INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

NCC/NERC CONTRACT HF3/03/199
ITE PROJECT 181
Annual Report to Nature Conservancy Council

BIRDS OF PREY AND POLLUTION

Part I		Monitoring
	II	Mersey bird mortality
	III	Incident investigations
	IV	PCB residues in PCB-dosed puffins

I NEWTON, M P HARRIS, K R BULL, D OSBORN,
A A BELL, M B HAAS & W J EVERY

Monks Wood Experimental Station
Abbots Ripton
Huntingdon
Cambs. PE17 2LS

June 1982

INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

NCC/NERC CONTRACT HF3/03/199
ITE PROJECT 181
Annual Report to Nature Conservancy Council

BIRDS OF PREY AND POLLUTION

Part	I	Monitoring
	II	Mersey bird mortality
	III	Incident investigations
	IV	PCB residues in PCB-dosed puffins

I NEWTON, M P HARRIS, K R BULL, D OSBORN,
A A BELL, M B HAAS & W J EVERY

Monks Wood Experimental Station
Abbots Ripton
Huntingdon
Cambs. PE17 2LS

June 1982

C O N T E N T S

INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

NCC/NERC CONTRACT HF3/03/199
ITE PROJECT 181
Annual Report to Nature Conservancy Council

BIRDS OF PREY AND POLLUTION

Part I Monitoring

I NEWTON, A A BELL & M B HAAS

Monks Wood Experimental Station
Abbots Ripton
Huntingdon
Cambs. PE17 2LS

June 1982

1 MONITORING

1.1 Organochlorines and metals in predatory birds

The main objective of this work was to analyse the carcasses of predatory birds, supplied by members of the public, in order to continue the monitoring of organochlorine and metal residues in livers. During 1981, the livers from 222 birds were analysed, including those from 72 kestrels, 64 sparrowhawks, 30 herons, 19 kingfishers, and 37 others. These totals included some birds received in earlier years but analysed in 1981. The results from all birds are given in Table 1, and, for easy comparison, those from 1981 casualties alone are given in Figures 1-5.

As in previous years, there was considerable variation in pollutant levels between individuals of each species. Nonetheless, the variation in residues between the four main species was significant in the case of DDE and mercury, with much the highest DDE levels in sparrowhawks and much the highest mercury levels in herons (Table 2). Within species, some significant changes in geometric mean residue levels were evident comparing 1981 birds with 1980 ones. These included declines in DDE residues in kestrels and kingfishers between 1980 and 1981, increases in HEOD in all four main species, a decline in PCBs in kestrels, declines in mercury in sparrowhawks and kestrels, and declines in cadmium in three species (Table 3).

The declines in residues of most pollutants were encouraging, and presumably reflected the various controls which have come into effect in recent years. The increase in HEOD was surprising, however, as the use of this chemical is supposed also to be on the decline. As this reverses the trend found in the past few years this chemical will need watching carefully in the next year.

1.2 Pollutants in gannet eggs

In 1981, gannet eggs were obtained from three colonies, at Hermaness (Shetland), Ailsa Craig (southwest Scotland), and Bass Rock (southeast Scotland). These eggs were analysed for residues of DDE, HEOD, PCBs and mercury (Table 4, Figures 6-9), and also for cadmium, which was not detected in any of them.

Significant variation between colonies was found for HEOD and PCBs, but not for the other pollutants (Table 5). Both HEOD and PCBs were at lower level in eggs from Hermaness than in eggs from the more southern colonies (Figures 7-8). Comparing 1981 eggs with 1979 or 1980 eggs from the same colonies, a significant decline in DDE residues was evident at Ailsa Craig, an increase in HEOD residues was evident at Bass Rock, declines in PCB residues at all three colonies, and increases in mercury residues at all three colonies (Table 6). The levels of all compounds were relatively very low, however, and probably of little biological significance.

1.3 Pollutants in guillemot eggs

In 1981, guillemot eggs were obtained from Skomer (southwest Wales), Fair Isle (Shetland), and Isle of May (southwest Scotland). These were analysed for organochlorines and metals, but, as in the gannet eggs, no cadmium was detected (Table 7, Figures 6-9).

Comparing colonies, significant variation was evident only in mercury, with higher residues in eggs from Skomer than in those from other colonies (Table 8, Figure 9). Comparing 1981 eggs with 1980 eggs from the same colonies, significant declines were evident in DDE at Fair Isle, and in PCBs at Fair Isle and Isle of May, while increases in mercury were evident at Skomer and Isle of May (Table 9).

Year-to-year changes in egg residues are always hard to interpret on small samples. Perhaps the most salient point, however, was that, in both guillemot and gannet, levels of pesticide residues were lower in 1979-81 than they were about ten years previously. Such longer term and general declines were consistent with known reductions in organochlorine usage. Nonetheless, it was of interest that in both seabirds, as well as in the terrestrial predators, declines in DDE residues were detected between 1980 and 1981.

1.4 Sparrowhawk survey

The sparrowhawk suffered a marked population decline in the late 1950s, following the widespread introduction of cyclodiene pesticides in agriculture. Since 1964, in each of several areas, known territories have been checked periodically for details of occupation and breeding success. In this way, it was hoped to find whether sparrowhawks were recovering in numbers, following successive restrictions in cyclodiene use. Two areas, in Anglesey and Suffolk, were searched during 1981, and findings are summarised in Table 10.

In Anglesey, 19 potential territories were checked in early June, and occupied nests with eggs were found in two: a clutch of 4, appearing fairly fresh, and a well-incubated clutch of 5. In neither of these nests was there any evidence of egg-loss. Four sites contained old nests, two of these having appeared since the previous visit in 1979; the others were in areas not previously searched. Evidence of hunting sparrowhawks was found in only one of the 17 sites not occupied by a current nest.

In the Suffolk study area, 30 potential territories were searched in early and late June. Apart from two territories still holding old nests (one remaining from 1977), the area was devoid of any recent evidence of sparrowhawk occupation.

The apparent poor status of sparrowhawks in Anglesey was puzzling. Fewer territories were found occupied in the last two surveys of this area than in the 1960s, implying a continued downward trend. A good deal of Anglesey is under cultivation, however, and the use of organochlorines (especially DDT) could still be substantial. The lack of nests in the Suffolk area is undoubtedly a reflection of the continuing poor status of sparrowhawks in East Anglia. In this region, the decline in the late 1950s was more marked than anywhere else in Britain, associated with exceptionally heavy organochlorine use.

1.5 Observations at Troy and Willoughby heronries

Throughout the 1960s and early 1970s, periodic visits were made to two Lincolnshire heronries, mainly to count the nests and to obtain eggs and broken shells for analysis. These birds had shown shell-thinning, apparently caused by DDE, but unlike some birds-of-prey, had not shown a marked population decline. In 1981, the opportunity was again taken to check these heronries.

The entire colony at Troy was checked on 20 May, when 71 nests were found to be occupied. Decomposing remains of young were beneath five nests, and shell fragments beneath eight (11.2%).

Five of these birds were examined at Monks Wood. All were found to be in good condition, with pellets of fur and down contained in the gizzards, and all exhibited thoracic haermorrhaging, confirming that death had occurred suddenly. The large-scale mortality was almost certainly due to the gales and torrential rain which occurred during the last week of April.

The livers of five birds were analysed, and found to contain residues of organochlorines and heavy metals, but not at sufficient concentration to have caused death (Table 11).

The Willoughby colony was visited on 19 May. Some 14 nests were found to be occupied, with destroyed shells beneath two (14.2%), and decomposing young at four. Notification has since been received from Mr R.B. Wilkinson, of the Lincolnshire Naturalists' Trust, that this colony has recently fragmented, and that on 17 May a count which included the splinter groups showed 26 nests then occupied.

The number of nests with destroyed shells was probably under-recorded at both colonies due to the lateness of the visits, but there was no reason to suspect that a marked decline in population had occurred.

1.6 Acknowledgments

We are grateful to all the many people who sent us carcasses and eggs for analysis.

1.7 Reference

BAILEY, N.T.J. 1959. *Statistical methods in biology*. London: English Universities Press.

TABLE 1

Residues of organochlorine insecticides (ppm wet weight) and heavy metals (ppm dry weight) in the livers of birds of prey, results reported April 1981–March 1982.

Specimen number	Collection date	*pp'*-DDE	Dieldrin	PCBs	Hg	Cd
Kestrel						
6745	Nov 80	2.6	0.1	3.3	ND	ND
6749	Nov 80	2.9	0.4	4.0	ND	ND
6776	Nov 80	5.3	0.5	5.9	0.28	0.46
6786	Dec 80	4.6	ND	7.4	ND	1.84
6791	Jan 81	18.1	0.4	43.1	11.84	0.20
6794	Jan 81	2.1	0.4	8.6	ND	ND
6795	Jan 81	27.2	2.7	38.0	1.01	0.36
6796	Jan 81	3.1	1.3	4.6	ND	ND
6800	Jan 81	2.2	0.2	7.7	2.57	0.19
6801	Jan 81	0.4	ND	1.1	ND	0.46
6802	Jan 81	ND	ND	1.5	ND	0.23
6807	Jan 81	6.0	0.5	4.1	ND	0.85
6809	Jan 81	0.6	0.04	1.9	ND	1.34
6831	Feb 81	6.4	0.3	13.5	2.56	1.49
6834	Mar 81	0.2	0.1	2.0	ND	2.70
6837	Mar 81	4.2	0.5	11.8	0.61	0.94
6839	Mar 81	3.1	ND	4.2	0.46	ND
6850	May 81	0.1	ND	ND	2.11	ND
6851	Mar 81	290.4	ND	116.0	ND	ND
6869	Apr 81	7.6	1.3	16.0	1.83	0.95
6876	Apr 81	4.9	0.2	15.0	2.48	3.79
6877	May 81	11.9	1.5	49.9	1.04	0.99
6910	Apr 81	10.0	0.7	34.6	2.06	1.46
6999	Jul 81	2.3	0.3	1.3	2.40	ND
7050	Jul 81	13.6	1.2	5.0	1.08	ND
7092	Jul 81	ND	0.2	5.2	0.70	ND
7106	Jul 81	2.9	0.9	2.7	1.71	ND
7248	Aug 81	2.2	0.3	0.7	1.63	ND
7249	Sep 81	0.7	0.2	0.3	1.46	ND
7250	Sep 81	0.2	0.4	0.2	ND	ND
7255	? 80	0.2	0.5	1.0	0.63	0.23
7256	Dec 80	2.1	0.6	0.3	0.47	0.16
7257	Jan 81	0.1	0.5	0.4	0.30	2.46
7280	Sep 81	0.2	0.5	0.3	0.74	ND
7284	Sep 81	0.9	0.6	1.5	0.55	ND
7339	Oct 81	0.5	0.4	1.0	0.42	ND
7340	Oct 81	ND	0.6	1.9	0.18	ND
7341	Oct 81	5.1	1.5	0.9	1.67	ND
7342	Oct 81	1.9	0.8	1.4	3.17	3.31
7357	Oct 81	0.1	0.1	2.0	0.54	ND
7359	Oct 81	0.2	ND	0.3	0.16	3.32
7360	Oct 81	ND	0.2	0.03	ND	ND

Specimen number	Collection date	*pp'*-DDE	Dieldrin	PCBs	Hg	Cd
Kestrel (contd)						
7361	Oct 81	ND	0.3	0.2	0.48	ND
7362	Oct 81	ND	0.1	1.6	1.36	6.45
7365	Oct 81	ND	0.1	0.02	ND	0.46
7369	Aug 81	ND	0.3	0.4	5.52	ND
7370	Oct 81	ND	0.1	0.1	0.19	ND
7371	Nov 81	0.4	1.5	0.1	ND	ND
7376	Nov 81	0.1	0.6	4.1	0.15	ND
7383	Nov 81	0.4	0.2	0.2	0.67	0.85
7400	Oct 81	0.2	0.4	0.1	ND	ND
7401	Dec 81	0.3	0.3	0.4	1.36	0.96
7405	Nov 81	0.3	0.3	0.2	1.89	ND
7406	Nov 81	0.3	0.2	0.1	ND	ND
7420	Dec 81	13.3	2.8	0.9	0.35	ND
7421	Dec 81	1.9	0.5	2.6	0.32	ND
7423	Dec 81	ND	ND	0.4	0.92	ND
7424	Dec 81	0.6	0.1	0.2	0.77	ND
7431	Dec 81	0.4	0.2	0.1	0.74	2.08
Sparrowhawk						
6748	Nov 80	4.4	0.7	6.8	1.16	ND
6785	Dec 80	18.1	ND	22.5	-	-
6792	Aug 80	17.8	ND	29.3	2.37	ND
6803	Jan 81	9.9	0.7	20.7	1.46	ND
6810	Jan 81	14.0	2.6	17.2	ND	0.77
6815	Jan 81	3.9	0.4	2.5	8.40	ND
6818	Jan 81	1.3	0.1	1.3	0.31	0.63
6819	Feb 81	2.1	0.4	1.8	ND	ND
6821	Feb 81	9.5	2.9	24.7	ND	ND
6824	Feb 81	3.2	0.7	4.0	ND	ND
6825	Feb 81	1.8	0.9	3.9	ND	ND
6826	Feb 81	1.7	0.3	3.6	ND	1.17
6829	Mar 81	48.5	0.8	46.5	0.49	ND
6830	Feb 81	7.1	0.5	27.0	0.35	ND
6832	Feb 81	1.2	0.9	0.8	0.63	0.23
6833	Mar 81	1.1	0.5	7.5	0.46	0.89
6838	Mar 81	11.3	0.04	23.0	ND	0.14
6840	Mar 81	4.5	0.3	4.8	2.93	1.56
6852	Mar 81	13.0	1.3	40.1	ND	0.28
6855	Mar 81	3.5	ND	3.1	1.79	ND
6857	Mar 81	10.6	ND	43.9	1.95	ND
6861	Mar 81	4.8	2.9	8.9	1.73	ND
6863	Apr 81	1.9	ND	1.9	ND	ND
6865	Apr 81	3.0	ND	ND	1.71	ND
6870	Apr 81	5.1	0.2	7.5	6.55	ND
6871	Apr 81	7.5	0.2	5.0	2.80	0.90
6874	Apr 81	4.5	0.3	7.4	2.24	0.58
6878	Mar 81	12.2	2.3	40.0	9.08	0.46
6924	May 81	1.8	ND	1.1	0.99	ND
6926	May 81	12.1	2.2	25.3	19.26	ND
6937	May 81	5.9	1.6	17.1	5.55	1.09

