CI**	**upper 95%CI**
mercury (Hg)	3.091	1.780	5.365
arsenic (As)	0.070	0.061	0.079
lead (Pb)	ND	-	-
cadmium (Cd)	0.002	0.001	0.005
copper (Cu)	2.431	1.851	3.193
zinc (Zn)	31.84	28.50	35.56

5.2. Long-term trends in contaminant concentrations in merlin eggs

There has not been a statistically significant change in total PCB concentrations in merlin eggs during the period 1979-2006 ($F_{1,26}$=0.22, P=0.644; Figure 5.1). However, there have been significant declines (Figure 5.1) in the liver concentrations of the Paris 10 congeners ($F_{1,8}$=9.06, P=0.017) and in PCB-TEQs ($F_{1,8}$=7.37, P=0.026). These results suggest that total PCB concentration may not be as sensitive to changes in PCB exposure than other measures of PCB contamination.

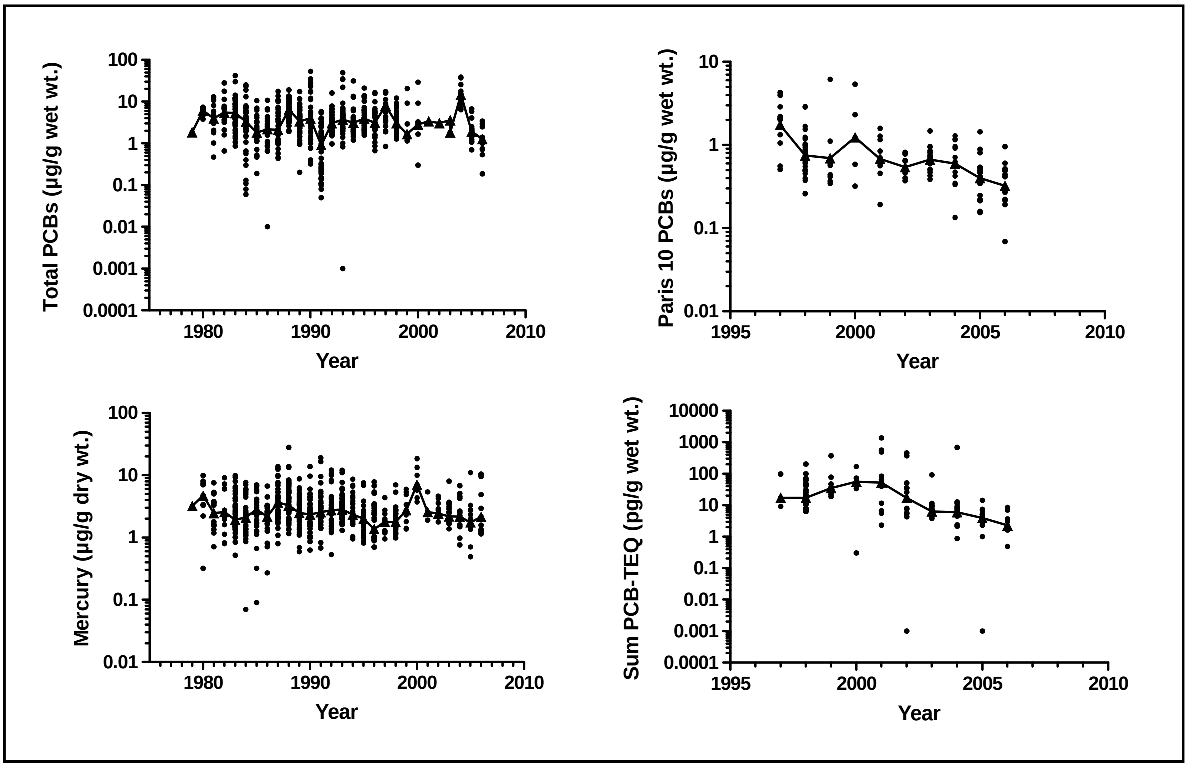

Figure 5.1. Long-term trends in liver total PCB, Paris 10 PCB, sum PCB-TEQ and Hg concentrations in melin eggs. Dots are concentrations in individual livers, and the triangles are annual median values with a connecting line

Mercury concentrations have not significantly changed during the period 1979-2006 ($F_{1,26}$=0.42, P=0.521). During this monitoring period the annual geometric mean concentrations of mercury have ranged between 1.74 and 7.72 µg/g dw, and so the level of mercury contamination quantified in eggs collected in 2006 is consistent with these observations. This is the first year that other metals have been quantified in egg contents and so time trend analysis has not been carried out for these analytes.

6. Persistent Organic Pollutants and Metals in golden eagle (*Aquila chrysaetos*) eggs

6.1. Introduction

The findings from the long-term monitoring of contaminants in golden eagle eggs carried out as part of the PBMS have been reported in previous reports by Newton and Galbraith (1991) and were recently summarised as part of the series of reports for the PBMS (Shore et al., 2005a). Eggs from 10 clutches were received in 2006; six were from coastal areas. The results of the chemical analyses are given in Table 4.1.

6.2. Contaminant concentrations in eggs collected in 2006

The PCB and Hg concentrations (Tables 6.1 and 6.2) in the eggs were below concentrations thought to impair reproduction (Blus, 1996, Hoffman et al., 1996, Peakall, 1996, AMAP, 1998, Thompson, 1996). Similarly, all the PCB-TEQ concentration measured in golden eagle eggs collected this year were within the range estimated to be the no observed effect concentration (NOEC).

Table 6.1. Concentrations of PCBs in the egg contents of golden eagles (n=10) received in 2006.

Analyte	GeoMean	lower 95%CI	upper 95%CI
Total PCBs (µg/g ww)	0.270	0.167	0.437
Sum TEQ (pg/g ww)	0.302	0.094	0.965
Congener sum (µg/g ww)	0.109	0.050	0.239
Selected congeners (ng/g ww):			
PCB 028	ND	ND	ND
PCB 031	ND	ND	ND
PCB 052	ND	ND	ND
PCB 101	0.342	0.046	2.536
PCB 105	0.092	0.013	0.664
PCB 118	5.115	2.222	11.78
PCB 138	8.742	3.621	21.11
PCB 153	33.56	14.90	75.56
PCB 156	1.885	0.458	7.762
PCB 180	23.91	11.74	48.69

ND is not detected

Table 6.2. Geometric mean concentrations of selected inorganic elements in the egg contents of golden eagles (n=10) received in 2006.

	Concentration (µg/g dry weight)		
Analyte	**GeoMean**	**lower 95%CI**	**upper 95%CI**
Hg	0.171	0.083	0.350
As	0.066	0.055	0.079
Pb	0.008	0.002	0.031
Cd	0.001	0.001	0.002
Cu	3.167	2.777	3.613
Zn	34.19	28.53	40.97

ND indicates not detected.

6.3. Long-term trends in contaminant concentrations in golden eagle eggs

Trends in residues in eggs from western and eastern areas have previously considered separately because regional variation in exposure of golden eagles to organochlorine pesticides has been noted previously (Lockie et al., 1969). This was thought to be due to sheep comprising a greater proportion of the diet of golden eagles in hilly western Scotland where sheep are abundant; the use of DDT and dieldrin in sheep dips up to the mid-1960s was probably one of the most important routes of exposure of eagles to these compounds (Newton and Galbraith, 1991) and references therein). However, as organochlorine insecticides are not currently the focus of the PBMS these regions are no longer considered separately. However, trends in residues in eggs from coastal and inland territories have been considered separately where possible as seabirds can accumulate high levels of mercury (Thompson, 1996) and are likely to be a more important component of the diet in coastal than inland nesting eagles. For the purposes of this analysis, coastal territories have been defined as those known to border the sea, or where such information was lacking, as sites within 3 km of the coast.

In eggs from inland nests (Figure 6.1), the total PCB ($F_{1,31}$=2.33, P=0.13) have not changed significantly over time. There are relatively few data on which to assess long-term trends for Paris 10 congener and PCB-TEQ concentrations but there are no obvious progressive trends over time. Annual median mercury concentrations range from non-detected to approximately 2 ug/g dry wt., and there are no clear progressive increases or decreases over time.

Total PCB, Paris 10, PCB-TEQ and mercury concentrations are all significantly higher in the eggs of eagles nesting within 3 km of the coastline than in birds nesting inland (Mann-Whitney U test, P<0.01 in all cases; Figure 6.2) However, as with inland-nesting birds, there is no statistically significant time trends in contaminant concentrations in the eggs of coastal nesting birds (Figure 6.2).

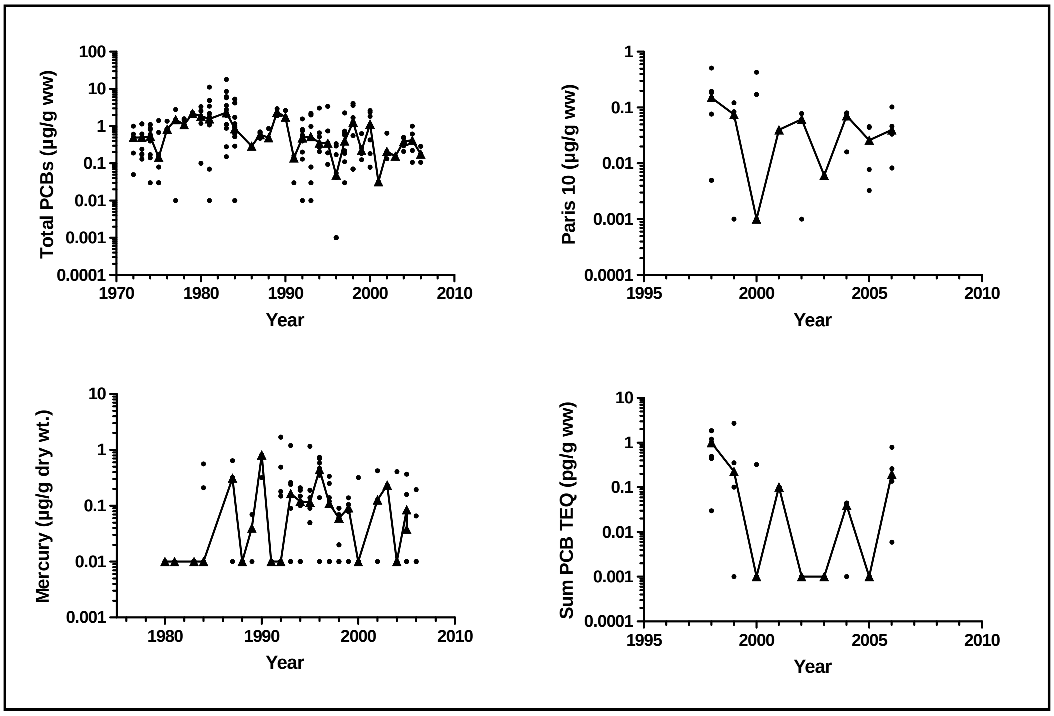

Figure 6.1. Long-term trends in total PCB, Paris 10 PCB, sum PCB-TEQ and Hg concentrations in the eggs of golden eagles that nest more than 3km inland. Dots are concentrations in individual livers, triangles are annual median values with a connecting line.

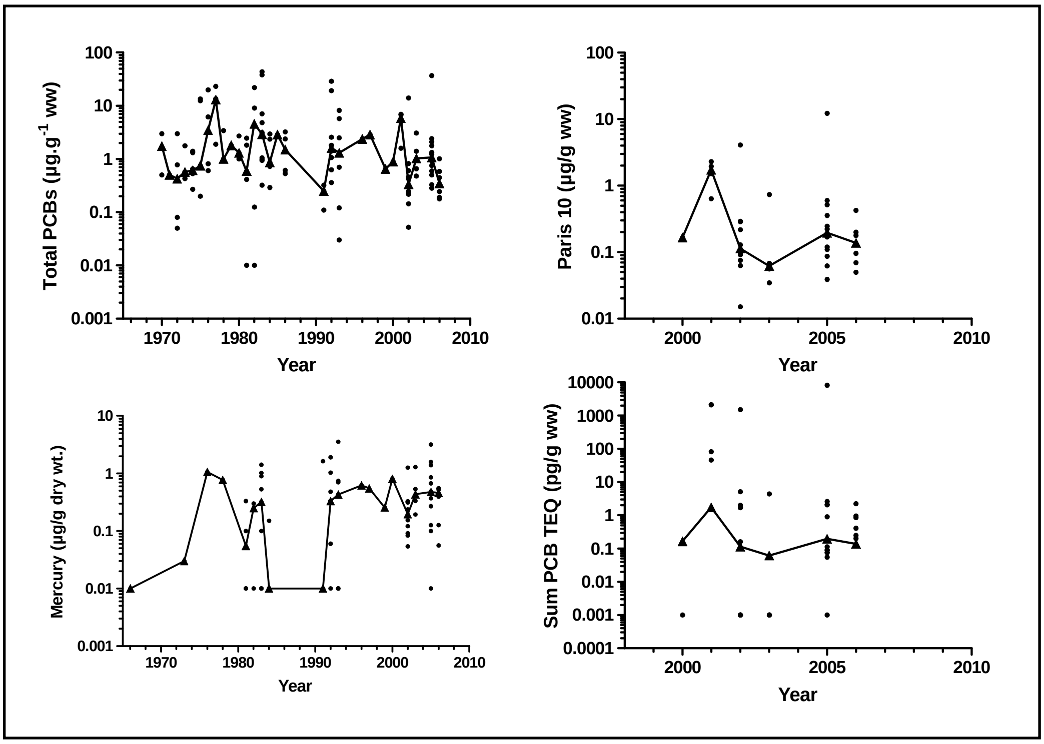

Figure 6.2. Long-term trends in total PCB, Paris 10 PCB, sum PCB-TEQ and Hg concentrations in the eggs of golden eagles that nest within 3km of the coast. Dots are concentrations in individual livers, triangles are annual median values with a connecting line

7. Persistent Organic Pollutants and Metals in northern gannet (*Morus bassanus*) eggs

7.1. Introduction

The results of monitoring of gannet eggs examined up to 1988 were published by Newton *et al*., (Newton et al., 1990a) and subsequent data, together with analysis of long-term trends, were recently summarised by Pereira et al. (2009). Gannet eggs are typically collected during visits to the colonies of Bass Rock and Ailsa Craig off the east and west coasts of Scotland, respectively. Collections are made during the laying or the early incubation period, and approximately ten eggs, each from a separate nest, are taken. Collections are made form each colony roughly every two years. In 2006 eggs were collected from the Bass Rock colony. This colony, located 2.5 kilometers off the coast of Midlothian in the Firth of Fourth, has approximately 30-40,000 breeding pairs of gannets that feed predominantly in the North Sea..

7.2. Contaminant concentrations in eggs collected in 2006

Total PCB and PCB-TEQ residues were detected in all 10 eggs (Table 7.1). The concentrations of total PCBs were generally low and below concentrations thought to be toxicologically significant (Blus, 1996, Hoffman et al., 1996, Peakall, 1996, AMAP, 1998). As discussed above (Section 5.1), No Observable Effect Concentrations (NOECs) for eggs of various experimental and wild bird species range between 1.5 and 200 pg TEQs/ g wet wt; LOECs range between 10 and 2200 pg/g wet wt and the LD_{50} for embryo mortality in white leghorn chickens, one of the more sensitive species, is 115-147 pg/g wet wt (AMAP, 1998). The geometric mean and the maximum calculated TEQ concentration associated with PCB contamination in the gannet eggs collected in 2006 was 21.1 pg/g wet wt and 57.3 pg/g wet wt, respectively, well within the NOEC range and at the bottom end of the LOEC range above. Therefore it is likely that the TEQ concentrations measured in the gannet eggs were not toxicologically significant, although there are no measured NOEC and LOEC values specifically for gannet eggs.

The geometric mean concentration of selected metals is given in Table 7.2. Mercury was detected in all 10 eggs collected in 2006. The geometric mean and maximum concentration was 2.09 µg/g dry wt and 3.08 µg/g dry wt respectively, and was typical of concentrations recorded in previous years (Shore et al., 2005a). When expressed on a wet wt basis, the maximum mercury concentration in gannet eggs received in 2006 was 0.77 µg/g ww, below the threshold of approximately 2 µg/g wet wt associated with impaired hatching in laboratory studies in some species (Thompson, 1996). Of the other non-essential elements, concentrations of lead and cadmium, which are not thought to accumulate in avian eggs (Furness, 1996), and arsenic concentrations were similar to those reported for were low and } and the mean arsenic concentration was similar to the range (0.073-0.382 µg/g dw) reported for common tern (*Sterna hirundo*) measured in the gannet eggs from Bass Rock (Burger et al., 2009, Burger and Gochfeld, 2003) but higher than that (0.048 µg/g dw) measured in glaucous-winged gulls (*Larus glaucescens*).

Table 7.1. Summary of PCB concentrations in northern gannet eggs (n=10) collected from the Bass Rock colony in 2006.

	Concentration		
Analyte	**GeoMean**	**lower 95%CI**	**upper 95%CI**
Sum TEQ (pg/g ww)	101.10	67.72	150.90
Congener sum (µg/g ww)	0.802	0.509	1.264
Selected congeners (ng/g ww):			
PCB 28	0.513	0.089	2.963
PCB 31	ND	-	-
PCB 52	ND	-	-
PCB 101	0.009	0.002	0.038
PCB 105	0.663	0.060	7.341
PCB 118	4.239	0.673	26.70
PCB 138	30.48	9.151	101.5
PCB 153	44.41	13.38	147.4
PCB 156	135.2	36.5	500.5
PCB 180	10.20	1.301	79.91

ND indicates not detected

Table 7.2. Summary of PCB concentrations in northern gannet eggs (n=10) collected from the Bass Rock colony in 2006.

	Concentration (µg/g dry wt.)		
Analyte	**GeoMean**	**lower 95%CI**	**upper 95%CI**
Hg	2.085	1.788	2.431
As	0.411	0.356	0.474
Pb	0.018	0.003	0.124
Cd	0.021	0.002	0.233
Cu	3.660	3.405	3.933
Zn	37.97	35.17	41.00

ND indicates not detected.

7.3. Long-term trends in contaminant concentrations in gannet eggs

There has been a statistically significant decline in total PCB concentration in gannet eggs during the monitoring period of 1973-2006 ($F_{1,16}$=10.16, P=0.006; Figure 7.1). The annual geometric mean total PCB concentration in gannet eggs has previously ranged between 0.082 and 1.532 µg/g wet wt., and so the total PCB concentrations detected in gannet egg contents collected in 2006 are the lowest to date.

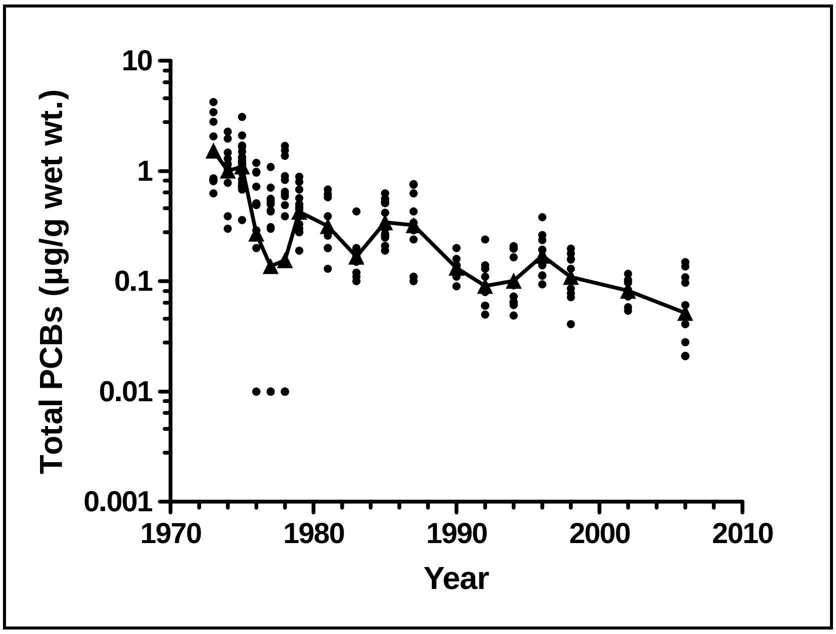

Figure 7.1. Total Polychlorinated Biphenyl (PCB) concentrations (µg/g wet weight) in northern gannet eggs collected between 1973 and 2006. Dots are concentrations in individual livers, and the triangles are geometric mean for each year with a connecting line

Sum Paris 10 and TEQ concentrations (Figure 7.2) have only been quantified for three years, (1998, 2002 and 2006) and so time-trend analysis is not possible for these measures of PCB contamination. Data to date suggest there may also be a downward trend over time.

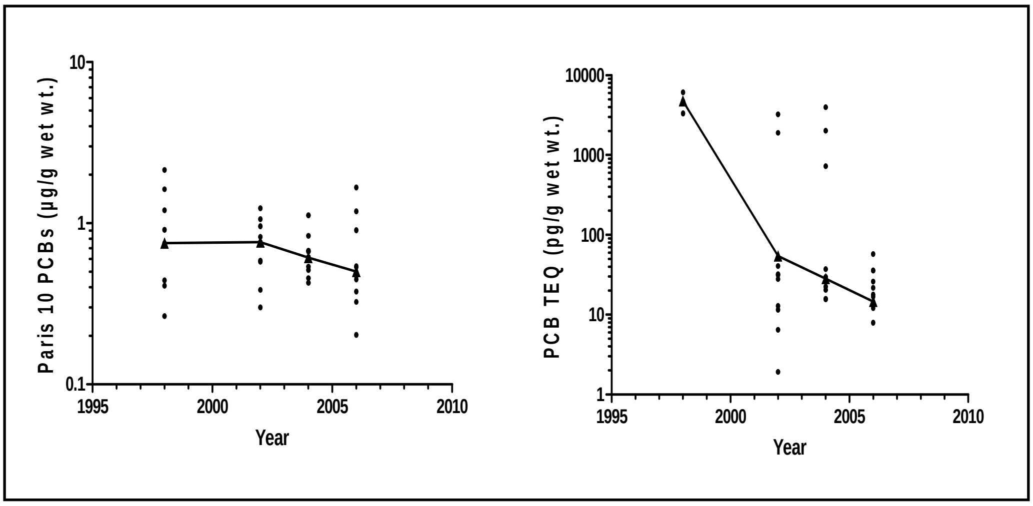

Figure 7.2. Paris 10 PCB and PCB-TEQ concentrations in northern gannet eggs collected between 1998 and 2006 from Bass Rock. Dots are concentrations in individual livers, triangles are geometric mean for each year with a connecting line

Mercury concentrations (Figure 7.3) have not significantly changed during the period 1973-2006 ($F_{1,16}$=0.08, P=0.775). During this monitoring period the annual geometric mean concentrations of mercury have ranged between 0.25 and 7.41 µg/g dw, and the level of mercury contamination quantified in eggs collected in 2006 is consistent with these observations. This is the first year that other metals have been quantified in egg contents and so time trend analysis has not been carried out for these analytes.