Table 1 (contd)

Specimen number	Collection date	pp'-DDE	Dieldrin	PCBs	Hg	Cd
Sparrowhawk (contd)						
6964	Jun 81	3.9	0.4	6.0	4.02	ND
6991	?	2.8	0.3	0.4	1.53	ND
6998	Jun 81	11.4	ND	2.2	3.00	ND
7051	Jul 81	46.0	1.8	10.7	8.56	ND
7241	Aug 81	3.7	2.1	4.1	1.37	ND
7242	Aug 81	0.6	0.02	0.6	1.63	ND
7243	Aug 81	2.4	0.1	0.4	4.50	ND
7245	Aug 81	0.5	0.4	0.04	1.09	ND
7247	Aug 81	0.3	ND	0.5	1.02	ND
7279	Sep 81	0.2	0.2	0.1	0.25	ND
7286	Mar 80	0.1	0.1	0.5	0.67	ND
7287	Aug 81	29.5	2.6	16.4	3.71	0.90
7288	Sep 81	3.3	0.1	2.5	0.95	ND
7337	Oct 81	18.8	2.4	11.2	2.23	ND
7338	Jan 81	6.4	0.9	1.0	6.16	ND
7343	Oct 81	1.3	0.2	0.9	1.18	ND
7344	Oct 81	14.4	1.2	8.6	8.27	3.04
7345	Oct 81	0.1	0.04	ND	0.29	ND
7346	Oct 81	8.2	0.1	0.2	2.23	ND
7358	Oct 80	0.3	0.1	ND	0.57	ND
7366	80?	13.4	0.8	2.4	5.23	ND
7367	Oct 81	13.5	2.1	0.5	ND	ND
7372	Nov 81	0.6	0.02	ND	1.66	ND
7373	Nov 81	1.2	0.5	0.1	1.70	0.48
7375	Nov 81	0.6	ND	0.3	0.15	ND
7377	Nov 81	0.3	0.1	0.02	0.38	ND
7381	Nov 81	0.9	0.2	0.2	0.59	ND
7399	Nov 81	0.4	0.2	0.1	2.30	ND
7408	Jul 81	4.8	0.9	0.1	1.29	ND
Merlin						
6812	Jan 81	3.0	ND	2.0	ND	ND
6817	Jan 81	5.9	2.5	12.4	3.96	0.54
6925	May 81	8.9	0.5	5.0	7.74	ND
7273	Aug 81	0.3	0.2	0.6	6.09	ND
Peregrine						
6733	Aug 80	2.7	0.1	3.1	ND	ND
6858	Mar 81	2.6	ND	4.2	ND	ND
6860	Apr 81	57.8	1.4	184.62	0.60	0.09
6986	Jun 81	0.1	0.1	0.9	0.77	ND
7168	Aug 81	46.3	3.5	15.8	4.20	ND
7378	Nov 81	-	-	-	1.78	ND
Barn Owl						
6797	Jan 81	2.8	0.4	2.9	ND	ND
6798	Jan 81	6.3	0.2	10.3	ND	ND

Table 1 (contd)

Specimen number	Collection date	*pp*'-DDE	Dieldrin	PCBs	Hg	Cd
<u>Long-eared owl</u>						
6779	Dec 80	4.3	0.3	4.2	ND	0.34
6799	Jan 81	9.6	2.4	27.7	1.90	0.76
6854	Mar 81	3.3	0.8	15.8	ND	ND
6868	Apr 81	0.2	ND	ND	0.30	ND
6872	Apr 81	10.2	2.1	9.8	1.46	ND
<u>Heron</u>						
6775	Nov 80	2.0	ND	0.4	5.11	ND
6780	Dec 80	2.4	0.1	9.4	4.61	ND
6782	Dec 80	10.2	0.2	30.2	23.60	0.11
6783	Dec 80	2.0	0.2	2.2	4.73	ND
6784	Dec 80	2.0	0.04	3.3	4.28	ND
6788	Jan 81	1.4	ND	2.2	0.30	0.28
6789	Jan 81	1.6	ND	6.9	33.49	2.02
6804	? 80	0.5	ND	1.1	1.60	ND
6805	? 80	10.6	ND	85.4	160.77	2.39
6806	? 80	10.8	ND	16.4	18.79	ND
6813	Jan 81	1.3	ND	0.3	5.53	0.88
6816	Jan 81	–	–	–	3.11	ND
6822	Feb 81	ND	1.7	7.2	17.82	1.42
6827	Feb 81	–	–	–	15.20	0.84
6828	Mar 81	1.1	0.6	2.9	4.74	1.14
6836	Mar 81	25.0	0.5	62.7	6.75	ND
6873	Apr 81	3.0	0.1	15.1	2.47	ND
6985	Jun 81	ND	0.1	0.1	2.25	ND
6988	Mar 79	0.7	0.8	1.0	21.36	ND
6989	Dec 79	0.3	0.2	0.5	3.19	ND
7246	Aug 81	1.5	0.1	0.5	4.42	ND
7258	Feb 81	1.2	0.6	0.2	0.65	ND
7382	Nov 81	3.7	0.8	0.6	8.56	ND
7385	Nov 81	0.1	0.1	0.01	4.81	ND
7422	Dec 81	3.0	2.1	0.8	15.46	ND
7425	Jan 82	0.6	ND	0.7	9.20	0.37
7427	Oct 81	5.3	2.0	2.7	13.21	ND
<u>Great crested grebe</u>						
6774	Nov 80	12.1	1.5	68.8	ND	0.52
<u>Kingfisher</u>						
6787	Dec 80	1.6	ND	1.5	0.40	ND
6835	Mar 81	14.3	6.1	19.7	5.30	ND
6864	Apr 81	6.7	1.3	4.5	ND	ND
6996	Jun 81	3.4	5.3	4.7	1.20	ND
7093	Jul 81	1.5	2.0	0.9	4.06	ND
7094	Jul 81	0.3	0.6	0.7	1.93	ND
7251	Sep 81	1.0	0.8	0.2	0.93	ND
7252	Sep 81	ND	1.4	0.2	1.45	ND
7253	Sep 81	0.5	1.5	0.1	1.04	ND
7254	Sep 81	1.5	3.2	4.3	0.87	ND
7356	Oct 81	10.1	1.4	0.8	1.55	ND
7364	Oct 81	ND	9.1	1.8	4.03	ND
7379	Oct 81	0.2	0.4	1.4	1.60	ND
7384	Nov 81	0.7	ND	1.1	1.40	ND

TABLE 2

Analyses of variance on residues in livers of four species

	Source	d.f.	Sum of squares	Mean square	F-ratio	Significance of variation between species
DDE	within species	3	26.9886	8.9962	6.8443	$P < 0.001$
	between species	129	169.5590	1.3144		
HEOD	within species	3	7.7736	2.5912	2.3471	NS
	between species	129	142.4150	1.1040		
PCBs	within species	3	1.3784	0.4595	0.5062	NS
	between species	129	117.0990	0.9077		
Hg	within species	3	20.3802	6.7934	8.3263	$P < 0.001$
	between species	131	106.8830	0.8159		
Cd†	within species	2	2.8594	1.4297	1.5562	NS
	between species	119	109.3270	0.9187		

Notes: † Kingfisher omitted as nil determined in any sample.

Zero values for DDE and HEOD taken as 0.001 ppm; for PCBs, Hg and Cd as 0.01 ppm. Analyses on $\log_{10}$ values.

Geometric mean concentrations (range within 1 standard error of mean) of residues in livers of four species

	N	DDE	HEOD	PCBs	Hg	Cd
Sparrowhawk	53	3.23 2.65-3.92	0.17 0.12-0.24	1.18 1.33-2.52	0.64 0.41-0.87	0.03 0.03-0.04
Kestrel	53	0.34 0.21-0.53	0.17 0.13-0.23	1.11 0.83-1.50	0.29 0.21-0.39	0.07 0.05-0.10
Heron*	16	0.66 0.30-1.46	0.12 0.05-0.24	1.18 0.64-2.16	5.09 3.74-6.91	0.06 0.03-0.10
Kingfisher	13	0.50 0.21-1.16	0.98 0.52-1.85	1.19 0.79-1.80	1.18 0.77-1.81	-

* Only 14 of the heron liver samples were analysed for organochlorine residues.

TABLE 3

Significance of differences in residues in livers of four avian species in 1980 and in 1981

	Sparrowhawk	Kestrel	Heron	Kingfisher
DDE	$t_{86} = 0.0432$ NS	$t_{67} = 4.5195$ $P < 0.001$	$t_{19} = 0.8128$ NS	$t_{15} = 2.4190$ $P < 0.05$
HEOD	$t_{87} = -6.8811$ $P < 0.001$	$t_{49} = -2.5254$ $P < 0.05$	$t_{19} = -2.1865$ $P < 0.05$	$t_{16} = -4.8367$ $P < 0.001$
PCBs	$t_{86} = 1.9258$ NS	$t_{82} = 3.5182$ $P < 0.001$	$t_{19} = 2.0145$ NS	$t_{16} = 1.3951$ NS
Hg	$t_{68} = 4.2644$ $P < 0.001$	$t_{68} = 5.2254$ $P < 0.001$	$t_{21} = 1.7333$ NS	$t_{16} = 0.7403$ NS
Cd	$t_{87} = 7.1786$ $P < 0.001$	$t_{76} = 6.9545$ $P < 0.001$	$t_{18} = 5.2641$ $P < 0.001$	-

Note: Degrees of freedom were calculated using the formula given in Bailey (1959) for the comparison of means of two samples where the variances were unequal.

Negative values indicate an increase from previous year, positive values a decrease.

TABLE 4

Residues of organochlorine insecticides (ppm wet weight) and heavy metals (ppm dry weight) in the eggs of gannets.

Specimen number	*pp'*-DDE	Dieldrin	PCBs	Hg	Cd
Hermaness					
6915	1.28	ND	0.48	2.05	ND
6916	0.41	ND	0.29	2.08	ND
6917	1.58	ND	0.59	1.28	ND
6918	0.58	ND	0.22	2.27	ND
6919	0.10	ND	0.79	2.10	ND
6920	0.32	0.22	0.36	2.30	ND
Ailsa Craig					
6938	0.36	0.18	0.79	1.78	ND
6939	0.32	0.38	0.39	2.64	ND
6940	3.03	0.20	0.96	4.04	ND
6941	0.44	0.36	1.15	1.81	ND
6942	1.36	0.25	1.10	3.21	ND
6943	0.23	ND	0.64	2.39	ND
6944	0.26	ND	0.96	2.43	ND
6945	0.50	0.10	1.48	1.87	ND
6946	0.83	0.11	2.83	6.86	ND
6947	0.73	ND	1.52	5.89	ND
Bass Rock					
7059	0.62	0.15	1.22	2.07	ND
7060	0.20	0.12	0.36	2.01	ND
7061	0.58	0.16	1.52	2.20	ND
7062	0.13	0.04	0.28	2.37	ND
7063	0.68	0.17	1.66	1.90	ND
7064	0.26	0.07	0.78	2.08	ND
7065	0.28	0.06	0.68	2.55	ND
7066	0.20	0.10	0.56	2.14	ND
7067	0.39	0.14	2.65	3.44	ND
7068	0.29	0.14	1.48	2.57	ND

TABLE 5

Analysès of variance on residues in gannet eggs.