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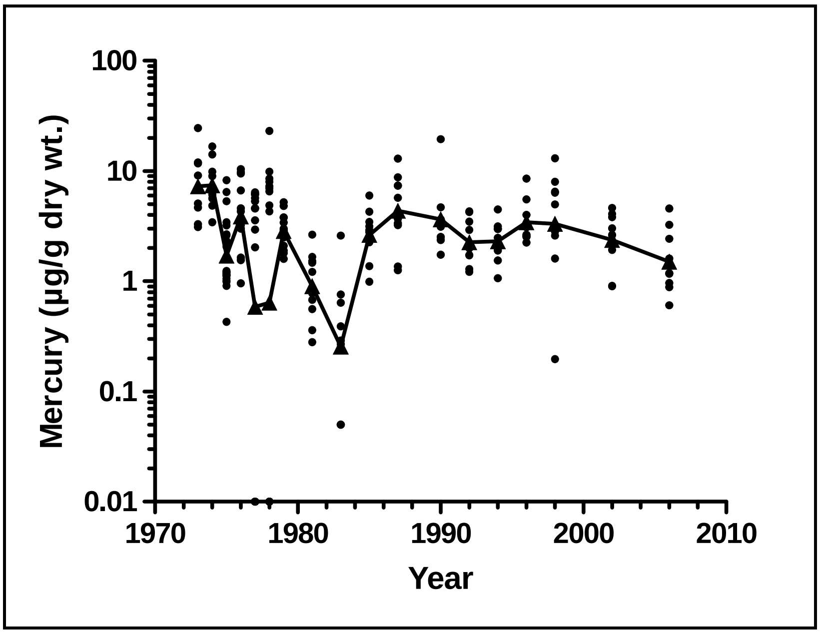

Figure 7.3 Mercury (µg/g dry wt) concentrations in northern gannet egg contents collected between 1973 and 2006 from Bass Rock. Dots are concentrations in individual livers, triangles are geometric mean for each year with a connecting line

8. Persistent Organic Pollutants and Metals in sea eagle (*Haliaeetus albicilla*) eggs

8.1. Introduction

Sea eagles were reintroduced to western Scotland between 1976 and 1985. They have had lower breeding success than individuals in some populations in continental Europe, although productivity has been similar to that of birds in Iceland. The relatively poor breeding success of the Scottish population is due to the number of total nest failures, and a few pairs persistently fail to rear young. One potential cause of breeding failure may be exposure to contaminants which the birds could acquire particularly from the marine component (various fish and seabirds) of their diet.

Some of the Scottish white-tailed eagles nest on inaccessible sea cliffs. This makes collection of samples difficult. One failed egg was collected in 2006 and a total of 13 eggs have been obtained and analysed during the course of this monitoring scheme.

8.2. Results

The wet weight contaminant concentrations in the egg collected in 2006 are given in Table 8.1.

The lipid weight equivalent concentrations of the DDE and total PCB wet wt concentrations in this egg were 130 µg/g and 469 µg/g, respectively. Lipid DDE concentrations in sea eagle eggs of 30-50 µg/g and 100-120 µg/g have been suggested as the LOECs for eggshell thickness and productivity, respectively. Complete reproductive failure has been associated with a DDE concentration of 900 µg/g lipid wt (Helander et al., 2002). Adverse effects on productivity due to PCBs appear to occur at lipid concentrations of about 300 µg/g in sea eagle eggs, although, because there is a strong association between PCB and DDE residues, there is some uncertainty about whether such effects are due to PCBs or DDE (Helander et al., 2002). The lipid DDE concentration in the egg collected from Mull exceeded the LOEC for eggshell thickness. Similarly the total PCB concentration in the sea eagle egg collected from Mull in 2005 was above the LOEC associated with adverse effects in sea eagles and within the range of 3.25 - 25 µg/g wet weight associated with decreased hatching success in various avian species (AMAP, 1998, Hoffman et al., 1996). The PCB TEQ concentration was within the range of NOECs and LOECs for reproduction that have been reported for various avian species (see section 3.2 and (AMAP, 1998). It is not certain that PCBs were a contributory cause of reproductive failure of this egg. However, the DDE concentration in this egg exceeds those previously suggested as LOECs for egg shell thickness. The egg had an egg shell index of 2.71, while there was not any embryo development apparent.

The mercury concentration in the egg collected in 2006 is within that range that is thought to be associated with impaired hatching in laboratory studies on some species, although the extent to which this effect level can be extrapolated to other species is uncertain as there appears to be considerable variation in sensitivity between species (Thompson, 1996).

Table 8.1. Concentrations of organochlorine insecticides and total PCBs (all in µg/g wet wt), TEQs (pg/g dry wt), mercury (µg/g dw) and the shell indices (SI) for the white-tailed sea eagle egg received in 2006. Lipid wt concentrations for organochlorines and PCBs can be calculated by multiplying the wet wt concentrations by the conversion factor (CF). Congener specific data for PCBs and TEQs are given in the Appendix

Egg Number	Year	Location	SI	CF	pp'-DDE	HEOD	Total PCB	PCB TEQ	Hg
Western Highlands									
E8921	2006	Mull	2.71	36.70	3.552	0.054	12.79	25.50	0.52

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10. Appendix

In the following tables, PCB congeners are identified using the nomenclature of Ballschmiter & Zell, (Ballschmiter and Zell, 1980) and the Toxic Equivalency Factors (TEFs) are from Ahlborg *et al*., (Van den Berg et al., 1998, Ahlborg et al., 1994) and Van de Berg *et al*., (Van den Berg et al., 1998, Ahlborg et al., 1994). Toxic Equivalent (TEQ) concentrations for individual congeners are calculated as the product of the congener concentration and the congener-specific TEF value. Non-detected values for specific congeners are assigned a concentration value of zero when calculating the TEQ; sum TEQ concentrations are the sum of the congener specific concentrations. Lipid wt concentrations for PCB congeners and TEQs can be calculated by multiplying the wet wt concentrations by the conversion factor (CF).

Table 10.1 Anticoagulant rodenticide concentrations in the livers of barn owls received in 2006.

	Concentration of rodenticide (µg/g wet wt.)							
	SGARs				Other anticoagulant rodenticides			
Bird	**Difen**	**Brom**	**Brod**	**Floc**	**Warf**	**Coum**	**Chloro**	**Diphac**
15040	ND	ND	ND	ND	ND	ND	ND	ND
15041	ND	0.018	ND	ND	ND	ND	ND	ND
15050	ND	ND	ND	ND	ND	ND	ND	ND
15051	ND	ND	ND	ND	ND	ND	ND	ND
15081	ND	ND	ND	ND	ND	ND	ND	ND
15085	0.089	0.052	0.014	ND	ND	ND	ND	ND
15087	ND	ND	ND	ND	ND	ND	ND	ND
15090	0.005	ND	ND	ND	ND	ND	ND	ND
15116	ND	0.017	ND	ND	ND	ND	ND	ND
15135	ND	ND	ND	ND	ND	ND	ND	ND
15136	ND	ND	ND	ND	ND	ND	ND	ND
15139	ND	ND	ND	ND	ND	ND	ND	ND
15145	ND	ND	ND	ND	ND	ND	ND	ND
15146	ND	ND	ND	ND	ND	ND	ND	ND
15252	ND	ND	ND	ND	ND	ND	ND	ND
15254	ND	0.022	ND	ND	ND	ND	ND	ND
15257	ND	ND	ND	ND	ND	ND	ND	ND
15265	0.008	0.019	ND	ND	ND	ND	ND	ND
15284	ND	0.396	0.013	ND	ND	ND	ND	ND
15287	0.089	ND	ND	ND	ND	ND	ND	ND
15290	ND	0.016	ND	ND	ND	ND	ND	ND
15345	0.007	ND	ND	ND	ND	ND	ND	ND
15350	ND	0.058	ND	ND	ND	ND	ND	ND
15368	0.103	0.063	0.03	ND	ND	ND	ND	ND
15375	ND	ND	ND	ND	ND	ND	ND	ND
15378	0.005	ND	ND	ND	ND	ND	0.004	ND
15383	ND	ND	ND	ND	ND	ND	ND	ND
15389	ND	ND	ND	ND	ND	ND	ND	ND
15390	ND	0.19	0.017	ND	ND	ND	ND	ND
15391	0.003	ND	ND	ND	ND	ND	ND	ND
15394	ND	ND	ND	ND	ND	ND	ND	ND
15407	ND	ND	ND	ND	ND	ND	ND	ND
15414	ND	ND	ND	ND	ND	ND	ND	ND
15418	ND	ND	ND	ND	ND	ND	ND	ND
15419	ND	0.008	ND	ND	ND	ND	0.009	ND
15424	ND	ND	ND	ND	ND	ND	ND	ND
15425	ND	ND	ND	ND	ND	ND	ND	ND
15426	ND	ND	ND	ND	ND	ND	ND	ND
15429	0.127	ND	ND	ND	ND	ND	ND	ND
15434	ND	ND	0.911	ND	ND	0.033	ND	ND
15436	ND	ND	0.004	ND	ND	ND	ND	ND
15439	ND	ND	ND	ND	ND	ND	ND	ND
15481	0.063	0.017	0.017	ND	ND	ND	ND	ND
15483	ND	0.01	0.005	ND	ND	ND	ND	ND
15485	ND	0.008	ND	ND	ND	ND	ND	ND
15492	ND	0.009	ND	ND	ND	ND	ND	ND
15494	0.005	0.005	ND	ND	ND	ND	ND	ND

Table 10.1 contd.

	Concentration of rodenticide (µg/g wet wt.)							
	SGARs				Other anticoagulant rodenticdes			
Bird	**Difen**	**Brom**	**Brod**	**Floc**	**Warf**	**Coum**	**Chloro**	**Diphac**
15506	0.005	ND	ND	ND	ND	ND	ND	ND
15509	0.004	ND	ND	ND	ND	ND	ND	ND
15512	0.017	0.027	0.004	ND	ND	ND	ND	ND
15531	ND	0.052	ND	ND	ND	ND	ND	ND
15551	0.026	ND	ND	ND	ND	ND	ND	ND
15553	0.005	ND	ND	ND	ND	ND	ND	ND
15555	ND	0.008	ND	ND	ND	ND	ND	ND
15618	ND	0.004	ND	ND	ND	ND	ND	ND
15620	0.005	0.007	0.004	ND	ND	ND	ND	ND
15655	0.045	ND	ND	ND	ND	ND	ND	ND
15707	0.019	0.059	ND	ND	ND	ND	ND	ND
15709	0.003	0.040	ND	ND	ND	ND	ND	ND
15711	0.033	0.015	0.006	ND	ND	ND	ND	ND
15716	ND	0.006	ND	ND	ND	ND	ND	ND
15718	ND	0.005	ND	ND	ND	ND	ND	ND

ND = Non-Detected; Difen – difenacoum; Brom – bromadiolone; Brod – brodifacoum; Floc – flocoumafen; Warf – warfarin; Coum – coumatetralyl; Chloro – chlorophacinone; Diph – diphacinone.

Table 10.2 Concentrations of anticoagulant rodenticides in the livers of kestrels received in 2006.

	Concentration of rodenticide (µg/g wet wt.)							
	SGARs				Other anticoagulant rodenticdes			
Bird	**Difen**	**Brom**	**Brod**	**Floc**	**Warf**	**Coum**	**Chloro**	**Diphac**
15023	1.074	0.232	0.009	ND	ND	ND	ND	ND
15055	ND	0.056	0.012	ND	ND	ND	ND	ND
15077	0.005	0.515	ND	ND	ND	ND	ND	ND
15080	ND	0.175	ND	ND	ND	ND	ND	ND
15097	0.299	0.069	ND	ND	ND	ND	ND	ND
15101	0.184	0.010	ND	ND	ND	ND	ND	ND
15160	ND	ND	ND	ND	ND	ND	ND	ND
15195	0.056	0.067	0.020	ND	ND	ND	ND	ND
15245	ND	ND	ND	ND	ND	ND	ND	ND
15288	0.036	0.127	0.115	ND	ND	ND	ND	ND
15303	0.015	0.188	ND	ND	ND	ND	ND	ND
15344	0.005	ND	ND	ND	ND	ND	ND	ND
15364	ND	ND	ND	ND	ND	ND	ND	ND
15560	0.035	0.019	0.079	ND	ND	ND	ND	ND
15141	ND	ND	0.010	ND	ND	ND	0.029	ND
15167	0.006	ND	ND	ND	ND	ND	ND	ND
15180	ND	ND	ND	ND	ND	ND	ND	ND
15162	0.012	0.039	ND	ND	ND	ND	ND	ND

ND = Non-Detected; Difen – difenacoum; Brom – bromadiolone; Brod – brodifacoum; Floc – flocoumafen; Warf – warfarin; Coum – coumatetralyl; Chloro – chlorophacinone; Diph – diphacinone.

Table 10.3. Provenance data and fat score juvenile (in first year) and adult (older than first year) sparrowhawks and herons received during 2006. Fat score is a non-linear categorization to assess the amount of fat in the carcass, where 0 indicates that no fat deposits were apparent while birds with a fat score of 5 have abundant amounts of fat within the body. Typically birds that are in a starved state have a fat score of 0 or 1.

Bird No.	Year Found	Vice-County	Age	Sex	Fat Score
Eurasian sparrowhawk *Accipiter nisus*					
15062	2006	South Hampshire	Juvenile	Female	4
15064	2006	Northamptonshire	Juvenile	Female	2
15089	2006	Cheshire	Adult	Female	4
15106	2006	Staffordshire	Juvenile	Female	3
15107	2006	Surrey	Juvenile	Male	0
15110	2006	South Northumberland	Juvenile	Male	2
15129	2006	South Devon	Adult	Male	0
15163	2006	Westmorland & N.	Adult	Male	3
15188	2006	Huntingdonshire	Juvenile	Female	3
15201	2006	Leicestershire (&	Adult	Female	3
15215	2006	Shropshire (Salop)	Juvenile	Female	4
15234	2006	Cambridgeshire	Juvenile	Female	0
15248	2006	Huntingdonshire	Juvenile	Female	3
15285	2006	Surrey	Adult	Female	0
15291	2006	*	Juvenile	Male	2
15294	2006	East Norfolk	Adult	Male	0
15295	2006	South Hampshire	Juvenile	Female	0
15299	2006	Northamptonshire	Adult	Female	3
15347	2006	Cardiganshire	Adult	Female	1
15349	2006	Cambridgeshire	Juvenile	Male	0
15356	2006	Cambridgeshire	Juvenile	Male	2
15365	2006	West Norfolk	Juvenile	Female	2
15376	2006	East Norfolk	Juvenile	Female	1
15384	2006	West Norfolk	Juvenile	Male	1
15395	2006	South Lancashire	Juvenile	Male	2
15410	2006	Cardiganshire	Juvenile	Male	0
15416	2006	South Aberdeenshire	Juvenile	Female	0
15420	2006	South Lancashire	*	Female	1
15423	2003	Isle of Man	Juvenile	Female	0
15427	2006	Northamptonshire	Juvenile	Female	0
Grey heron *Ardea cinerea*					
15054	2006	North Somerset	Juvenile	Female	2
15108	2006	East Suffolk	Juvenile	Male	0
15293	2006	Cambridgeshire	Adult	Female	0
15296	2006	East Norfolk	Adult	Male	0

Table 10.4. Congener specific TEFs and PCB congener concentrations (µg/g wet wt) in the livers of sparrowhawks and herons received in 2006

	TEF	Liver PCB congener concentration in birds (µg/g wet wt)											
		15054	**15062**	**15064**	**15089**	**15106**	**15107**	**15108**	**15110**	**15129**	**15163**	**15188**	**15201**
CF		42.32	26.52	28.53	26.65	17.99	36.96	45.45	30.92	42.64	37.00	26.79	15.74
8		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28		ND	ND	ND	ND	ND	0.004	0.003	0.007	0.002	ND	ND	0.002
29		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
31		ND	ND	ND	ND	ND	ND	ND	0.002	ND	ND	ND	ND
52		ND	0.001	ND	0.001	0.002	0.006	ND	0.009	0.004	ND	ND	0.004
77	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
101		ND	0.010	0.029	0.065	0.032	0.195	0.025	0.057	0.072	0.006	0.016	0.123
105	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
114	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
118	0.00001	0.001	0.006	0.005	0.007	0.017	0.177	0.040	0.108	0.107	0.010	0.009	0.086
123	0.00001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
126	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
128		ND	0.003	0.003	0.004	0.011	0.089	0.011	0.040	0.057	0.005	0.006	0.342
138		0.001	0.014	0.010	0.014	0.044	0.441	0.074	0.235	0.292	0.022	0.022	1.348
141		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
149		ND	0.002	0.002	0.004	0.008	0.050	0.005	0.016	0.037	0.002	0.005	ND
153		0.002	0.037	0.028	0.039	0.096	0.949	0.156	0.524	0.688	0.065	0.058	1.140
156	0.0001	ND	0.004	0.004	0.005	0.012	0.123	0.014	0.070	0.098	0.012	0.007	0.203
157	0.0001	ND	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
163		0.001	0.009	0.006	0.011	0.028	ND	0.026	0.090	0.229	0.016	0.017	0.182
167	0.00001	ND	0.001	0.001	0.001	0.002	0.034	0.004	0.031	0.030	0.004	0.002	0.013
169	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
170		ND	0.006	0.006	0.008	0.017	0.196	0.024	0.108	0.130	0.018	0.006	0.308
171		ND	0.001	0.001	0.002	0.004	0.044	0.006	0.018	0.019	0.003	0.002	0.065
180		0.001	0.018	0.017	0.031	0.061	0.655	0.090	0.354	0.451	0.067	0.029	0.716
183		0.000	0.005	0.004	0.006	0.013	0.137	0.023	0.063	0.077	0.011	0.006	0.134
187		0.002	0.029	0.026	0.047	0.093	0.638	0.101	0.181	0.564	0.055	0.059	0.384
189	0.00001	ND	ND	ND	ND	ND	0.015	ND	0.011	0.012	0.002	ND	0.015
194		ND	0.005	0.004	0.008	0.012	0.167	0.019	0.062	0.099	0.018	0.007	0.100
199		ND	ND	ND	ND	ND	0.013	ND	ND	0.003	ND	ND	ND
201		ND	0.007	0.008	0.014	0.024	0.222	0.031	0.061	0.155	0.023	0.013	0.106
205		ND	ND	ND	ND	ND	0.008	ND	0.006	0.006	ND	ND	0.004
206		ND	ND	0.002	0.003	0.004	0.065	0.009	0.024	0.035	0.005	0.003	0.021
209		ND	0.002	0.001	0.004	0.004	0.021	0.007	0.022	0.028	0.004	0.003	0.004
	Sum	0.009	0.161	0.158	0.276	0.485	4.248	0.668	2.097	3.197	0.347	0.269	5.301
	Total PCBs	0.022	0.33	0.334	0.625	0.942	8.602	1.307	4.532	6.584	0.654	0.574	9.322
	Paris 10	0.006	0.090	0.094	0.163	0.264	2.549	0.401	1.365	1.715	0.183	0.141	3.623

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.4 cont:

	TEF	Liver PCB congener concentration in birds (µg/g wet wt)											
		15215	**15234**	**15248**	**15285**	**15291**	**15293**	**15294**	**15295**	**15296**	**15299**	**15347**	**15349**
CF		30.36	30.26	20.89	42.48	28.71	32.67	39.07	42.27	44.47	31.81	47.39	34.81
8		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28		ND	0.004	ND	ND	ND	0.004	ND	0.002	0.006	ND	ND	0.002
29		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
31		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
52		ND	0.010	ND	0.006	ND	ND	0.003	0.001	ND	ND	ND	0.012
77	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
101		0.007	0.167	0.025	4.142	0.009	0.028	5.589	0.035	0.011	0.010	0.009	0.638
105	0.0001	ND	ND	ND	ND	ND	0.049	ND	ND	0.019	ND	ND	ND
114	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
118	0.00001	0.006	0.087	0.008	0.143	0.014	0.210	0.185	0.037	0.084	0.006	0.012	0.162
123	0.00001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
126	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
128		0.004	0.057	0.004	0.075	0.006	0.028	0.089	0.014	0.018	0.003	0.008	0.060
138		0.019	0.241	0.015	0.338	0.030	0.224	0.404	0.073	0.128	0.010	0.042	0.272
141		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
149		0.003	0.057	0.002	0.039	0.004	0.003	0.027	0.007	0.002	0.002	0.004	0.022
153		0.039	0.536	0.040	0.908	0.068	0.273	1.000	0.229	0.252	0.026	0.098	0.894
156	0.0001	0.004	0.068	0.005	0.112	0.008	0.047	0.160	0.025	0.027	0.004	0.013	0.152
157	0.0001	ND	0.013	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
163		0.012	0.196	0.010	0.229	0.019	0.040	0.259	0.040	0.049	0.008	0.025	0.206
167	0.00001	0.001	0.013	0.001	0.029	0.002	0.016	0.039	0.007	0.010	0.001	0.003	0.030
169	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
170		0.006	0.118	0.007	0.147	0.012	0.040	0.222	0.039	0.047	0.005	0.020	0.230
171		0.001	0.020	0.001	0.025	0.002	0.009	0.032	0.006	0.010	0.001	0.004	0.034
180		0.016	0.380	0.021	0.586	0.034	0.106	0.839	0.141	0.168	0.016	0.077	0.900
183		0.004	0.073	0.005	0.094	0.008	0.026	0.123	0.025	0.034	0.004	0.014	0.137
187		0.033	0.700	0.039	0.790	0.046	0.076	0.818	0.143	0.112	0.032	0.092	0.973
189	0.00001	ND	0.007	ND	0.014	ND	0.002	0.018	0.003	0.003	ND	0.002	0.018
194		0.004	0.071	0.005	0.119	0.008	0.022	0.185	0.030	0.033	0.005	0.020	0.240
199		ND	ND	ND	0.003	ND	ND	0.006	ND	ND	ND	ND	0.003
201		0.007	0.137	0.010	0.218	0.012	0.029	0.259	0.041	0.035	0.012	0.029	0.320
205		ND	0.004	ND	0.008	ND	ND	0.009	0.002	0.002	ND	ND	0.012
206		ND	0.027	0.002	0.042	0.003	0.012	0.060	0.011	0.011	0.003	0.006	0.077
209		0.002	0.021	0.002	0.027	0.003	0.003	0.045	0.008	0.004	0.002	0.005	0.030
	Sum	0.009	0.168	3.007	0.200	8.091	0.288	1.247	10.37	0.919	1.067	0.150	0.483
	Total PCBs	0.348	5.834	0.764	17.12	0.58	2.185	22.82	1.735	2.085	0.301	0.875	10.57
	Paris 10	0.090	1.492	0.114	6.235	0.163	0.942	8.179	0.544	0.696	0.072	0.251	3.033

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.4 cont:

	TEF	Liver PCB congener concentration in birds (µg/g wet wt)									
		15356	**15365**	**15376**	**15384**	**15395**	**15410**	**15416**	**15420**	**15423**	**15427**
CF		39.42	34.70	45.35	38.67	34.54	37.74	37.34	41.28	43.30	23.59
8		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28		ND	ND	ND	ND	ND	0.001	0.001	ND	0.001	ND
29		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
31		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
52		ND	ND	ND	ND	ND	0.004	0.001	0.001	0.001	ND
77	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
101		0.003	ND	0.028	0.003	0.013	0.021	0.214	0.120	0.211	0.004
105	0.0001	ND	ND	ND	ND	ND	0.011	0.006	ND	ND	ND
114	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
118	0.00001	0.001	0.002	0.003	0.005	0.007	0.050	0.035	0.029	0.063	0.002
123	0.00001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
126	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
128		ND	ND	0.002	0.002	0.002	0.013	0.013	0.018	0.027	0.001
138		0.002	0.002	0.008	0.008	0.010	0.065	0.082	0.054	0.167	0.005
141		ND	ND	ND	ND	ND	0.003	ND	ND	ND	ND
149		ND	ND	ND	ND	ND	0.006	0.006	0.005	0.007	ND
153		0.006	0.006	0.020	0.021	0.023	0.134	0.208	0.189	0.528	0.011
156	0.0001	0.001	ND	0.002	0.003	0.003	0.020	0.024	0.026	0.058	0.001
157	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
163		0.002	0.001	0.005	0.005	0.006	0.027	0.037	0.046	0.096	0.002
167	0.00001	ND	ND	ND	0.001	0.001	0.007	0.007	0.005	0.013	ND
169	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
170		0.001	0.001	0.003	0.004	0.004	0.024	0.037	0.047	0.095	0.002
171		ND	ND	ND	ND	0.001	0.005	0.007	0.009	0.016	ND
180		0.004	0.004	0.010	0.013	0.013	0.077	0.135	0.162	0.413	0.007
183		0.001	0.001	0.002	0.003	0.003	0.017	0.025	0.029	0.064	0.001
187		0.006	0.003	0.017	0.014	0.016	0.062	0.116	0.149	0.360	0.007
189	0.00001	ND	ND	ND	ND	ND	ND	0.003	0.003	0.009	ND
194		ND	ND	ND	0.004	0.003	0.021	0.030	0.035	0.080	ND
199		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
201		ND	ND	0.004	0.005	0.005	0.027	0.034	0.049	0.119	0.002
205		ND	ND	ND	ND	ND	ND	ND	0.001	0.004	ND
206		ND	ND	ND	ND	ND	0.007	0.008	0.009	0.027	ND
209		ND	ND	0.002	ND	0.001	0.005	0.006	0.004	0.018	ND
	Sum	0.009	0.027	0.019	0.105	0.089	0.110	0.609	1.034	0.993	2.378
	Total PCBs	0.070	0.047	0.223	0.177	0.243	1.095	2.068	1.982	4.299	0.099
	Paris 10	0.017	0.014	0.070	0.053	0.068	0.384	0.705	0.581	1.442	0.030