	Source	d.f.	Sum of squares	Mean square	F-ratio	Significance of variation between colonies
DDE	within colonies	2	0.3485	0.1743	1.5626	$P < 0.25$
	between colonies	23	2.5648	0.1115		
HEOD	within colonies	2	10.2231	5.1116	7.1514	$P < 0.005$
	between colonies	23	16.4396	0.7148		
PCBs	within colonies	2	0.6425	0.3212	4.6837	$P < 0.025$
	between colonies	23	1.5774	0.0686		
Hg	within colonies	2	0.1223	0.0612	2.8689	$P < 0.1$
	between colonies	23	0.4903	0.0213		

Note: Zero values for DDE and HEOD are taken as 0.001 ppm. Analyses on $\log_{10}$ values.

TABLE 6

Significance of differences in residues in gannet eggs.

	Hermaness 1980 and 1981		Ailsa Craig 1979 and 1981		Bass Rock 1979 and 1981	
DDE	t_{12} = -0.4085	NS	t_{12} = 3.3062	$P < 0.01$	t_{22} = 1.4789	NS
HEOD	t_{12} = -1.1711	NS	t_{10} = 1.9059	NS	t_{17} = -2.7869	$P < 0.02$
PCBs	t_{12} = 3.0585	$P < 0.01$	t_{18} = 9.4868	$P < 0.001$	t_{12} = 4.6464	$P < 0.001$
Hg	t_9 = -2.5665	$P < 0.05$	t_{18} = -7.6679	$P < 0.001$	t_{22} = -19.5122	$P < 0.001$

Note: Degrees of freedom were calculated using the formula given in Bailey (1959) for the comparison of means of two samples where the variances were unequal.

Negative values indicate an increase from previous year, positive values a decrease.

TABLE 7

Residues of organochlorine insecticides (ppm wet weight) and heavy metals (ppm dry weight) in the eggs of guillemots.

Specimen number	*pp'*-DDE	Dieldrin	PCBs	Hg	Cd
Skomer					
6927	1.17	ND	0.70	2.61	ND
6928	0.65	ND	0.63	3.07	ND
6929	0.42	ND	0.56	3.19	ND
6930	0.57	ND	0.58	2.22	ND
6931	1.05	0.09	1.29	2.14	ND
6932	0.84	ND	1.16	1.93	ND
6933	0.42	ND	0.17	2.28	ND
6934	0.83	ND	0.63	1.79	ND
6935	0.57	ND	0.55	2.65	ND
6936	0.59	0.06	1.04	2.33	ND
Fair Isle					
6978	0.60	ND	0.57	1.08	ND
6979	0.74	0.19	0.44	0.66	ND
6980	0.36	ND	0.44	0.72	ND
6981	0.39	ND	0.62	0.60	ND
6982	0.79	ND	0.62	0.79	ND
6983	0.05	0.04	0.04	0.58	ND
6984	0.74	ND	0.59	0.49	ND
Isle of May					
6879	0.71	0.13	0.59	1.35	ND
6880	0.49	ND	0.53	1.30	ND
6881	0.62	ND	1.00	0.56	ND
6882	0.79	ND	0.84	0.70	ND
6883	0.59	ND	0.27	0.70	ND
6884	0.76	ND	0.23	0.53	ND
6885	0.74	ND	1.25	0.97	ND
6886	0.54	ND	0.53	0.77	ND
6887	0.77	ND	1.04	0.74	ND
6888	0.90	ND	2.11	1.13	ND

TABLE 8

Analyses of variance on residues in guillemot eggs.

	Source	d.f.	Sum of squares	Mean square	F-ratio	Significance of variation between colonies
DDE	within colonies	2	0.2553	0.1277	2.2754	$P < 0.25$
	between colonies	24	1.3465	0.0561		
HEOD	within colonies	2	0.4871	0.2436	0.3841	NS
	between colonies	24	15.2175	0.6341		
PCBs	within colonies	2	0.3356	0.1678	1.6376	$P < 0.25$
	between colonies	24	2.4594	0.1025		
Hg	within colonies	2	1.5564	0.7782	58.4780	$P < 0.001$
	between colonies	24	0.3194	0.0133		

Note: Zero values for DDE and HEOD are taken as 0.001 ppm. Analyses on $\log_{10}$ values. NS - not significant.

TABLE 9

Significance of differences in residues in guillemot eggs in 1980 and in 1981.

	Skomer		Fair Isle		Isle of May	
DDE	t_{17} = 1.6660	NS	t_{14} = 2.8563	$P < 0.02$	t_{18} = 1.7385	NS
HEOD	t_{17} = 0.9307	NS	t_{14} = 0.2153	NS	t_{18} = 0.4508	NS
PCBs	t_9 = 1.7896	NS	t_{14} = 4.3993	$P < 0.001$	t_{18} = 4.8334	$P < 0.001$
Hg	t_{11} = -4.2104	$P < 0.01$	t_{14} = -0.9060	NS	t_{18} = -4.0664	$P < 0.001$

Note: Degrees of freedom were calculated using the formula given in Bailey (1959) for the comparison of means of two samples where the variances were unequal.

Negative values indicate an increase from previous year, positive values a decrease.

TABLE 10

Occupancy of sparrowhawk territories, 1981

	Anglesey	Suffolk
Total territories checked	19	30
Number with successful nests	2	0
Number with failed nests	0	0
No new nest, but other signs	1	0
No sign	16	30
Number territories with old nests	4	2
Proportion of territories with old nests	0.21	0.07

TABLE 11

Residues of organochlorine insecticides (ppm wet weight) and heavy metals (ppm dry weight) in five heron nestlings

	pp'-DDE	Dieldrin	PCBs	Hg	Cd	Zn	Cu
1	3.63	0.06	3.72	1.51	ND	200.8	39.12
2	0.69	ND	0.71	1.55	ND	246.7	23.28
3	1.68	ND	3.86	0.91	ND	168.6	18.14
4	2.36	ND	4.08	1.10	ND	177.3	21.75
5	1.72	0.02	3.68	1.28	ND	144.5	18.59

Fig. 1. DDE concentrations in livers of various predatory birds in 1981. Geometric mean values (——) are shown. ND - nil determined.

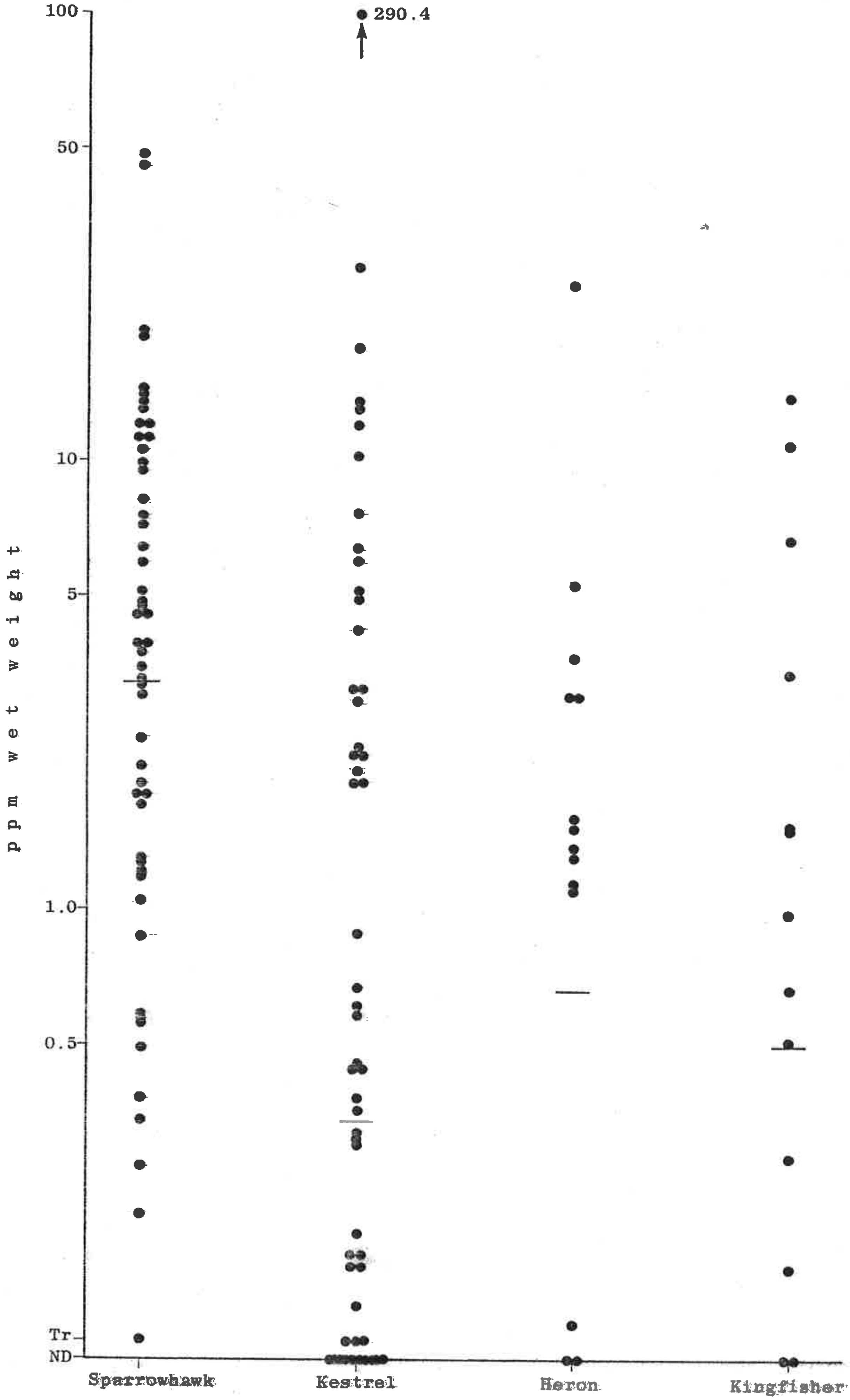


Fig. 2. HEOD concentrations in livers of various predatory birds in 1981. Geometric mean values (——) are shown. ND - nil determined.

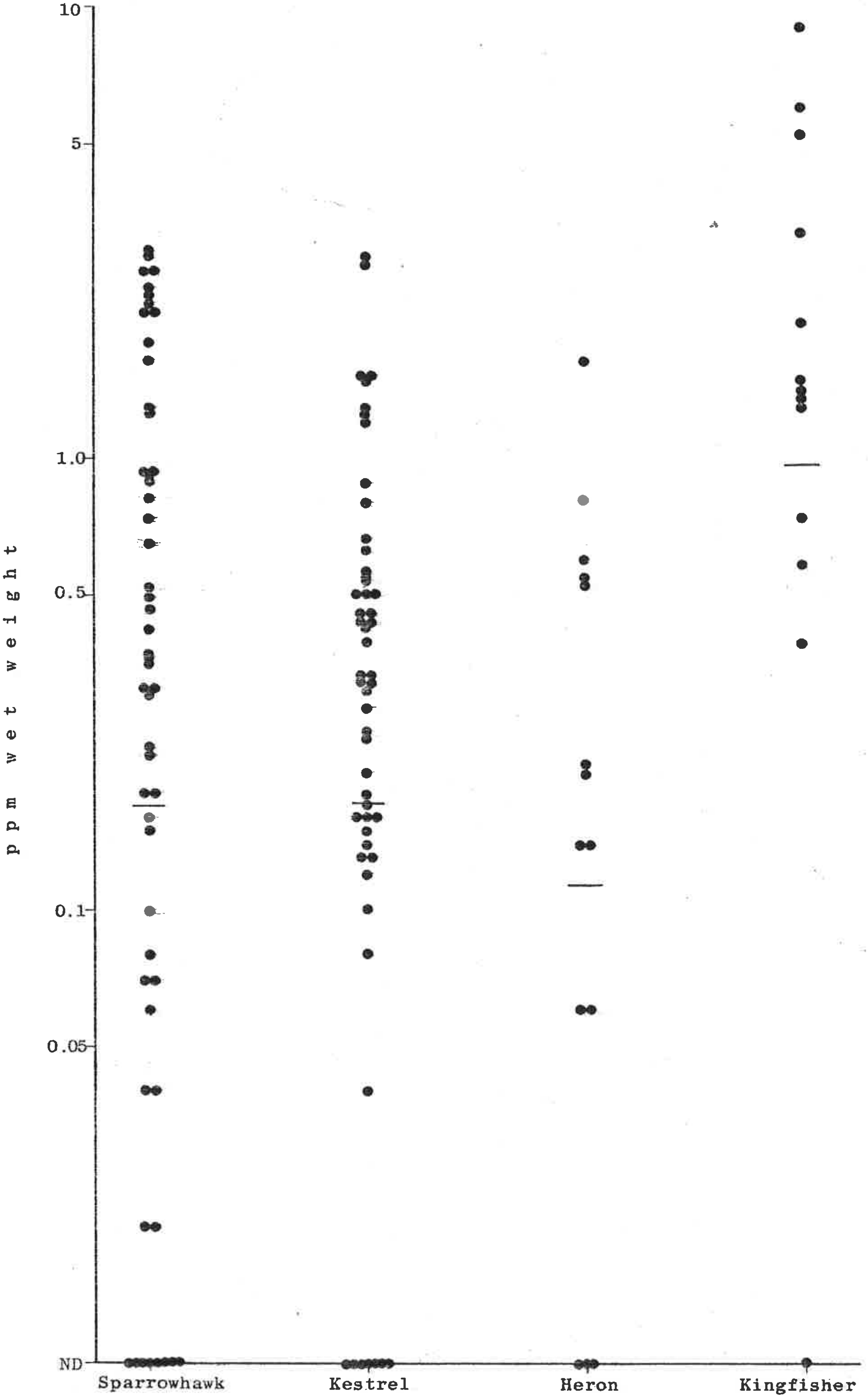


Fig. 3. PCB concentrations in livers of various predatory birds in 1981. Geometric mean values (——) are shown. ND - nil determined.