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.5. Congener specific and sum TEQ concentrations (pg/g wet wt) in the livers of sparrowhawks and herons received in 2006

	TEQ concentration in livers of birds (pg/g wet wt)											
	15054	**15062**	**15064**	**15089**	**15106**	**15107**	**15108**	**15110**	**15129**	**15163**	**15188**	**15201**
CF	42.32	26.52	28.53	26.65	17.99	36.96	45.45	30.92	42.64	37.00	26.79	15.74
77	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
105	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
118	0.008	0.065	0.055	0.069	0.173	1.766	0.397	1.079	1.071	0.099	0.093	0.865
123	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
156	ND	0.439	0.359	0.548	1.186	12.33	1.371	6.978	9.829	1.215	0.679	20.32
157	ND	0.103	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
167	ND	0.010	0.007	0.011	0.024	0.337	0.044	0.307	0.297	0.035	0.016	0.128
169	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
189	ND	ND	ND	ND	ND	0.152	ND	0.113	0.118	0.018	ND	0.154
Sum	0.008	0.616	0.420	0.628	1.383	14.59	1.811	8.476	11.32	1.368	0.788	21.47

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.5: continued

	TEQ concentration in livers of birds (pg/g wet wt)											
	15215	**15234**	**15248**	**15285**	**15291**	**15293**	**15294**	**15295**	**15296**	**15299**	**15347**	**15349**
CF	30.36	30.26	20.89	42.48	28.71	32.67	39.07	42.27	44.47	31.81	47.39	34.81
77	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
105	ND	ND	ND	ND	ND	4.915	ND	ND	1.942	ND	ND	ND
114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
118	0.057	0.869	0.077	1.426	0.136	2.102	1.845	0.374	0.841	0.056	0.117	1.623
123	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
156	0.384	6.805	0.474	11.20	0.816	4.747	15.96	2.493	2.729	0.374	1.305	15.20
157	ND	1.313	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
167	0.006	0.133	0.010	0.289	0.022	0.160	0.394	0.068	0.104	0.011	0.028	0.300
169	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
189	ND	0.074	ND	0.137	ND	0.025	0.183	0.033	0.026	ND	0.017	0.176
Sum	0.447	9.194	0.561	13.05	0.974	11.95	18.38	2.969	5.641	0.441	1.467	17.30

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.5 continued

	TEQ concentration in livers of birds (pg/g wet wt)									
	15356	**15365**	**15376**	**15384**	**15395**	**15410**	**15416**	**15420**	**15423**	**15427**
CF	39.42	34.70	45.35	38.67	34.54	37.74	37.34	41.28	43.30	23.59
77	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
105	ND	ND	ND	ND	ND	1.098	0.582	ND	ND	ND
114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
118	0.012	0.018	0.033	0.049	0.066	0.501	0.351	0.290	0.630	0.019
123	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
156	0.078	ND	0.213	0.293	0.295	1.955	2.357	2.634	5.795	0.118
157	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
167	ND	ND	ND	0.008	0.008	0.073	0.069	0.051	0.128	ND
169	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
189	ND	ND	ND	ND	ND	ND	0.035	0.034	0.092	ND
Sum	0.090	0.018	0.246	0.351	0.369	3.626	3.395	3.009	6.645	0.137

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table10.6 Organochlorine insecticide concentrations (µg/g wet wt) in the livers of sparrowhawks and herons received in 2006

		Organochlorine Insecticide Concentrations (µg/g wet wt)						
Bird No.	***CF***	**HCB**	**a-HCCH**	**g-HCCH**	**HEOD**	**DDE**	**DDT**	**TDE**
Sparrowhawk								
15062	26.52	0.068	ND	ND	0.033	1.068	ND	0.027
15064	28.53	0.028	ND	ND	0.015	0.272	ND	0.005
15089	26.65	0.012	ND	ND	0.051	0.213	ND	ND
15106	17.99	0.013	ND	ND	0.109	0.336	ND	ND
15107	36.96	0.076	ND	ND	0.640	79.327	ND	5.514
15110	30.92	0.057	ND	ND	0.466	3.733	ND	0.807
15129	42.64	0.065	ND	ND	0.497	12.641	ND	0.016
15163	37.00	0.008	ND	ND	0.022	0.328	ND	ND
15188	26.79	0.008	ND	ND	0.155	4.543	ND	0.029
15201	15.74	0.024	ND	ND	0.074	0.831	ND	0.010
15215	30.36	0.006	ND	ND	0.040	0.370	ND	ND
15234	30.26	0.058	ND	ND	1.199	69.696	ND	0.938
15248	20.89	0.157	ND	ND	0.050	0.457	ND	ND
15285	42.48	0.052	ND	ND	0.287	13.591	ND	0.027
15291	28.71	0.008	ND	ND	0.019	0.502	ND	ND
15294	39.07	0.023	ND	ND	0.232	19.753	ND	0.011
15295	42.27	0.018	ND	ND	0.067	1.706	ND	0.006
15299	31.81	0.003	ND	ND	0.020	0.103	ND	ND
15347	47.39	0.003	ND	ND	0.039	0.747	ND	ND
15349	34.81	0.012	ND	ND	0.299	20.175	ND	0.038
15356	39.42	0.002	ND	ND	0.007	0.103	ND	ND
15365	34.70	ND	ND	ND	0.010	0.074	ND	ND
15376	45.35	0.002	ND	ND	0.014	0.217	ND	ND
15384	38.67	0.002	ND	ND	0.015	0.372	ND	ND
15395	34.54	0.002	ND	ND	0.015	0.151	ND	ND
15410	37.74	0.005	ND	ND	0.019	0.389	ND	ND
15416	37.34	0.010	ND	ND	0.079	13.849	ND	ND
15420	41.28	0.003	ND	ND	0.308	1.860	ND	ND
15423	43.30	0.011	ND	ND	0.226	2.358	ND	ND
15427	23.59	0.001	ND	ND	0.037	0.224	ND	ND
Heron								
15054	42.32	ND	ND	ND	0.005	ND	ND	ND
15108	45.45	0.008	ND	ND	1.061	1.180	ND	ND
15293	32.67	0.020	ND	ND	0.142	1.042	ND	ND
15296	44.47	0.013	ND	ND	0.054	0.441	ND	ND

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10. 7. Inorganic element concentrations (µg/g dry wt) in the livers of sparrowhawks and herons received in 2006.

	Inorganic elements concentrations in sparrowhawk livers (µg/g dry wt)											
Bird No.	**15062**	**15064**	**15089**	**15106**	**15107**	**15110**	**15129**	**15163**	**15188**	**15201**	**15215**	**15234**
% moisture	67.87	68.67	68.77	67.34	70.77	68.13	71.81	66.89	68.92	68.21	68.18	76.07
Aluminum$^{(27)}$	6.590	3.140	2.350	2.240	1.570	1.020	1.340	2.800	2.420	4.160	1.880	2.230
Manganese	7.860	5.700	7.610	8.460	13.10	9.340	17.00	8.360	6.710	7.710	7.630	16.00
Iron$^{(57)}$	808.0	1110	1100	660.0	787.0	1430	988.0	1140	941.0	1250	1070	2940
Nickel$^{(58)}$	<0.003	<0.003	<0.003	<0.003	<0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
Cobalt	0.080	0.091	0.096	0.066	0.108	0.095	0.150	0.068	0.063	0.045	0.060	0.084
Nickel$^{(60)}$	<0.003	<0.003	<0.003	<0.003	<0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005
Copper	11.70	12.30	12.20	16.10	24.50	19.40	28.20	16.40	12.80	11.60	13.20	45.80
Zinc	63.70	67.20	48.80	78.90	123.0	76.20	149.0	60.20	64.70	70.50	69.00	342.0
Arsenic	0.129	0.038	0.061	0.038	0.047	0.063	0.092	0.053	0.067	0.047	0.064	0.068
Selenium	5.140	2.810	5.010	3.210	3.930	5.260	6.710	3.290	5.730	2.460	6.530	7.000
Molybdenum	1.490	1.610	1.710	1.950	2.250	1.820	2.760	1.890	1.510	1.150	2.030	1.230
Cadmium	0.403	0.148	0.423	0.637	0.440	0.432	0.764	0.464	0.509	0.317	0.506	0.496
Tin	<0.003	0.014	<0.003	<0.003	<0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.022
Lead	0.144	0.323	0.307	1.450	0.093	<0.003	<0.003	0.082	0.011	12.700	0.150	0.590
Mercury$^{(202)}$	1.760	0.863	2.320	1.660	3.490	9.110	7.240	5.500	3.080	1.000	4.290	3.820

Bird No.	**15248**	**15285**	**15291**	**15294**	**15295**	**15299**	**15347**	**15349**	**15356**	**15365**	**15376**	**15384**
% moisture	*66.25*	*71.62*	*67.98*	*75.94*	*73.35*	*66.72*	*69.41*	*73.39*	*69.38*	*70.28*	*69.98*	*71.32*
Aluminum$^{(27)}$	0.984	2.070	1.950	1.290	2.000	1.110	2.170	<1.05	3.830	2.000	<0.188	1.790
Manganese	7.230	18.00	6.510	13.30	11.30	7.170	9.510	15.20	6.600	7.380	9.590	10.10
Iron$^{(57)}$	988.0	1860	947.0	1020	976.0	1040	1140	3690	819.0	2410	823.0	622.0
Nickel$^{(58)}$	<0.003	<0.003	<0.003	<0.013	0.102	0.236	0.131	0.386	0.074	0.089	0.062	0.035
Cobalt	0.055	0.170	0.077	0.106	0.100	0.143	0.084	0.277	0.056	0.052	0.070	0.078
Nickel$^{(60)}$	<0.003	<0.003	<0.003	<0.013	0.027	0.174	0.084	0.221	0.027	0.025	0.029	0.027
Copper	9.32	42.10	13.20	21.40	14.80	11.00	9.90	45.90	34.20	11.00	11.70	18.50
Zinc	51.50	163.000	63.00	163.0	141.0	69.00	68.70	291.0	74.10	82.50	99.30	90.60
Arsenic	0.030	0.041	0.027	0.050	0.336	0.028	0.041	0.028	0.022	0.033	0.038	0.035
Selenium	3.280	4.760	4.850	5.040	3.570	3.900	3.330	4.570	3.350	2.960	5.570	3.920
Molybdenum	1.530	2.680	2.340	1.550	2.620	2.290	2.070	1.750	2.080	2.040	1.870	2.210
Cadmium	0.341	1.800	0.384	0.965	0.247	0.235	0.670	0.894	0.061	0.083	0.250	0.122
Tin	0.003	<0.003	<0.003	<0.013	<0.003	<0.003	<0.003	<0.018	<0.003	<0.003	<0.003	<0.004
Lead	0.315	0.250	<0.003	<0.013	2.110	0.101	<0.003	<0.018	<0.003	<0.003	0.066	0.157
Mercury$^{(202)}$	1.150	6.880	3.680	4.630	2.530	1.530	1.200	4.120	0.162	0.372	0.903	0.593