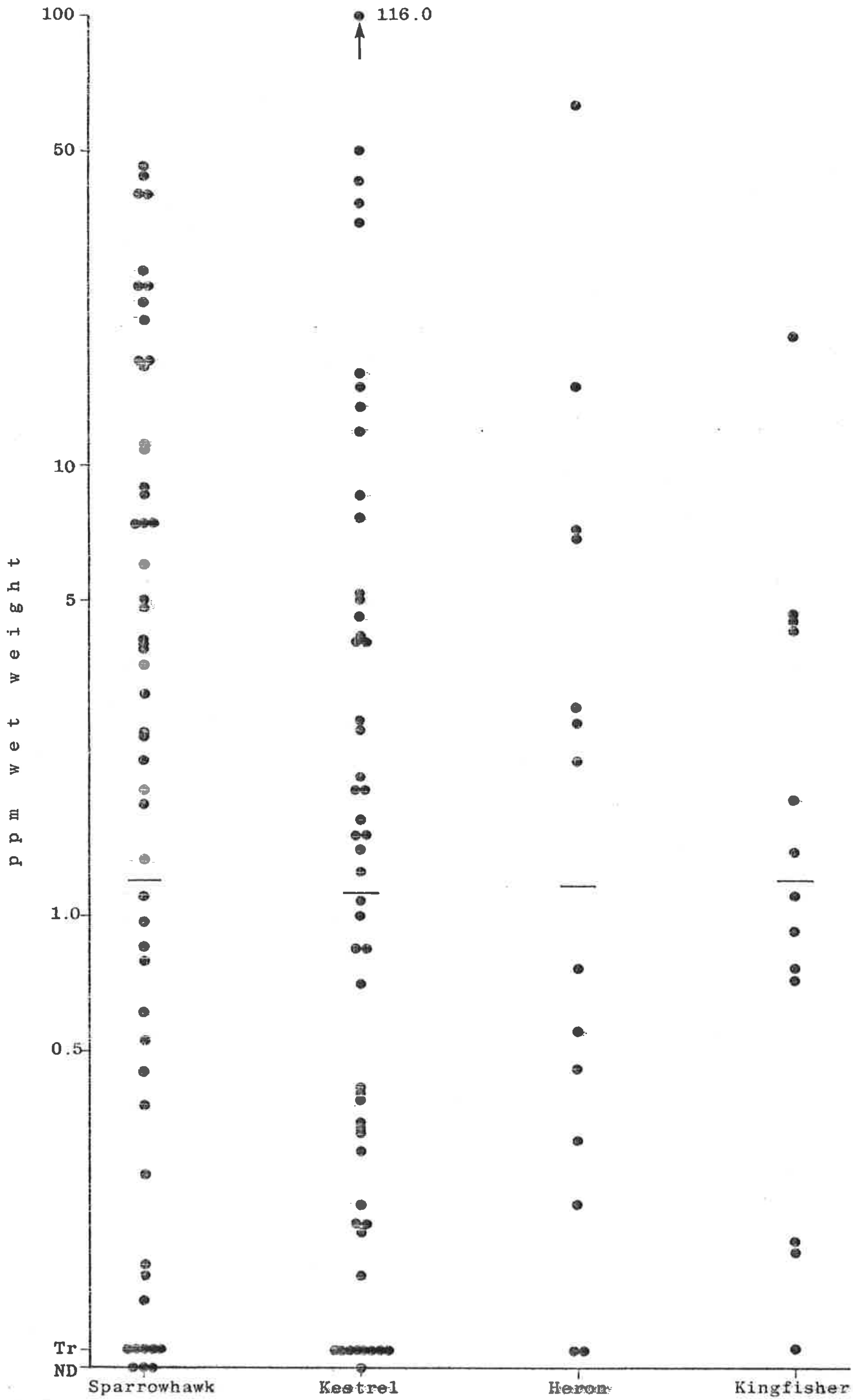


Fig. 4. Mercury concentrations in livers of various predatory birds in 1981. Geometric mean values (——) are shown. ND - nil determined.

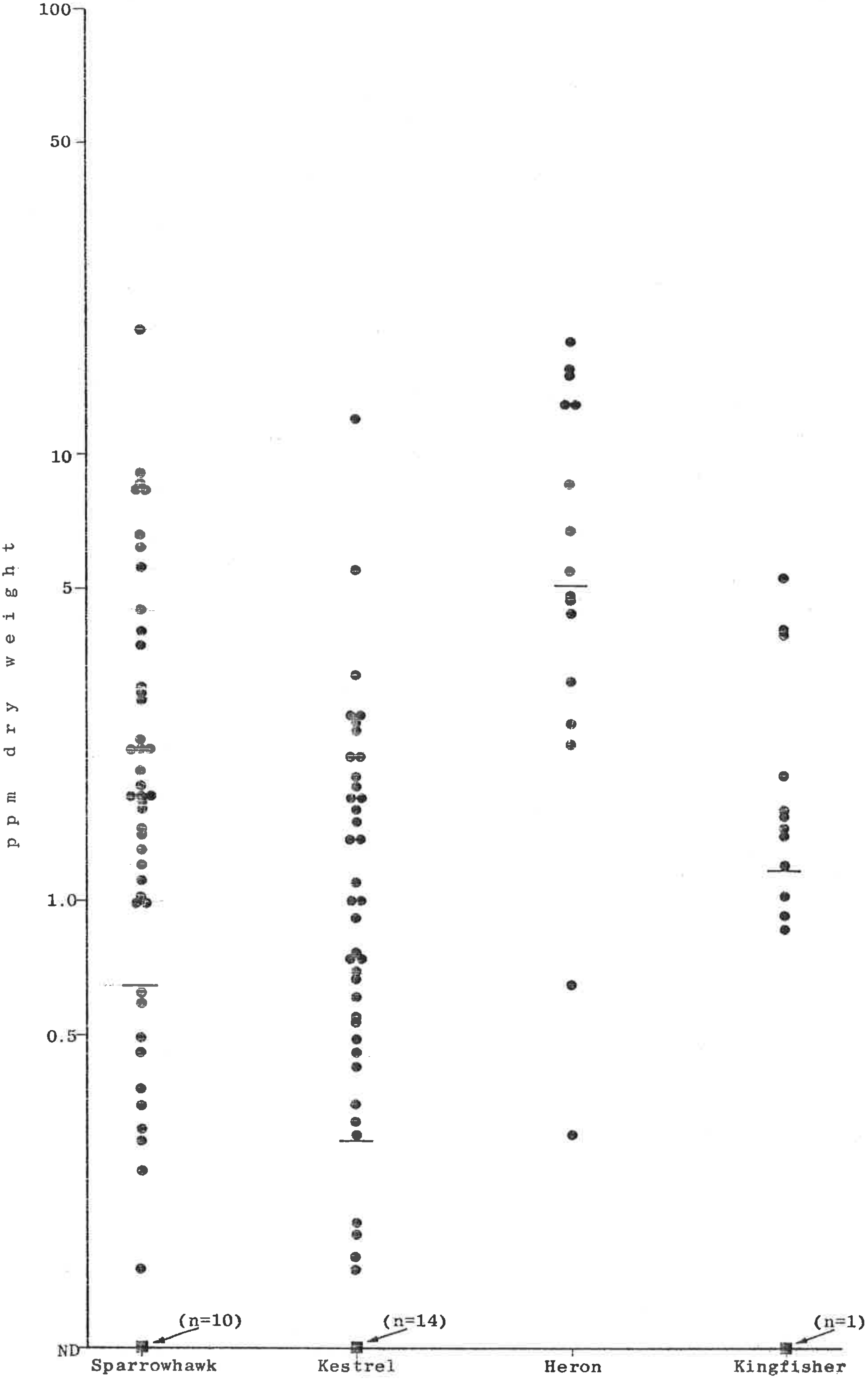


Fig. 5. Cadmium concentrations in livers of various predatory birds in 1981. ND - nil determined.

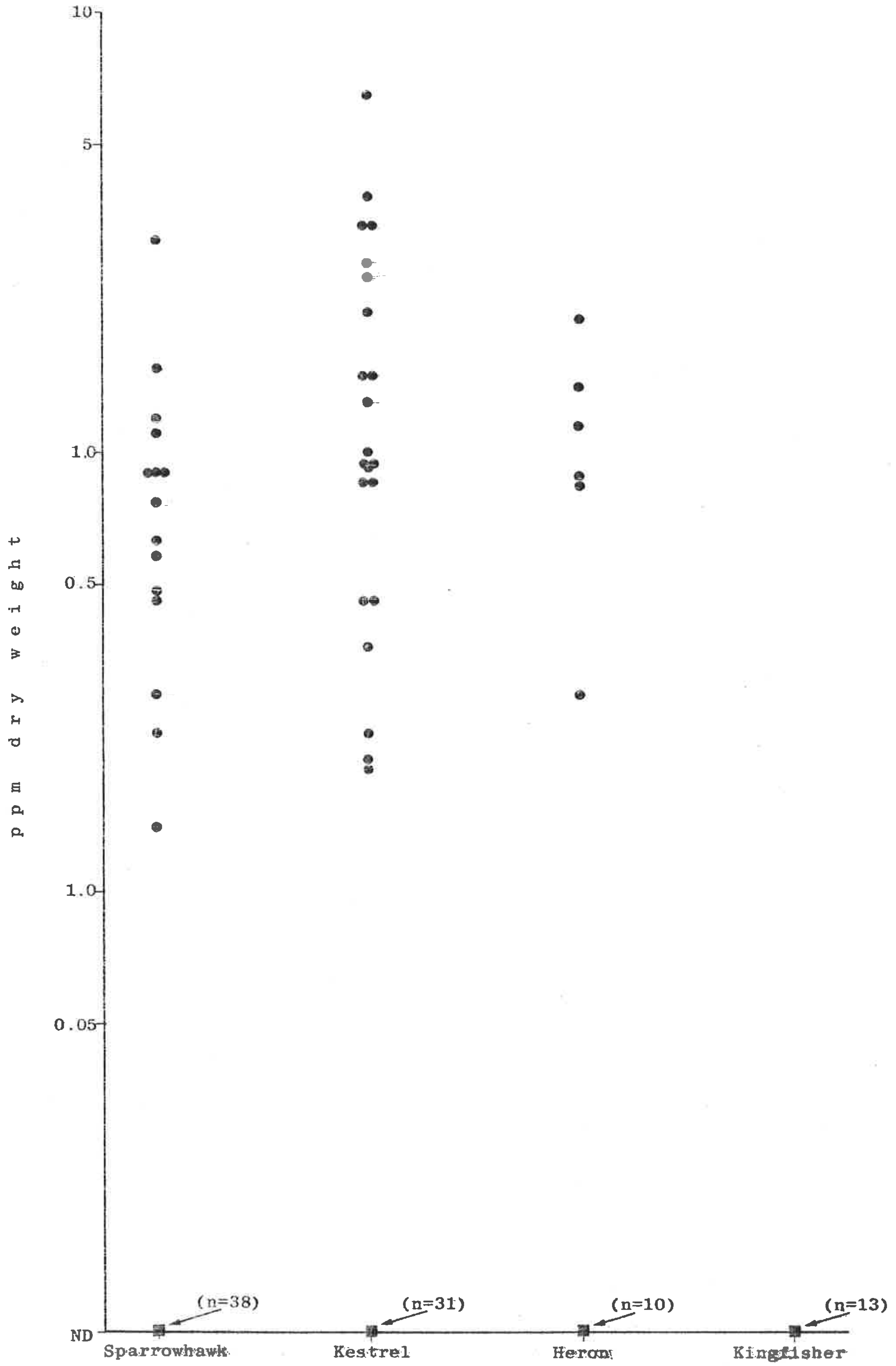


Fig. 6. DDE (left) and HEOD (right) concentrations in eggs of gannets in 1981. ND - nil determined.

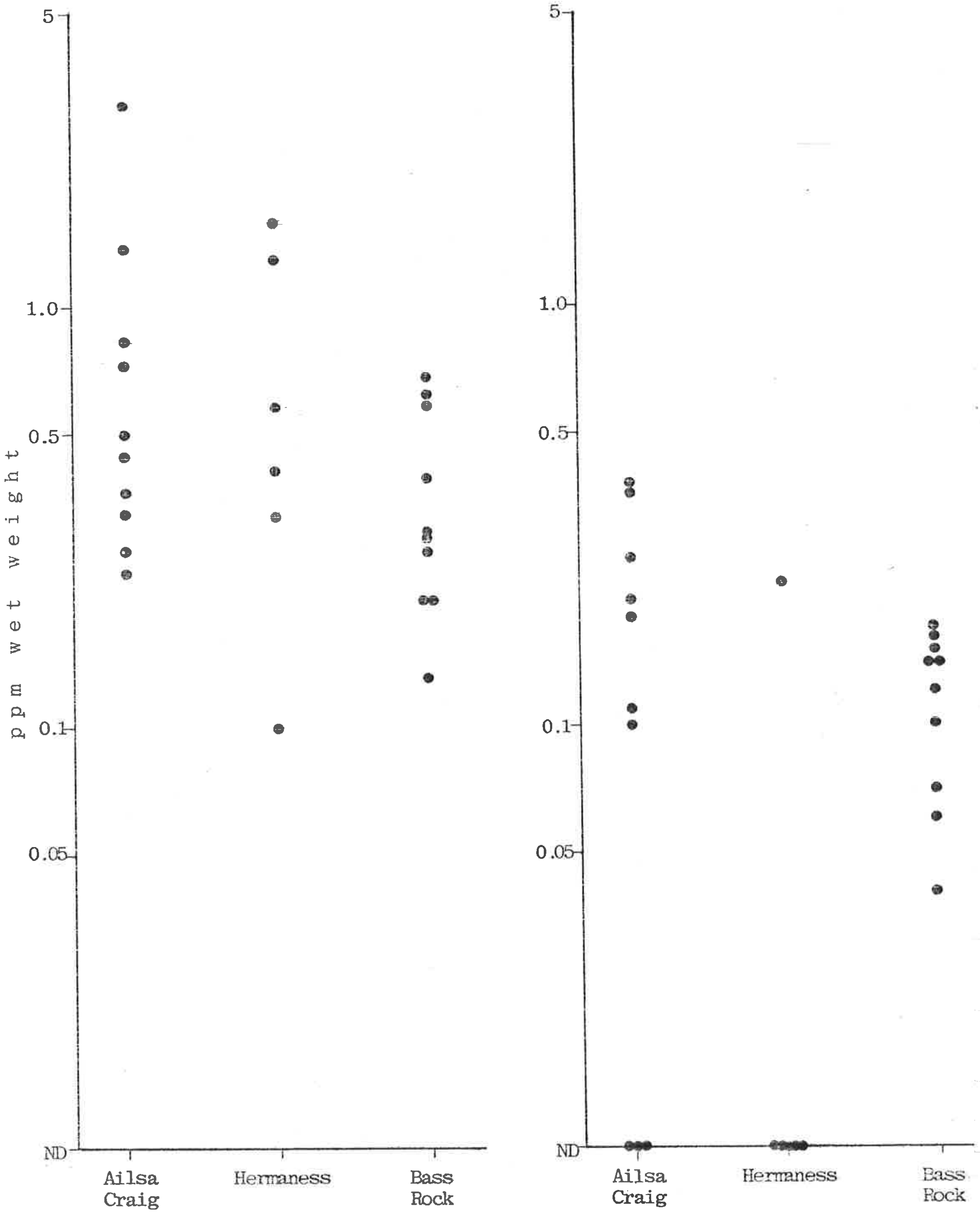


Fig. 7. PCB (left) and Mercury (right) concentrations in eggs of gannets in 1981. ND - nil determined.

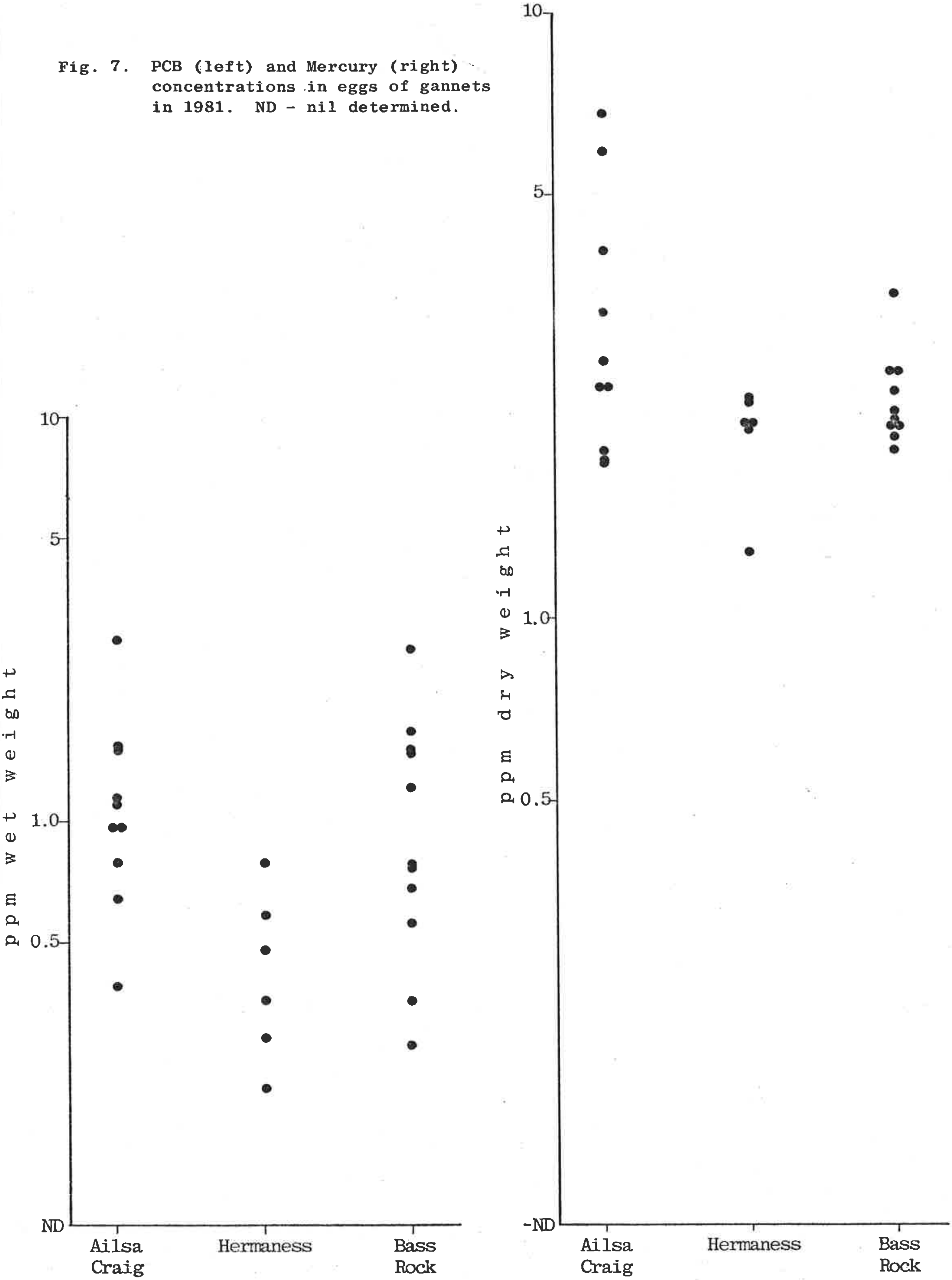


Fig. 8. DDE (left) and HEOD (right) concentrations in eggs of guillemots in 1981.
ND - nil determined.

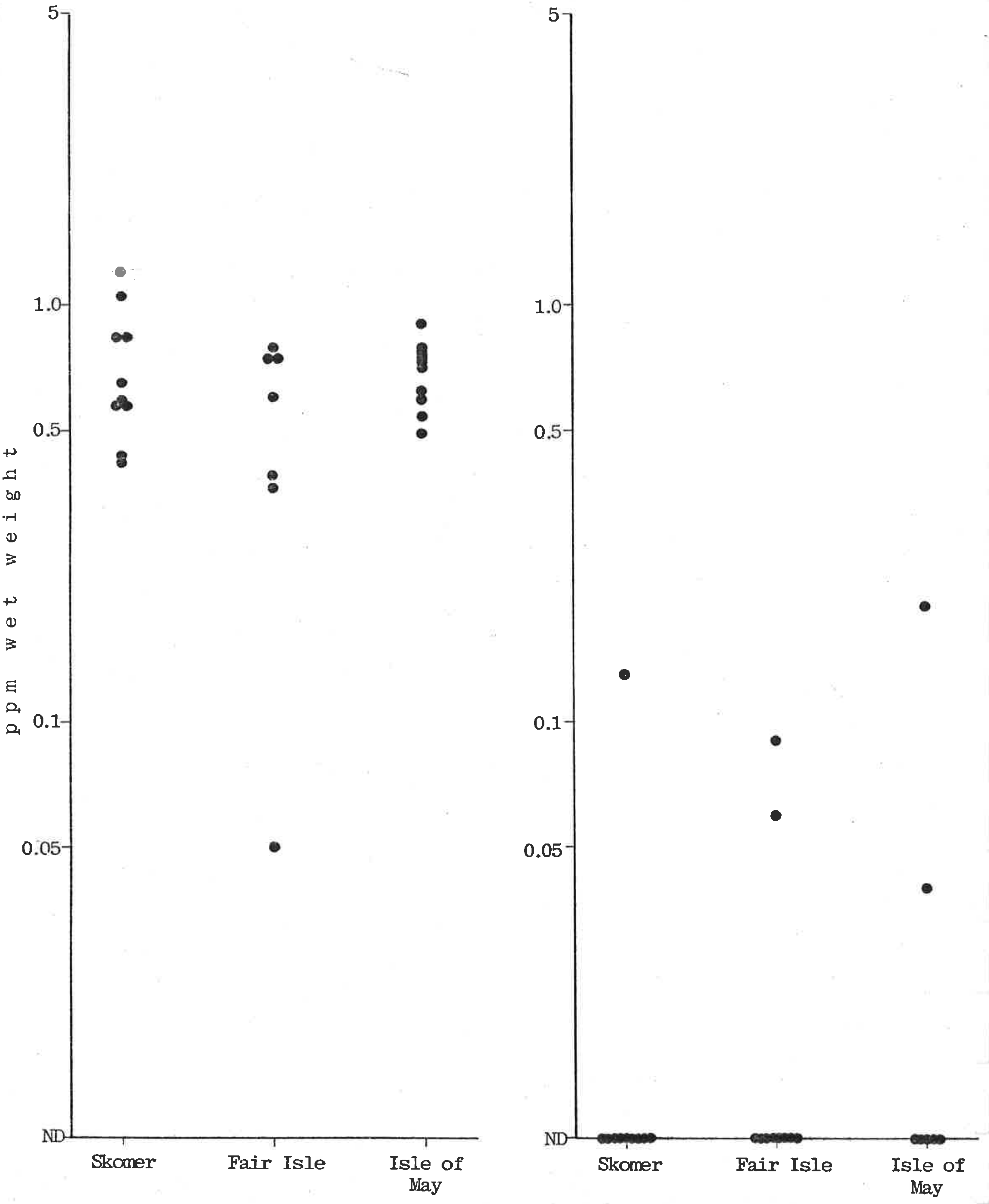
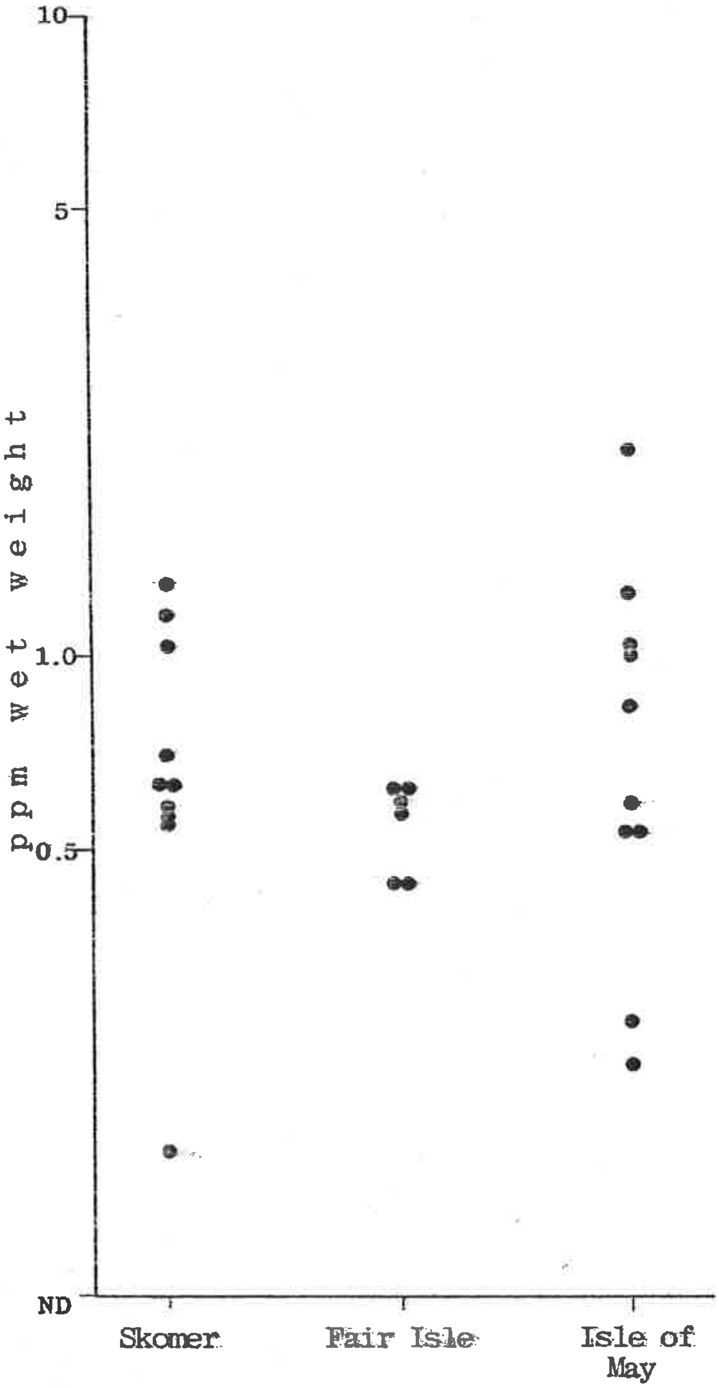
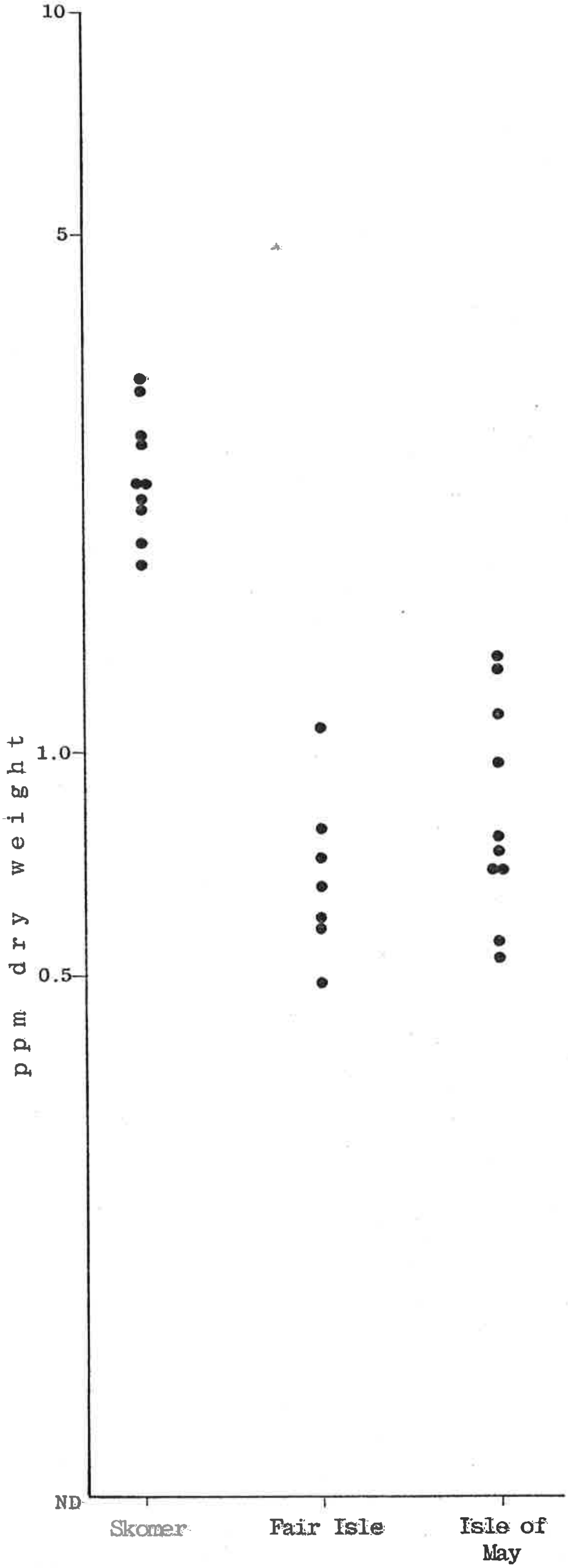