Table 10.7 continued

	Inorganic elements concentrations in bird livers									
	Sparrowhawk						**Heron**			
Bird No.	**15395**	**15410**	**15416**	**15420**	**15423**	**15427**	**15054**	**15108**	**15293**	**15296**
% moisture	*68.06*	*73.94*	*74.96*	*72.49*	*73.90*	*68.71*	*72.52*	*74.66*	*71.98*	*70.45*
Aluminum(27)	<0.199	3.050	2.000	1.590	0.770	1.300	4.600	21.700	8.130	4.170
Manganese	8.110	7.480	9.160	14.60	15.90	6.050	9.760	18.10	10.50	12.40
Iron(57)	877.0	744.0	1020	817.0	1160	753.0	2300	14000	4260	3010
Nickel(58)	0.093	0.066	0.076	<0.004	0.071	0.014	0.058	14.700	0.054	0.067
Cobalt	0.068	0.087	0.070	0.074	0.090	0.061	0.434	0.342	0.145	0.187
Nickel(60)	0.029	0.040	0.019	0.017	0.034	0.036	0.100	0.019	0.054	0.009
Copper	12.60	23.20	31.00	23.60	28.30	11.30	22.40	93.30	20.00	533.0
Zinc	69.20	142.0	138.0	147.0	214.0	62.70	80.80	425.0	321.0	169.0
Arsenic	0.027	0.053	0.063	0.036	0.820	0.039	0.240	0.507	0.227	0.143
Selenium	3.120	3.380	4.360	2.630	3.870	2.850	7.610	5.460	6.240	48.30
Molybdenum	1.990	2.010	2.670	2.560	2.070	2.160	3.280	9.640	4.420	4.040
Cadmium	0.309	0.154	0.261	0.959	0.833	0.128	1.340	3.080	2.430	2.080
Tin	<0.003	0.008	<0.004	0.425	<0.004	<0.003	0.005	0.030	0.024	<0.003
Lead	0.145	0.892	0.073	0.558	0.754	<0.003	0.050	5.460	0.691	0.307
Mercury(202)	0.569	1.570	3.280	0.190	6.490	0.324	1.760	8.500	9.200	5.630

Table 10.8. Provenance, lipid & moisture content, and biometric data for for merlin eggs received in 2006. CF = conversion factor for conversion of data from a wet weight to a lipid weight basis or wet weight to a dry weight basis. L = length of shell, B = breadth of shell, SI = Egg shell thickness index, and Dev indicates whether embryo development was evident in the egg.

			Lipid		Moisture		Biometrics			
Egg No/	**Year**	**Vice-County**	**%**	**CF**	**%**	**CF**	**L (cm)**	**B (cm)**	**SI**	**Dev.**
South Scotland										
E8896	2006	Berwickshire	3.68	27.2	78.9	4.68			*	None
E8897	2006	Berwickshire	5.32	18.8	81.1	5.28	3.97	3.24	1.38	None
E8898	2006	Berwickshire	5.99	16.7	80.4	5.10	3.97	3.03	1.26	Yes
Orkney										
E8892	2006	Orkney	4.60	21.8	82.2	5.62	3.96	3.21	1.15	Yes
E8893	2006	Orkney	4.92	20.3	83.7	6.14	4.07	3.08	1.25	None
E8894	2006	Orkney	4.79	20.9	81.9	5.51	4.03	3.19	1.38	None
E8895	2006	Orkney	6.05	16.5	78.1	4.56	4.62	2.96	1.19	None
Western Isles										
E8925	2006	Isle of Rum	5.33	18.8	89.2	9.24	*	*	*	None
E8926	2006	Isle of Rum	20.1	4.98	57.0	2.32	*	*	*	None
North East England										
E8164	2003	N-E Yorkshire	6.80	14.7	71.2	3.47	7.46	5.88	1.16	None
E8923	2006	N-E Yorkshire	5.06	19.8	80.5	5.13	4.25	3.01	1.36	None
E8924	2006	N-E Yorkshire	6.63	15.1	79.6	4.91	4.10	3.24	1.25	None
E8937	2006	N-E Yorkshire	8.70	11.5	82.0	5.55	4.17	3.07	1.28	Yes
North West England										
E8891	2006	M-W Yorkshire	5.90	16.9	80.8	5.21	3.70	3.10	1.18	None

Table 10.9. Congener specific TEFs and PCB congener concentrations (µg/g wet wt) for merlin eggs received in 2006

	TEF	PCB congener concentration in merlin eggs						
		E8164	**E8891**	**E8892**	**E8893**	**E8894**	**E8895**	**E8896**
CF		*14.71*	*16.95*	*21.76*	*20.34*	*20.86*	*16.52*	*27.17*
8		0.001	ND	ND	ND	ND	ND	ND
18		0.001	ND	ND	ND	ND	ND	ND
28		0.002	0.001	ND	ND	0.001	0.001	ND
29		ND	ND	ND	ND	ND	ND	0.001
31		ND	ND	ND	ND	ND	ND	ND
52		ND	ND	ND	ND	ND	ND	ND
77	0.05	ND	ND	ND	ND	ND	ND	ND
101		0.005	0.010	ND	ND	ND	ND	0.006
105	0.0001	0.012	0.005	0.004	0.004	0.004	0.014	0.008
114	0.0001	ND	ND	ND	ND	ND	ND	ND
118	0.00001	0.066	0.028	0.027	0.023	0.022	0.066	0.048
123	0.00001	0.001	0.000	0.001	ND	ND	0.001	0.001
126	0.1	0.001	ND	ND	ND	ND	ND	ND
128		0.013	0.007	0.005	0.004	0.004	0.008	0.010
138		0.085	0.046	0.036	0.027	ND	0.055	0.077
141		ND	ND	ND	ND	ND	ND	ND
149		0.002	0.002	ND	ND	ND	ND	0.001
153		0.257	0.119	0.131	0.094	0.121	0.235	0.219
156	0.0001	0.034	0.014	0.013	0.009	0.012	0.041	0.020
157	0.0001	ND	ND	ND	ND	ND	0.007	ND
163		0.043	ND	0.018	0.015	0.012	0.048	0.027
167	0.00001	0.015	0.006	0.006	0.005	0.006	0.018	0.011
169	0.001	ND	ND	ND	ND	ND	ND	ND
170		0.043	0.021	0.021	0.013	0.020	0.067	0.034
171		0.006	0.004	0.002	0.002	0.002	0.009	0.005
180		0.134	0.075	0.059	0.035	0.062	0.107	0.109
183		0.024	0.014	0.011	0.007	0.010	0.021	0.019
187		0.093	0.062	0.038	0.028	0.028	0.061	0.060
189	0.00001	0.005	0.002	0.002	ND	0.003	0.005	0.003
194		0.044	0.023	0.019	0.011	0.022	0.032	0.027
199		ND	ND	ND	ND	ND	ND	ND
201		0.038	0.023	0.015	0.009	0.014	0.020	0.022
205		0.003	0.001	ND	ND	ND	0.002	ND
206		0.016	0.009	0.006	0.003	0.006	0.007	0.010
209		0.012	0.010	0.006	0.003	0.004	0.006	0.006
	Sum	0.955	0.482	0.421	0.292	0.352	0.830	0.725
	Total PCBs	1.814	0.996	0.749	0.534	3.425	1.408	1.356
	Paris 10	0.596	0.298	0.270	0.192	0.222	0.518	0.488

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.9. continued

	TEF	PCB congener concentration in merlin eggs						
		E8897	**E8898**	**E8923**	**E8924**	**E8925**	**E8926**	**E8937**
CF		*18.80*	*16.70*	*19.77*	*15.09*	*18.77*	*4.98*	*11.49*
8		ND	ND	ND	ND	ND	ND	ND
18		0.001	ND	ND	ND	0.001	ND	ND
28		0.001	0.001	0.002	0.001	ND	0.005	0.001
29		ND	ND	ND	ND	ND	ND	ND
31		ND	ND	ND	ND	ND	ND	ND
52		ND	ND	ND	ND	ND	ND	ND
77	0.05	ND	ND	ND	ND	ND	ND	ND
101		0.003	0.001	0.001	ND	ND	0.014	0.002
105	0.0001	0.006	0.007	0.007	0.019	0.001	0.018	0.004
114	0.0001	ND	ND	ND	ND	ND	ND	ND
118	0.00001	0.029	0.042	0.037	0.079	0.006	0.087	0.022
123	0.00001	0.000	0.001	0.001	0.001	ND	0.002	ND
126	0.1	ND	ND	ND	ND	ND	ND	ND
128		0.006	0.007	0.009	0.012	0.002	0.018	0.004
138		0.038	0.056	0.060	0.079	0.010	0.119	0.031
141		ND	ND	ND	ND	ND	ND	ND
149		ND	ND	ND	0.002	ND	0.002	ND
153		0.134	0.209	0.179	0.264	0.031	0.424	0.094
156	0.0001	0.013	0.024	0.019	0.055	0.003	0.046	0.011
157	0.0001	ND	ND	ND	ND	ND	ND	ND
163		0.016	0.033	0.027	0.120	0.003	0.049	0.017
167	0.00001	0.007	0.011	0.008	0.014	0.002	0.025	0.005
169	0.001	ND	ND	ND	ND	ND	ND	ND
170		0.023	0.035	0.036	0.081	0.007	0.082	0.016
171		0.003	0.005	0.005	0.012	0.001	0.011	0.003
180		0.068	0.098	0.111	0.107	0.018	0.246	0.051
183		0.012	0.018	0.020	0.040	0.003	0.040	0.010
187		0.037	0.082	0.072	0.195	0.007	0.112	0.041
189	0.00001	0.002	0.005	0.003	0.011	ND	0.008	0.002
194		0.020	0.037	0.037	0.080	0.006	0.085	0.021
199		ND	ND	ND	ND	ND	ND	ND
201		0.016	0.032	0.031	0.079	0.004	0.059	0.018
205		ND	0.002	0.002	0.005	ND	0.005	ND
206		0.006	0.012	0.012	0.027	ND	0.027	0.008
209		0.005	0.009	0.010	0.028	0.001	0.016	0.008
	Sum	0.447	0.728	0.689	1.312	0.103	1.499	0.369
	Total PCBs	1.099	1.316	1.273	2.507	0.186	2.926	0.709
	Paris 10	0.293	0.439	0.416	0.604	0.069	0.958	0.216

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.10. Congener specific and sum TEQ concentrations (pg/g wet wt) for merlin eggs received in 2006

	TEQ concentration in merlin eggs						
	E8164	**E8891**	**E8892**	**E8893**	**E8894**	**E8895**	**E8896**
CF	*14.71*	*16.95*	*21.76*	*20.34*	*20.86*	*16.52*	*27.17*
77	ND	ND	ND	ND	ND	ND	ND
105	1.218	0.500	0.443	0.442	0.360	1.426	0.832
114	ND	ND	ND	ND	ND	ND	ND
118	0.660	0.284	0.273	0.228	0.225	0.657	0.475
123	0.010	0.003	0.005	ND	ND	0.010	0.005
126	87.10	ND	ND	ND	ND	ND	ND
156	3.371	1.390	1.298	0.914	1.228	4.060	2.035
157	ND	ND	ND	ND	ND	0.664	ND
167	0.152	0.059	0.064	0.045	0.064	0.177	0.113
169	ND	ND	ND	ND	ND	ND	ND
189	0.053	0.024	0.024	ND	0.025	0.051	0.032
Sum	92.56	2.261	2.109	1.629	1.902	7.045	3.492
	E8897	**E8898**	**E8923**	**E8924**	**E8925**	**E8926**	**E8937**
CF	*18.80*	*16.70*	*19.77*	*15.09*	*18.77*	*4.98*	*11.49*
77	ND	ND	ND	ND	ND	ND	ND
105	0.565	0.686	0.727	1.900	0.110	1.775	0.419
114	ND	ND	ND	ND	ND	ND	ND
118	0.291	0.422	0.373	0.786	0.058	0.866	0.218
123	0.005	0.007	0.006	0.011	ND	0.017	ND
126	ND	ND	ND	ND	ND	ND	ND
156	1.322	2.410	1.941	5.505	0.304	4.639	1.064
157	ND	ND	ND	ND	ND	ND	ND
167	0.073	0.111	0.079	0.140	0.016	0.245	0.053
169	ND	ND	ND	ND	ND	ND	ND
189	0.021	0.047	0.034	0.112	ND	0.082	0.021
Sum	2.276	3.683	3.160	8.454	0.487	7.625	1.774

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.11. Organochlorine insecticide concentrations (µg/g wet wt) for merlin eggs received in 2006.