Fig. 9. PCB (left) and Mercury (right) concentrations in eggs of guillemots in 1981.
ND - nil determined.





INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

NCC/NERC CONTRACT HF3/03/199
ITE PROJECT 181
Annual Report to Nature Conservancy Council

BIRDS OF PREY AND POLLUTION

Part II Mersey bird mortality

D OSBORN, K R BULL & W J EVERY

Monks Wood Experimental Station
Abbots Ripton
Huntingdon
Cambs. PE17 2LS

June 1982

2 MERSEY BIRD MORTALITY

2.1 Introduction

2.1.1 This report summarises the studies on the mass mortalities of birds that have occurred on the Mersey estuary during 1979-1981.

Further details are given in two papers now ready for submission to scientific journals. Other papers will be prepared in due course, using information contained in this report, together with the results of other studies still in progress.

2.1.2 In investigating the 1979-81 incidents, two lines of research were followed. First, sick, dead and apparently healthy birds were collected from the Mersey, and healthy birds were collected from other areas. Tissues from these birds were analysed for various toxic chemicals, including total lead and alkyl lead compounds. This work suggested that the bird deaths had been caused by alkyl lead compounds, which probably originate from petrochemical industries on the Mersey (Head *et al.* 1980). Second, detailed observations were made of captive birds that had been exposed to alkyl lead compounds, and these observations confirmed the earlier suspicion that alkyl lead compounds could have caused the mass deaths that occurred on the Mersey.

2.1.3 All methods followed standard techniques used at Monks Wood in previous years.

2.2 Field studies

2.2.1 The 1979 casualties

In 1979, dead and dying birds were first observed on the estuary in mid-September. From then until early 1980, when the last few casualties were reported, about 2400 birds were known to have been affected, the majority of which died. Most casualties were waders, ducks or gulls (Table 12). About half the recorded deaths were in one wader species, namely dunlin *(Calidris alpina)*. Deaths of about 400 black-headed gulls *(Larus ridibundus)* were also recorded. It is not known what proportion the available figures represented of the true number of affected animals, as many carcasses may have been lost to the river, taken by scavengers, or washed ashore in inaccessible or unsearched areas.

Most of the sick birds found were unable to fly and were unco-ordinated in their movements. Lack of feeding activity was also reported, and the waders, especially dunlin, exhibited a head 'shiver' not previously noted in pollution incidents. The droppings, when dry, consisted of a white disk with a brilliant green centre.

20-30% of affected waders and wildfowl were found before they died. In contrast only 3% of the affected gulls were found alive. Veterinary investigations by other laboratories have been summarised elsewhere (Head *et al.* 1980). None was able to attribute the deaths to any disease. Similarly, early post-mortems at Monks Wood eliminated the possibility that food shortage and subsequent starvation were the cause of death, as several of the birds found dead had died before their fat and protein reserves were exhausted. However, these post-mortems did show that affected birds often had discoloured livers and brilliant green bile. Intestinal contents were also green in some birds. This was not, evidently, due to plant remains, as it was observed in species which take animal prey, as well as in plant feeders. During dissection of affected wildfowl and waders, a distinctive and pungent odour was often noted, different from that of decaying tissues. Dead dunlin had activated tibia bone marrow (red in colour). Too few wildfowl were examined at this time to determine whether bone marrow was also activated in these birds. Birds having one or more of these symptoms were said to show abnormal internal features.

In the first batch of casualties received at Monks Wood, no detectable amounts of organochlorine compounds were found. Analysis of livers for metals showed that only lead was present in unusual amounts, the range being 8-31 ppm wet weight in three dead dunlin and two dead redshank (Table 13).

These lead values were much higher than those normally found in waders, even those from industrialised estuaries (Figure 10). Subsequent analyses of 1979 birds concentrated on dunlin (Table 14). A range of tissues was analysed for lead in order to determine (i) which organs were accumulating large concentrations, and (ii) whether the body distribution of lead was consistent with chronic or acute exposure. Further, because lead-based petrol additives are manufactured and used on the Mersey, 25 of the 35 affected dunlin analysed for total lead content were also analysed for alkyl lead content.

These further studies confirmed the initial findings (Table 13), and demonstrated that much of the lead in the tissues was a trialkyl lead compound, most probably trimethyl lead. Trialkyl lead was widely distributed in the body, with a high proportion in the liver, and relatively little in bone. We consider the high proportion in the liver to be indicative of alkyl lead poisoning.

Six dunlin collected sick, but not seriously affected, contained less total lead than did dead and seriously affected birds (Table 14).

Perhaps surprisingly, four live dunlin caught in January 1980 at the mouth of the estuary contained elevated total lead levels an order of magnitude above almost any other lead level recorded for waders (Figure 10). This suggested more birds were at risk than had been involved in the incident.

2.2.2 1980 casualties

In the late summer and autumn of 1980, another mortality incident occurred, involving at least 850 casualties (Table 12). On this occasion, most casualties were gulls, especially black-headed gulls, with few wildfowl and waders. As in 1979, very few (2%) of the gull casualties were found before they died.

a. Waders and wildfowl

Few ducks and waders were found dead or sick in 1980, but those wildfowl and waders which were analysed had lead levels similar to those found in the 1979 casualties (Newton *et al.* 1981). Symptoms displayed by sick birds and post-mortem findings were also similar. A possible reason for only a few dunlin being involved in 1980 was that many of those which would have arrived in September had been killed in 1979; there were less than 100 dunlin counted in September 1980 as against an expected count of 3900 (Table 15).

b. Gulls

Gull tissues were mainly analysed at MAFF laboratories. Gull casualties contained lower lead levels than did wildfowl and wader casualties of 1979 and 1980. The majority of waders and wildfowl contained more than 10 mg Pb kg^{-1} wet wt, while only 1 out of 19 gulls contained this amount.

Whilst lead concentrations in gulls killed in the 1980 incident were noticeably lower than those found in waders and wildfowl casualties (very few gulls were analysed in 1979), these lead levels are substantially greater than those in most gull casualties from other areas (Figure 11). Also the kidney/liver ratio of lead concentrations in the majority of Mersey gull casualties is similar to that in the wader and wildfowl casualties, eg for 19 gulls from the 1980 incident 13 had kidney/liver ratios ranging from 0.5-1.5 the remaining six ranging 1.6-3.0; in comparison, equivalent wildfowl values were 0.6-1.5 for casualties ($n = 11$) and 1.7-4.9 for apparently healthy birds ($n = 11$). The lower kidney/liver ratio for casualties we took as indicative of recent acute exposure for wildfowl, waders (see Table 14) and gulls.

The evidence for trialkyl lead playing an important role in the deaths of the gulls is supported by the results of the laboratory experiments (see section 2.3.3). From these experiments we would expect the lead levels found in dead Mersey gulls to be sufficient to interfere with feeding and nutritional reserves. This in turn would reduce survival prospects, especially if adverse environmental factors or disease were met, eg botulism. Equally, however, it may be that gulls are more sensitive to alkyl lead compounds than waders or wildfowl, in which case it may be significant that virtually all gull casualties were found already dead.

Because gulls were the main group involved in 1980, and because they are often affected by type C botulism in Britain, NWWA and MAFF laboratories undertook an investigation of botulism in affected birds. Two herring gulls *(Larus argentatus)* were found to have the botulism toxin in their blood (K. Wilson, personal communication).

Any role of botulism is less clear than that of alkyl lead. It is true that some of the symptoms in a number of the gulls found alive resembled those of botulism and that botulism toxin has been identified in the blood of four herring gulls (not the main gull species affected, Table 12) in two years. However, botulism has not been confirmed in other gulls examined and the evidence for botulism being the cause of large scale mortalities in the Mersey remains scant.

Possibly, gull deaths must be considered further after examination of tissues and carcasses from the incidents and after experiments to test the sensitivity of gulls to alkyl lead poisoning. We will simply conclude here that the elevated lead levels in the 1980 gulls were probably sufficient to have contributed to their deaths.

2.2.3 1981 casualties

Relatively few casualties were reported in the early autumn of 1981 (Table 12). The behaviour of sick birds was similar to that in the previous incidents, post-mortem examinations yielded similar results, and analysis again showed that the birds were contaminated with alkyl lead compounds.