		Organochlorine Insecticide Concentration (µg/g ww)						
Egg No.	***CF***	**HCB**	**a-HCCH**	**g-HCCH**	**HEOD**	**DDE**	**DDT**	**TDE**
E8164	14.71	0.018	ND	ND	0.454	10.101	0.016	ND
E8891	16.95	0.013	ND	ND	0.182	6.123	ND	ND
E8892	21.76	0.012	ND	ND	0.011	2.183	ND	ND
E8893	20.34	0.011	ND	ND	0.014	1.791	ND	ND
E8894	20.86	0.010	ND	ND	0.009	ND	ND	ND
E8895	16.52	0.010	ND	ND	0.008	0.788	ND	ND
E8896	27.17	0.015	ND	ND	0.044	4.912	ND	ND
E8897	18.80	0.018	ND	ND	0.033	0.989	ND	ND
E8898	16.70	0.019	ND	ND	0.032	3.167	ND	ND
E8923	19.77	0.012	ND	ND	0.042	3.183	ND	ND
E8924	15.09	0.013	ND	ND	0.041	2.439	ND	ND
E8925	18.77	0.001	ND	ND	0.003	0.392	ND	ND
E8926	4.98	0.052	ND	ND	0.129	4.110	ND	ND
E8937	11.49	0.010	ND	ND	0.024	2.518	ND	0.016

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations. HCB = Hexachlorobenzene; a-HCCH = 1a,2a,3,4a,5b,6b-hexachlorocyclohexane; g-HCCH = 1a,2a,3b,4a,5a,6b-hexachlorocyclohexane; HEOD = (1R,4S,4aS,5R,6R,7S,8S,8aR)-1,2,3,4,10,10-hexachloro-1,4,4a,5,6,7,8,8a-octahydro-6,7-epoxy-1,4:5,8-dimethanonaphthalene; DDE = 1,1'-(dichloroethenylidene)bis[4-chlorobenzene]; DDT = 1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane; TDE = 1,1-dichloro-2,2-bis(4-chlorophenyl)ethane.

Table 10.12: Inorganic element concentrations (µg/g dry wt) for individual merlin eggs received in 2006

TEF	Egg Number						
	E8164	**E8891**	**E8892**	**E8893**	**E8894**	**E8895**	**E8896**
% moisture	*71.21*	*80.80*	*82.22*	*83.71*	*81.85*	*78.07*	*78.65*
Aluminum(27)	2.300	7.920	1.160	<0.353	3.000	0.861	2.200
Manganese	0.404	1.130	0.855	0.539	0.615	0.381	0.650
Iron(57)	56.20	49.80	118.0	60.10	58.20	42.80	13.00
Nickel(58)	0.034	0.063	0.134	0.229	0.204	0.142	0.083
Cobalt	0.003	0.010	0.005	0.013	0.010	0.007	0.007
Nickel(60)	<0.003	0.018	0.090	0.161	0.143	0.084	0.011
Copper	4.310	1.090	2.400	2.380	2.220	3.020	2.000
Zinc	27.30	39.00	28.30	30.30	38.80	24.90	28.70
Arsenic	0.058	0.074	0.058	0.081	0.056	0.057	0.093
Selenium	2.210	2.310	3.280	3.690	2.240	2.380	2.350
Molybdenum	0.033	0.054	0.114	0.093	0.095	0.047	0.045
Cadmium	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Tin	<0.003	<0.005	<0.005	<0.006	<0.005	<0.005	<0.005
Lead	<0.003	<0.005	<0.005	<0.006	<0.005	<0.005	<0.005
Mercury(202)	1.260	1.340	9.480	10.400	2.950	10.300	1.180
	E8897	**E8898**	**E8923**	**E8924**	**E8925**	**E8926**	**E8937**
% moisture	*81.05*	*80.39*	*80.51*	*79.62*	*89.18*	*56.96*	*81.97*
Aluminum(27)	2.230	3.830	0.856	8.330	9.740	3.330	1.630
Manganese	0.228	0.478	0.151	1.110	0.706	1.690	0.740
Iron(57)	42.20	22.10	38.00	78.20	63.20	50.80	94.00
Nickel(58)	0.110	0.089	0.118	0.069	0.253	0.107	0.320
Cobalt	0.010	0.011	0.011	0.010	0.015	0.012	0.009
Nickel(60)	0.057	0.036	0.066	<0.005	0.127	0.019	0.204
Copper	2.370	1.700	7.830	1.830	3.150	3.070	2.220
Zinc	33.50	30.80	32.70	36.30	23.80	44.80	28.50
Arsenic	0.052	0.061	0.079	0.073	0.103	0.068	0.068
Selenium	1.810	1.920	2.880	2.540	4.110	3.310	2.880
Molybdenum	0.028	0.034	0.036	0.035	<0.026	0.064	0.073
Cadmium	<0.001	<0.001	0.090	0.048	<0.002	<0.000	<0.001
Tin	<0.005	<0.005	<0.005	<0.005	<0.009	<0.002	<0.005
Lead	<0.005	<0.005	<0.005	<0.005	<0.009	<0.002	<0.005
Mercury(202)	1.140	1.260	1.580	2.150	10.200	4.880	2.040

ND is not detected.

Table 10.13. Congener specific TEFs and PCB congener concentrations (µg/g wet wt) for golden eagle eggs received in 2006

	TEF	PCB congener concentrations in golden eagle eggs									
		E8846	**E8847**	**E8867**	**E8899**	**E8906**	**E8909**	**E8910**	**E8918**	**E8919**	**E8920**
CF		*28.79*	*22.93*	*22.11*	*78.59*	*28.47*	*26.76*	*33.28*	*79.67*	*29.29*	*21.43*
8		ND	ND	ND	ND	ND	ND	ND	0.002	ND	ND
18		ND	ND	ND	ND	ND	ND	ND	0.001	ND	ND
28		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
31		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
52		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
77	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
101		0.004	0.005	ND	ND	ND	0.002	0.008	ND	0.002	0.001
105	0.0001	0.001	0.001	ND	ND	ND	ND	0.005	ND	0.002	ND
114	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
118	0.00001	0.011	0.012	0.001	0.001	0.003	0.005	0.033	0.005	0.011	0.005
123	0.00001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
126	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
128		0.003	0.004	ND	0.002	ND	0.001	0.009	0.001	0.003	0.001
138		0.024	0.027	0.001	0.004	0.004	0.008	0.057	0.007	0.014	0.008
141		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
149		ND	ND	ND	ND	ND	ND	0.001	ND	ND	ND
153		0.084	0.093	0.003	0.017	0.018	0.023	0.182	0.032	0.044	0.042
156	0.0001	0.006	0.007	ND	0.001	0.002	0.002	0.013	0.002	0.004	0.003
157	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
163		0.009	0.010	0.000	0.001	0.002	0.002	0.008	0.003	0.008	0.004
167	0.00001	0.002	0.003	ND	ND	0.001	0.001	0.008	0.001	0.002	0.002
169	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
170		0.014	0.015	0.001	0.002	0.004	0.003	0.031	0.005	0.007	0.007
171		0.002	0.002	ND	ND	ND	ND	0.004	0.001	0.001	0.001
180		0.049	0.055	0.004	0.011	0.020	0.011	0.128	0.023	0.024	0.036
183		0.008	0.010	0.000	0.002	0.002	0.002	0.020	0.004	0.004	0.004
187		0.019	0.021	0.001	0.004	0.005	0.005	0.027	0.007	0.015	0.009
189	0.00001	ND	ND	ND	ND	ND	ND	0.002	ND	ND	ND
194		0.012	0.013	ND	0.004	0.007	ND	0.023	0.006	0.007	0.011
199		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
201		0.007	0.008	ND	ND	0.003	ND	0.006	0.003	0.005	0.005
205		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
206		ND	0.002	ND	ND	ND	ND	0.004	ND	0.002	ND
209		ND	0.001	ND	ND	ND	ND	0.001	ND	ND	ND
	Sum	0.254	0.289	0.011	0.049	0.070	0.064	0.571	0.103	0.156	0.140
	Total PCBs	0.445	0.581	0.107	0.175	0.180	0.189	1.005	0.178	0.286	0.243
	Paris 10	0.178	0.200	0.008	0.034	0.046	0.050	0.426	0.071	0.103	0.096

Table 10.14: Congener specific and sum TEQ concentrations (pg/g wet wt) for golden eagle eggs received in 2006

	TEQ concentrations in golden eagle eggs									
	E8846	**E8847**	**E8867**	**E8899**	**E8906**	**E8909**	**E8910**	**E8918**	**E8919**	**E8920**
CF	*28.79*	*22.93*	*22.11*	*78.59*	*28.47*	*26.76*	*33.28*	*79.67*	*29.29*	*21.43*
77	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
105	0.132	0.148	ND	ND	ND	ND	0.550	ND	0.224	ND
114	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
118	1.107	1.232	0.059	0.145	0.265	0.463	3.334	0.452	1.140	0.498
123	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
156	0.585	0.661	ND	0.122	0.220	0.150	1.252	0.195	0.436	0.343
157	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
167	0.235	0.268	ND	ND	0.131	0.065	0.821	0.089	0.169	0.163
169	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
189	ND	ND	ND	ND	ND	ND	0.209	ND	ND	ND
Sum	2.060	2.309	0.059	0.267	0.616	0.678	6.166	0.736	1.969	1.004

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.15. Organochlorine insecticide concentrations (µg/g wet wt) in the eggs of golden eagles received in 2006

Bird No.	*CF*	Organochlorine Insecticide Concentrations (µg/g ww)						
		HCB	a-HCCH	g-HCCH	HEOD	DDE	DDT	TDE
E8846	28.79	0.003	ND	ND	0.013	0.031	ND	ND
E8847	22.93	0.003	ND	ND	0.015	0.038	ND	ND
E8867	22.11	0.001	ND	ND	0.005	ND	ND	ND
E8899	78.59	0.001	ND	ND	0.012	0.011	ND	ND
E8906	28.47	0.002	ND	ND	0.006	0.008	ND	ND
E8909	26.76	0.002	ND	ND	0.006	0.022	ND	ND
E8910	33.28	0.002	ND	ND	0.008	0.169	ND	ND
E8918	79.67	0.001	ND	ND	0.009	0.009	ND	ND
E8919	29.29	0.004	ND	ND	0.012	0.046	ND	ND
E8920	21.43	0.003	ND	ND	0.009	0.018	ND	ND

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.16. Inorganic element concentrations (µg/g dry wt) for individual golden eagle eggs received in 2006.

	Inorganic element concentrations in golden eagle eggs									
	E8846	**E8847**	**E8867**	**E8899**	**E8906**	**E8909**	**E8910**	**E8918**	**E8919**	**E8920**
% moisture	*81.25*	*80.87*	*81.39*	*83.00*	*82.29*	*81.37*	*81.08*	*81.53*	*82.46*	*82.60*
Aluminum(27)	2.510	1.660	2.690	2.470	3.170	2.080	2.300	1.770	0.317	1.940
Manganese	1.400	2.300	1.160	0.222	0.721	0.519	0.656	0.498	1.880	0.425
Iron(57)	11.20	49.10	63.00	<0.577	<0.533	25.20	8.790	11.30	62.90	46.80
Nickel(58)	0.040	0.058	0.032	<0.006	<0.005	<0.005	0.011	0.116	0.216	0.054
Cobalt	<0.003	0.005	0.003	<0.003	<0.003	0.003	0.004	0.007	0.014	0.011
Nickel(60)	<0.005	<0.005	<0.005	<0.006	<0.005	<0.005	<0.005	0.076	0.158	0.028
Copper	3.050	3.320	3.410	4.840	2.430	3.050	2.940	3.400	3.110	2.640
Zinc	37.80	42.10	34.30	25.50	30.40	26.00	28.00	34.00	59.50	35.00
Arsenic	0.084	0.077	0.045	0.064	0.056	0.057	0.054	0.097	0.088	0.060
Selenium	1.470	1.350	1.220	1.090	1.280	1.340	1.210	1.130	2.290	1.200
Molybdenum	0.306	0.261	0.244	0.146	0.134	0.191	0.131	0.178	0.356	0.177
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.010
Tin	<0.005	<0.005	<0.005	<0.006	<0.005	<0.005	<0.005	<0.004	<0.005	<0.006
Lead	<0.005	<0.005	<0.005	<0.006	<0.005	<0.005	<0.005	0.463	<0.005	0.212
Mercury(202)	0.550	0.553	<0.050	<0.058	0.066	0.396	0.520	0.056	0.194	0.126

ND is not detected. CF is conversion factor needed to convert from dry wt to wet wt concentrations.