Of three wildfowl found dead, one contained < 0.3 mg Pb kg^{-1} in all three tissues, and had no abnormal internal features. The second contained 0.91, 5.2, and 6.7 and the third 2.5, 2.2, and 6.1 mg Pb kg^{-1}; and both had internal abnormalities. Two sick dunlin were also examined. These contained trialkyl lead, with values in wet muscle, liver and kidney of 0.83, 2.2 and 3.7, and 0.98, 4.2, 7.0 mg Pb kg^{-1} respectively, and both showed internal abnormalities.

Again, type C botulism was found in two herring gulls. One of these was analysed for trialkyl lead and was found to contain 0.57, 1.4 and 3.1 mg Pb kg^{-1} in wet muscle, liver, and kidney tissue respectively.

2.2.4 Other birds

Three other birds, a teal, redshank and dunlin, were received for alkyl lead analysis. They had been found dead in the region. Liver residues were 0.27, 1.49, and < 0.06, respectively. Only the value in the redshank could be of biological significance. Interestingly this bird was found dead after striking power cables, and Newton *et al.* (1981) cite two other waders with elevated alkyl lead concentrations found dead in similar circumstances. Possibly the alkyl lead concentrations were sufficient to affect co-ordination and increase the chances of such birds hitting power cables.

2.2.5 Studies on live birds from the Mersey and elsewhere: comparison with Mersey casualties

a. Lead concentrations

Although it proved impossible to implement month-by-month sampling of wildfowl and waders, a larger number of apparently healthy birds were collected from the Mersey and other estuaries and analysed for total lead (eg Figure 10). Many birds were also analysed for alkyl lead. Those birds from the Mersey had lower concentrations of lead than casualties from the Mersey, but higher concentrations than birds from other areas. Much of the lead in the Mersey birds was the trialkyl form (Tables 14 and 16). While there was a significant difference between the two Mersey live dunlin samples (Table 14) the samples came from different races of dunlin and perhaps cannot be directly compared. The implication is that levels have declined. There was no clear decline in wildfowl levels during the period September 1980 to September 1981.

However recent analyses from the period November-December 1981 suggest that a decline may now be in progress, although some individuals still have high levels of alkyl lead (Figure 11).

b. Morphological examinations

Many livers of Mersey birds had some of the internal features found in dead and sick Mersey birds (Table 16), suggesting that many apparently healthy birds are at some risk.

c. Significance of lead in apparently healthy wildfowl and waders

There is only limited information about the significance of sublethal lead concentrations in apparently healthy birds. However, Mersey birds with liver levels $\lesssim 0.5$ mg Pb kg^{-1} trialkyl lead seldom had internal morphological changes, whilst birds containing more than this often had such changes (Table 16).

Moreover, laboratory experiments (see section 2.3) showed that birds are at risk when alkyl lead levels reach those associated with internal abnormalities in Mersey birds, for experimental birds with mean liver trialkyl lead concentrations of 3 mg Pb kg^{-1} had internal abnormalities indistinguishable from those seen in wild birds with similar levels (Table 16). Further, such experimental birds had a disrupted feeding pattern and difficulty in feeding was another feature of birds in the incident. Also, these sublethally affected experimental birds had reduced nutritional reserves, an effect not yet established quantitatively for the birds caught on the Mersey, but which is the subject of continuing research.

These results suggest that birds with > 0.5 mg Pb kg^{-1} trialkyl lead could have been at some risk, especially if they met adverse environmental conditions like disease, food shortage, bad weather, or other toxic chemicals. If the same percentage of the estuary's total population was sublethally affected as in our shot and netted samples of wildfowl and waders (Table 16), then several thousand birds could have been suffering some ill-effects from the alkyl lead concentrations they were carrying.

2.2.6 Counts of live birds on the Mersey Estuary

Table 15 shows counts for the seven species of wildfowl and waders most affected in the 1979 incident. Numbers of waders early in the 1980-81 season were low or moderate compared to counts in these months in the 1970s. By mid winter, however, numbers had recovered to 'normal', except for redshank and possibly curlew. For these two species, relatively higher proportions of the birds on the Estuary appear to have been affected (compare Tables 12 and 15). In 1980 and 1981, several species were present on the Estuary in numbers not previously attained. Perhaps, this increase was partially due to a reduction in shooting activity, following warnings issued to wildfowlers about the alkyl lead contamination of the wildfowl. The marked reduction in dunlin numbers in the early part of the season that was seen in both 1980-81 and 1981-82 (as compared to the 1970s data) suggests that an early arriving sub-section of the dunlin population has been particularly badly affected.

2.3 Experimental studies

2.3.1 Background

Even though there was extensive evidence from field studies to suggest that a particular toxic chemical might be causing a problem, the evidence was 'circumstantial' or 'correlative'. The possibility existed that an important environmental factor had not been measured, and that the conclusions would have been different had measurement of the 'missing factor' been included in the research programme. A laboratory-based experimental study enabled us to test hypotheses in controlled conditions.

The toxicity of a variety of trialkyl lead compounds to man and animals had been studied (see Cremer (1965) for a review), but no data existed for birds. Accordingly, experiments were done to test the hypothesis that an alkyl lead compound could kill birds and that its presence at sublethal concentrations could place others at risk. For this hypothesis to be confirmed, alkyl lead compounds would have to be administered to birds, which would then i) have to exhibit behavioural phenomenon similar to the affected Mersey birds, ii) have the same internal lesions and abnormalities as affected birds, and iii) contain similar amounts of lead. The results of one of the experiments has already been reported, but is referred to here for comparison.

2.3.2 Methods

Two experiments were performed, using 2 alkyl lead compounds with which the birds were most likely to come into contact, triethyl lead and trimethyl lead, the latter being the predominant form in the birds. Three different levels of treatment were given to starlings, a convenient and relatively well-known bird for laboratory work: 2 mg trialkyl lead chloride/day, 200 μg trialkyl lead chloride/day, and 0 trialkyl lead chloride/day - the last being the control. It was expected that such dosing with trialkyl lead would result in tissue levels close to those found on the Mersey. The higher dose was expected to be lethal in a short period of time, and the low dose was expected to help determine the 'no effect level' of trialkyl lead in birds.

Birds were dosed at 1400 hours each day with a gelatin capsule containing alkyl lead solution. All birds were dosed daily until they died or until the experiment was ended after 11 doses had been given. It was realised that continuing to dose birds with severe symptoms, which were likely to die shortly, could well lead to concentrations in their tissues higher than those necessary to kill them; nevertheless the procedure was followed for the sake of experimental consistency. Presumably, in the wild, the exposure of birds to alkyl lead and consequent tissue accumulation ceases when birds become unable to feed on contaminated prey. Thus, the concentrations in birds killed in the experiment might be expected to be somewhat higher than in the birds found dead in the wild.

2.3.3 Experimental results

Tissue levels of trialkyl lead in the high- and low-dose laboratory starlings were similar to those found in substantial numbers of birds on the Mersey in the autumn and later summer periods (Table 17, Figure 10).

Morphological changes in the laboratory birds (Table 18) were similar to those found in Mersey birds containing similar levels of trialkyl lead compounds, eg green-stained livers, discoloured intestines, enlarged gall bladders. In the trimethyl lead experiment, all the low dose birds had the same characteristic odour found in Mersey casualties, but fewer birds had this odour in the triethyl lead experiments. In addition, some activation of bone marrow was observed in both groups.

The results suggest that the presence of trialkyl lead compounds cause a number of characteristic internal lesions, all probably deleterious. The internal morphological changes to the enterohepatic system may be 'diagnostic' of trialkyl lead poisoning. They do not seem so apparent in inorganic lead poisoning.

The low dose birds all retained the capacity to fly in the triethyl experiment, and all low dose birds in the trimethyl experiment flew apparently normally. The high dose birds in the triethyl experiment became very quiet and fluffed their feathers as if cold. However, some flew briefly until just before death, which was sudden and often unheralded by anything but the mildest 'symptoms'.

The trimethyl high dose birds exhibited a syndrome so disturbing that 4 of the 6 experimental birds had to be killed before they died. The other two died between inspections. It consisted of head tremors, some shivering, inability to perch, and severe disorientation. They had great difficulty in locating the food. These birds could not have flown. Green droppings were seen in some low dose birds in both experiments, and in many of the high dose birds. The trimethyl birds' droppings were more like those of the affected Mersey birds. These behaviour observations add to the view that trialkyl lead compounds caused the Mersey bird mortalities.

Feeding records during both of the experiments revealed that birds dosed with trialkyl lead compounds had disrupted feeding patterns, in comparison with control birds (Figures 12a and b, and Newton *et al.* 1981). This effect would be of considerable importance for wild birds whose food supply was less certain, particularly as the effect seemed to commence immediately after the first dose, when actual tissue levels may have been low.

Physiological measurements were taken mainly to help determine the 'no effect' level of trialkyl lead, below which birds would be unaffected, and above which they would be subject to serious, if sublethal effects.

In birds, levels of body fat and protein are of great significance for breeding, survival, and migration. Indices of these levels were determined from the bird's total fat content and by the weight of the pectoral muscle (Table 19). In both experiments, these measures were much reduced in the high dose birds, and slightly reduced in the low dose birds. The most marked effect in the low dose groups was the reduction in muscle weight that occurred in the trimethyl experiment, which was probably first evident after 6 doses.

An additional useful measure of physiological function is organ weight, particularly of the liver and kidney (Table 20). It was found that kidney weight was reduced in the high dose trimethyl group and liver weight was increased in the low dose trimethyl group. (The liver often enlarges in the presence of a toxic chemical.) No clear effects on liver or kidney weight were seen in the triethyl experiment.

The physiological observations suggest that, even at low levels, trialkyl lead compounds can adversely affect the physiology of birds.

2.3.4 Experimental conclusions

Trimethyl and triethyl lead compounds killed laboratory birds, whose tissue levels were similar to those of birds on the Mersey. At levels insufficient to cause death, physiology and internal morphology were affected in ways likely to reduce survival, or to make the bird less able to deal successfully with food shortage, bad weather, or disease. These sublethal effects may have begun when concentrations in liver, muscle, kidney or brain reached 0.5-1 μg Pb per gram of tissue (on a wet weight basis).

2.4 Items awaiting further results and research

A number of points raised by the field studies remain to be resolved, and this will only be possible when investigations by the North West Water Authority into the hydrodynamics of alkyl lead compounds in the water and biota of the estuary are complete. It may then be possible to answer such questions as: What is the exact pathway by which the lead reached the birds? Why were mortalities, on the whole, restricted to late summer and autumn? Why, at least initially, were the mortalities associated with high tides? Why were there no noticeable mortalities prior to 1979 and why were they less severe in 1981?

Data from the preliminary report from the water authority (Head *et al.* 1980) suggests that sufficient trialkyl lead compounds are discharged into the Mersey-Manchester ship canal system (estimated as being of the order of 80 kg day^{-1}) to account for the levels found in invertebrates on which the birds could feed, eg *Macoma bathica* contained around 1 mg kg^{-1} lead (mostly alkyl lead) at the time of the 1979 incident. Such concentrations in invertebrates could easily lead to birds accumulating the levels of trialkyl lead found in their tissues. So the pathway to the birds from the factory producing alkyl lead compounds for petrol seems fairly straightforward.

Equally simply we believe the reduction in mortalities in 1980 and 1981, was probably due to the reduced effluent emanating from the factory producing alkyl lead compounds. The reductions were part of the company's continuing policy of effluent improvement.

Probably we shall never fully understand why mortalities were not seen before 1979. Ironically it could be that, as the Mersey has become less polluted, the invertebrate and plant foods which birds eat have themselves increased, attracting more birds to feed in areas where prey are contaminated with alkyl lead compounds, which because of the lack of prey in previous years had not been used as feeding grounds. If so, the Mersey mortalities may be one instance where a general decrease in pollution has led to wildlife mortalities because of the continued presence of harmful quantities of a specific pollutant.

2.5 Conclusions and recommendations

2.5.1 Compared with live birds from other estuaries, dead, sick and live birds from the Mersey contain elevated levels of lead in their tissues, mostly in the trialkyl form. Birds killed with alkyl lead compounds in dosing experiments contain similar amounts of lead to the levels found in dead Mersey birds. In addition, the behaviour and internal features of dosed birds were similar to those of dead and sick Mersey birds.

2.5.2 Assuming that wild waders and ducks respond to lead poisoning in a similar way to captive starlings, we can conclude that the death of birds on the Mersey was primarily the result of contamination of the environment with alkyl lead compounds (see also Head *et al.* 1980).