Table 10.17. Provenance, lipid & moisture content, and biometric data for for merlin eggs received in 2006. CF = conversion factor for conversion of data from a wet weight to a lipid weight basis or wet weight to a dry weight basis. L = length of shell, B = breadth of shell, SI = Egg shell thickness index, and Dev indicates whether embryo development was evident in the egg.

			Lipid		Moisture		Biometrics			
Egg No/	**Year**	**Vice-County**	**%**	**CF**	**%**	**CF**	**L (cm)**	**B (cm)**	**SI**	**Dev.**
E8849	2006	Bass Rock	4.71	21.22	82.46	5.70	7.93	4.75	2.56	None
E8850	2006	Bass Rock	4.13	24.2	83.08	5.91	8.26	4.67	3.14	None
E8851	2006	Bass Rock	4.52	22.12	84.17	6.32	7.89	4.80	2.90	None
E8852	2006	Bass Rock	4.31	23.2	84.6	6.49	8.08	5.06	3.04	None
E8853	2006	Bass Rock	4.30	23.25	83.04	5.90	7.85	4.71	2.78	Yes
E8854	2006	Bass Rock	3.01	33.2	85.01	6.67	8.21	4.99	3.34	None
E8855	2006	Bass Rock	3.32	30.12	84.62	6.50	8.54	4.94	3.12	None
E8856	2006	Bass Rock	4.08	24.5	83.38	6.02	7.78	4.91	2.80	None
E8857	2006	Bass Rock	4.00	24.97	83.37	6.01	*	*	*	Yes
E8858	2006	Bass Rock	3.29	30.35	82.12	5.59	*	*	*	None

* Data unavailable as egg damaged on arrival

Table 10.18. Congener specific TEFs and PCB congener concentrations (ng/g wet wt) for northern gannet eggs received in 2006

	TEF	PCB congener concentrations in northern gannet eggs									
		E8849	E8850	E8851	E8852	E8853	E8854	E8855	E8856	E8857	E8858
CF		*21.22*	*24.20*	*22.12*	*23.20*	*23.25*	*33.20*	*30.12*	*24.50*	*24.97*	*30.35*
8		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28		4.807	1.374	3.351	2.632	7.425	1.741	1.236	1.559	1.907	3.745
29		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
31		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
52		11.15	1.442	ND	3.410	13.76	1.811	1.876	1.198	3.588	ND
77	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
101		55.71	12.73	33.42	23.84	49.97	15.98	11.07	14.39	19.58	31.48
105	0.0001	26.26	8.334	13.48	13.55	47.18	9.281	5.334	9.612	11.26	22.21
114	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
118	0.00001	104.8	33.84	56.55	55.19	179.02	39.93	22.14	43.39	47.81	90.32
123	0.00001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
126	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
128		53.85	13.88	25.31	22.86	77.32	16.46	9.192	19.31	20.18	40.54
138		238.8	60.13	117.0	106.9	353.7	74.87	41.03	80.57	90.98	191.5
141		ND	1.458	4.365	ND	ND	ND	1.252	ND	2.178	3.646
149		44.86	10.02	27.12	18.08	67.72	9.089	8.030	8.328	14.66	26.64
153		492.9	140.6	218.0	226.9	729.7	161.4	85.14	195.2	191.3	380.9
156	0.0001	32.96	9.255	13.86	14.91	41.05	10.34	5.580	14.45	11.95	25.24
157	0.0001	7.718	3.052	4.205	ND	11.43	3.683	1.708	5.202	3.863	7.246
163		68.75	15.33	38.84	30.47	111.4	19.68	11.82	16.85	25.22	56.34
167	0.00001	17.48	5.928	7.509	8.567	22.57	6.472	3.081	9.843	6.922	10.16
169	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
170		76.64	20.80	28.46	32.28	90.19	21.95	10.70	35.77	24.98	54.94
171		17.08	3.422	7.918	6.821	22.06	4.761	2.459	ND	5.639	12.51
180		216.1	56.94	79.71	93.48	247.7	61.80	29.19	108.3	68.58	159.9
183		44.43	10.70	18.65	17.09	52.92	11.53	6.827	13.35	13.54	30.80
187		168.1	38.44	72.74	69.86	214.3	45.59	26.42	49.24	57.68	128.4
189	0.00001	3.417	ND	1.483	1.578	4.272	ND	ND	2.392	ND	2.842
194		27.88	7.397	10.86	13.24	31.36	9.669	4.183	19.62	10.04	23.14
199		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
201		30.38	6.916	12.10	12.31	35.92	8.704	4.978	10.34	10.14	22.40
205		ND	ND	ND	ND	1.874	ND	ND	ND	ND	ND
206		4.611	ND	2.085	ND	7.364	ND	ND	5.224	2.029	3.747
209		2.467	ND	1.193	1.502	3.548	1.489	0.999	2.700	1.399	1.975
	*Sum	1.751	0.462	0.798	0.775	2.424	0.536	0.294	0.667	0.645	1.331
	*Total PCBs	3.244	0.882	1.610	1.460	4.552	0.967	0.604	1.184	1.169	2.426
	*Paris 10	1.184	0.325	0.535	0.541	1.669	0.377	0.203	0.469	0.447	0.905

* concentrations given in µg/g wet wt. ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.19. Congener specific and sum TEQ concentrations (pg/g wet wt) for northern gannet eggs received in 2006

	TEQ concentrations in northern gannet eggs									
	E8849	**E8850**	**E8851**	**E8852**	**E8853**	**E8854**	**E8855**	**E8856**	**E8857**	**E8858**
CF	*21.22*	*24.20*	*22.12*	*23.20*	*23.25*	*33.20*	*30.12*	*24.50*	*24.97*	*30.35*
77	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
105	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
114	2.626	0.833	1.348	1.355	4.718	0.928	0.533	0.961	1.126	2.221
118	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
123	1.048	0.338	0.565	0.552	1.790	0.399	0.221	0.434	0.478	0.903
126	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
156	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
157	3.296	0.925	1.386	1.491	4.105	1.034	0.558	1.445	1.195	2.524
167	0.772	0.305	0.421	ND	1.144	0.368	0.171	0.520	0.386	0.725
169	0.175	0.059	0.075	0.086	0.226	0.065	0.031	0.098	0.069	0.102
189	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sum	0.034	ND	0.015	0.016	0.043	ND	ND	0.024	ND	0.028

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.20. Organochlorine insecticide concentrations (µg/g wet wt) for northern gannet eggs received in 2006.

		Organochlorine Insecticide Concentration (µg/g ww)						
Egg No.	***CF***	**HCB**	**a-HCCH**	**g-HCCH**	**HEOD**	**DDE**	**DDT**	**TDE**
E8849	*21.22*	0.016	ND	ND	0.058	0.136	ND	0.011
E8850	*24.20*	0.006	ND	ND	0.022	0.021	ND	ND
E8851	*22.12*	0.008	ND	ND	0.035	0.109	ND	0.008
E8852	*23.20*	0.009	ND	ND	0.040	0.061	ND	0.005
E8853	*23.25*	0.014	ND	ND	0.077	0.149	ND	0.019
E8854	*33.20*	0.006	ND	ND	0.029	0.028	ND	ND
E8855	*30.12*	0.004	ND	ND	0.019	0.021	ND	ND
E8856	*24.50*	0.007	ND	ND	0.030	0.021	ND	ND
E8857	*24.97*	0.006	ND	ND	0.028	0.041	ND	0.004
E8858	*30.35*	0.010	ND	ND	0.058	0.097	ND	0.007

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.21. Inorganic element concentrations (µg/g dry wt) for individual northern gannet eggs received in 2006

	Inorganic element concentrations in northern gannet eggs									
	E8849	**E8850**	**E8851**	**E8852**	**E8853**	**E8854**	**E8855**	**E8856**	**E8857**	**E8858**
% moisture	*82.46*	*83.08*	*84.17*	*84.60*	*83.04*	*85.01*	*84.62*	*83.38*	*83.37*	*82.12*
Aluminum	4.340	5.980	7.440	1.950	4.930	5.520	3.580	2.850	4.250	5.080
Manganese	0.774	0.667	1.350	0.909	0.792	0.968	0.599	1.110	0.982	1.130
Iron(57)	66.90	26.90	72.80	72.70	40.40	78.30	69.20	123.00	65.60	53.20
Nickel(58)	0.047	0.038	0.040	0.076	0.045	0.090	0.065	0.124	0.065	0.048
Cobalt	0.008	0.007	0.012	0.014	0.007	0.010	0.013	0.020	0.013	0.006
Nickel(60)	<0.006	<0.006	<0.006	<0.006	<0.006	<0.007	<0.006	<0.005	<0.006	<0.005
Copper	3.830	3.940	3.710	3.210	3.930	3.930	3.040	3.400	3.610	4.160
Zinc	38.10	31.60	35.40	43.20	36.20	34.40	38.80	43.50	37.30	43.20
Arsenic	0.399	0.403	0.413	0.343	0.502	0.335	0.332	0.354	0.531	0.575
Selenium	3.440	3.790	2.790	3.160	3.120	4.230	2.990	3.320	3.310	3.910
Molybdenum	0.599	0.371	0.525	0.481	0.782	0.412	0.341	0.499	0.375	0.349
Cadmium	<0.001	0.013	0.032	0.199	<0.001	0.008	<0.001	4.890	4.730	<0.001
Tin	<0.006	<0.006	<0.006	<0.006	<0.006	<0.007	0.012	<0.005	<0.006	<0.005
Lead	<0.006	<0.006	<0.006	2.450	<0.006	<0.007	<0.006	3.720	<0.006	<0.005
Mercury(202)	1.770	1.900	1.960	2.120	3.080	2.220	1.590	1.810	2.940	1.920

ble 10.22 Congener specific and sum PCB and TEQ wet wt concentrations for the sea eagle egg (E8921) received in 2006

	TEF	PCB concentration (μg/g wet wt)	TEQ concentration (pg/g wet wt)
CF		*36.70*	*36.70*
8		ND	
18		ND	
28		0.002	
29		ND	
31		ND	
52		0.002	
77	0.05	ND	ND
101		0.068	
105	0.0001	0.065	6.470
114	0.0001	ND	ND
118	0.00001	0.359	3.589
123	0.00001	ND	ND
126	0.1	ND	ND
128		0.112	
138		0.773	
141		ND	
149		0.008	
153		2.294	
156	0.0001	0.143	14.336
157	0.0001	ND	ND
163		0.077	
167	0.00001	0.085	0.849
169	0.001	ND	ND
170		0.486	
171		0.042	
180		1.973	
183		0.255	
187		0.265	
189	0.00001	0.026	0.256
194		0.334	
199		ND	
201		0.051	
205		0.008	
206		0.058	
209		0.017	
Congener Sum		7.502	25.50
Total PCBs		12.79	
Paris 10		5.679	

Table 10.23. Organochlorine insecticide concentrations (µg/g wet wt) for white-tailed sea eagle egg received in 2006.

		Organochlorine Insecticide Concentration (µg/g ww)						
Egg No.	***CF***	**HCB**	**a-HCCH**	**g-HCCH**	**HEOD**	**pp'-DDE**	**DDT**	**TDE**
E8921	*36.70*	0.023	ND	ND	0.054	3.552	ND	0.003

ND is not detected. CF is conversion factor needed to convert from wet wt to lipid wt concentrations

Table 10.24. Inorganic element concentrations (µg/g dry wt) for white-tailed sea eagle egg received in 2006.

	Inorganic element concentrations (µg/g dry wt)
	E8921
% moisture	*81.90*
Aluminum	4.600
Manganese	0.428
Iron(57)	14.80
Nickel(58)	0.051
Cobalt	0.003
Nickel(60)	<0.005
Copper	4.080
Zinc	40.30
Arsenic	0.440
Selenium	2.330
Molybdenum	0.166
Cadmium	0.005
Tin	<0.005
Lead	<0.005
Mercury(202)	0.792

ND is not detected.