2.5.3 The experimental results also suggest that birds containing more than 0.5 mg Pb kg^{-1} (wet weight) as alkyl lead have changed internal and physiological features which will reduce their survival prospects. As many Mersey birds contain this amount of alkyl lead, and as such birds often have some internal features similar to those in both the experimental birds and the sick Mersey birds, it seems reasonable to conclude that many of the thousands of birds using the Mersey estuary - one of Britain's most important overwintering grounds for ducks and waders - may be at some risk from the sublethal levels of alkyl lead compounds they contain.

2.5.4 Monitoring of alkyl lead compounds in the Mersey area should continue until acceptable concentrations have been reached in water and biota.

2.6 Acknowledgments

We are grateful to the staff of ITE Chemistry and Instrumentation, Monks Wood, for analytical help, and the following who have co-ordinated and carried out collection of birds: Dr K. Wilson (NWWA), Mr D. Jones, Mr R. Cockbain.

2.7 References

CREMER, J.E. 1965. Toxicology and biochemistry of alkyl lead compounds. *Occup. Hlth Rev.*, 17, 14-19.

HEAD, P.C., d'ARCY, B.J. & OSBALDESTON, P.J. 1980. *The Mersey estuary bird mortality autumn-winter 1979 - preliminary report.* North West Water. Directorate of Scientific Services. Scientific Report Ref. no.DSS-EST-80-1.

NEWTON, I., HARRIS, M.P., BULL, K.R., OSBORN, D., BELL, A.A., HAAS, M.B. & EVERY, W.J. 1981. *Birds of prey and pollution.* Natural Environment Research Council contract report to the Nature Conservancy Council. Abbots Ripton: Institute of Terrestrial Ecology (unpublished).

TABLE 12

Birds found dead and sick on the Mersey Estuary 1979-1981. The counts were carried out between August and the February of the following year, most being completed before mid-December

	1979		1980		1981	
	Total dead & sick	% sick	Total dead & sick	% sick	Total dead & sick	% sick
WADERS						
Dunlin	1336	19	2	100	5	100
Redshank	116	46	5	60	5	100
Curlew	49	41	8		3	100
Knot	6				1	100
Grey plover	5					
Little stint	5					
Green sandpiper	4					
Ruff	2				2	100
Lapwing	2		4	25		
Golden plover	1					
Greenshank	1					
Bar-tailed godwit			1			
Common sandpiper			1	100		
Totals or overall % sick	1577	22	21	5	16	100
GULLS						
Black-headed gull	363	2	343	1	11	10
Herring gull	29	7	87*	2	11	18
Common gull	16	12	22			
Lesser black-backed gull	4		50	4	1	
Greater black-backed gull	1		50	4	1	
Unidentified gulls	15		197			
Totals or overall % sick	433	3	699	2	23	8
WILDFOWL						
Teal	48	25			1	100
Pintail	37	40	1			
Mallard	34	20	30		7	71
Shelduck	16	20			1	
Mute swan	2					
Wigeon	2					
Barnacle goose	1					
Totals or overall % sick	140	27	31	10	9	67
OTHERS						
Starling	5					
Heron	2					
Cormorant	1					
Moorhen	1	100				
Carrion crow	1					
Total or overall % sick	10	10				
Unidentified birds	232		c.113			
Total overall	2392		864		48	

*Type C botulism confirmed in 2 of these gulls in both 1980 and 1981.

TABLE 13

Metal concentrations in livers of dunlin and redshank found dead on the Mersey

	Zn	Cu	Fe	Hg	Cd	Pb	Organochlorine compounds
Dunlin	29.9	4.25	544	2.1	ND	18.5	ND
	26.3	8.00	383	2.7	ND	31.0	ND
	22.2	6.25	370	1.4	ND	12.8	ND
Redshank	15.2	7.75	812	0.8	ND	7.5	ND
	45.2	30.0	1867	4.7	ND	20.2	ND

Figures are mg kg^{-1} wet wt, ND = none detected, limit of detection: metals, approximately 0.1 mg kg^{-1}; organochlorines, 0.2 mg kg^{-1}. The last bird was badly emaciated and the essential metal levels in the liver are no greater than would be expected in such a bird.

TABLE 14

Total and alkyl lead concentrations in dunlin from the Mersey and elsewhere

	n	Total lead mg kg^{-1} wet weight					n	Alkyl lead as mg Pb kg^{-1} wet weight				
		Liver	Kidney	Muscle	Brain	Bone		Liver	Kidney	Muscle	Brain	Bone
Dead, Mersey Nov 1979*	15	$21.2^{x,y}$ ±1.5	30.4 ±2.7	5.39 ±0.37	$7.44^{p,o}$ ±0.32 (7)	15.6 ±12.8 (12)	15	11.4 ±0.81	17.7 ±1.72	3.00 ±0.21	5.13 ±0.42 (7)	-
Nov 1979	20	11.14 ±0.46	13.5 ±0.71	4.10 ±0.24	5.72 ±0.53 (18)	17.2 ±2.08	10	10.10 ±0.79	13.8 ±0.51	4.05 ±0.16	7.69 ±0.30	1.04 ±0.10
Sick, Mersey Oct 1979	6	8.85^{x} ±0.93	7.00 ±0.57	1.20 ±0.18	2.02^{p} ±0.27	23.17 ±3.87			))	b.		
Live, Mersey Jan 1980	4	$4.50^{y,w,u}$ ±1.31	9.40^{s} ±2.52	0.90^{t} ±0.18	$1.78^{o,m}$ ±0.42	15.6 ±3.17			))	b.		
Aug 1981	10	0.39^{w} ±0.10	-	0.19 ±0.03	-	-	10	0.72 ±0.18	1.18 ±0.27	0.33 ±0.18	-	-
Live, Severn Mar 1980	10	0.14^{u} ±0.06	0.18^{s} ±0.05	0.03^{t} ±0.01	0.14^{m} ±0.06	3.44 ±0.67		-	-	-	-	-

a. Where sample sizes differed from that shown for n the number of samples analysed is shown in brackets.

b. Industrial analyst attempted to analyse tissue from these birds which remained after total lead analysis. However, amounts available were too small to allow accurate analysis. It appeared that a high proportion of the lead was in the alkyl form (pers. comm. Associated Octel Co.).

\- = sample not analysed. Means marked by the same letter are significantly different. Student's t-test $P < 0.05$. Only the means believed to be of some biological importance have been so marked.

*from Head *et al.* (1980), all others ITE analysis.

TABLE 15

Winter numbers of selected duck and wader species on the Mersey estuary: mean for 1971/1977 compared with counts for 1979/80, 1980/81 and 1981/82 (G. Thomason and others pers. comm.)

		Sep	Oct	Nov	Dec	Jan	Feb	Mar
Mallard	1971/77	920	740	910	1350	1150	890	500
	1979/80	310	770	850	1250	1750	1400	560
	1980/81	1250	1700	2400	1750	2400	1300	660
	1981/82	190	660	2300	800*	1200	1300	800
Teal	1971/77	2400	4200	6900	7100	7900	6100	3400
	1979/80	460	1000	1250	13000	17500	14000	6800
	1980/81	2500	7200	11000	18000	20000	26000	13000
	1981/82	5400	7300	9400	35000	8000	6100	2300
Pintail	1971/77	1200	3300	6200	8500	7700	5300	1250
	1979/80	110	4200	4700	9800	10000	2800	165
	1980/81	1950	13000	18500	8000	3900	12500	4000
	1981/82	260	4200	11500	6000	4900	2100	52
Shelduck	1971/77	180	360	700	1300	2300	2500	2600
	1979/80	120	390	2700	7400	3600	4000	920
	1980/81	1000	1300	8100	11000	9400	12000	3900
	1981/82	360	2200	12000	6500*	4900	4000	1850
Dunlin	1971/77	3900	11500	25000	23000	26000	25000	11500
	1979/80	1800	2400	22000	21000	22000	29000	2500
	1980/81	63	10000	21000	40000	24000	31000	18500
	1981/82	720	7100	18000	13500*	12000	1850	430
Redshank	1971/77	670	860	1400	960	1100	870	900
	1979/80	160	300	260	670	530	480	290
	1980/81	250	510	670	380	210	1050	600
	1981/82	98	780	550	530	460	460	600
Curlew	1971/77	900	520	400	570	480	560	720
	1979/80	530	210	230	135	220	780	450
	1980/81	1250	430	490	91	330	300	880
	1981/82	810	780	390	145	570	400	120

<u>December 1981 count:</u> Because of the weather conditions, totals for some species were rough estimates, while some areas were not counted, eg Ince Marsh. Species marked * are believed to have been under-counted. On an extra count on 27.12.81, totals included 10700 pintail and 25000 dunlin.

<u>1982 counts:</u> The low counts for several species, eg dunlin, might be blamed on the bad weather.

TABLE 16

Tissue concentrations of alkyl lead compounds in some apparently healthy birds collected from the Mersey and elsewhere, and the proportion with internal characteristics similar to dead and sick Mersey birds

	Alkyl lead as mg Pb kg^{-1} (wet tissue)				Number with abnormalities	Mean liver alkyl lead (mg Pb kg^{-1}) in abnormal birds	Mean liver alkyl lead in normal birds
	n	muscle	liver	kidney			
Wildfowl							
Mersey	24	1.02±0.19 (0.02-3.42)	1.90±0.30 (0.02-5.38)	3.26±0.63 (0.92-13.0)	18	2.34±0.34 (0.2 -5.28)	0.55±0.26 (ND-1.60)
Non-Mersey	4	0.05±0.02 (0.02-0.1)	0.03±0.01 (0.02-0.04)	0.14, n=2 (0.19, 0.09)	0		
Waders	10	0.33±0.08 (0.11-0.97)	0.72±0.18 (0.17-1.94)	1.18±0.27 (0.40-2.81)	4	0.79±0.40 (0.23-1.94)	0.68±0.20 (0.26-1.39)

TABLE 17

Trialkyl lead levels (as mg Pb kg^{-1} wet weight) in tissues of dosed starlings.

Details	Mean	S.E.	Range
<u>Triethyl lead experiment</u>			
Low dose starlings			
Muscle	1.47	0.36	0.4-2.9
Liver	1.07	0.2	0.6-1.9
Kidney	1.85	0.17	1.4-2.5
Bone	0.19	0.02	0.1-0.3
Brain	0.54	0.04	0.4-0.7
High dose starlings			
Muscle	20.0	2.78	9.5-30.0
Liver	40.2	9.35	14.6-92.3
Kidney	19.9	3.22	9.9-28.7
Bone	6.0	1.59	1.4-9.6
Brain	7.3	1.27	3.8-12.3
<u>Trimethyl lead experiment</u>			
Low dose starlings			
Muscle	3.07	0.55	1.6-5.3
Liver	3.70	0.56	2.1-5.6
Kidney	5.38	0.88	2.8-8.0
Bone	0.39	0.12	0.1-0.9
Brain	3.50	0.79	1.3-6.6
High dose starlings			
Muscle	11.0	2.20	6.1-19.4
Liver	32.4	4.93	18.5-49.7
Kidney	30.2	6.21	17.0-57.3
Bone	4.3	1.14	0.2-8.5
Brain	16.7	2.65	10.0-26.7

Levels in control birds were less than 0.1 in all cases.
Low dose = 200 µg day^{-1} PbR_3Cl

High dose = 2 mg day^{-1} PbR_3Cl

TABLE 18

Scores of morphological changes in trialkyl lead dosed starlings. Figures are sum of scores for all six birds in the group. The range of individual scores is in parentheses

	Gall bladder		Bone		Gut		Muscle	
	Triethyl	Trimethyl	Triethyl	Trimethyl	Triethyl	Trimethyl	Triethyl	Trimethyl
Controls	0	3.5(1-1.5)	0	9.5(1-2.5)	0	0	-	17.25(2.5-3)
Low dose	12(2-2)	14.5(2-3)	6(1-1)	11.5(1-2.5)	1(0-1)	7(1-2)	-	12.5(1.5-2.5)
High dose	21(3-4)	22 (2-4)	20(2-4)	17 (1-4)	3(1-2)	16(1-4)	-	0

Gall bladder score is for enlargement; Bone score is for redness of marrow; Gut score is for discolouration; Muscle score is for "condition" or "quantity/quality" of muscle.

Except for muscle: 0 = normal; 4 = greatly different from normal.

For muscle: 0 = wasted; 4 = best possible condition.

TABLE 19

Measures of body condition in starlings. (Means ± S.E.; n = 6; Range shown for lipid values)

	Lean dry body weight (g)	Pectoral muscle (g)	Body lipid (g)	Intramuscular fat (g)
Triethyl experiment				
Controls	21.5±0.7	1.88±0.08	2.92 [2-5]	0.10 [0.04-0.13]
Low dose	21.5±1.0	1.85±0.14	1.72** [0.7-2.4]	0.05 [0.02-0.08]
High dose	17.7±0.3	1.25±0.05*	0.39* [0.3-0.5]	0.005* [0-0.01]
Trimethyl experiment				
Controls	20.5±0.8 (21.3±0.3)	1.98±0.07 (2.03±0.07)	4.5 (5) [2-7.5]	0.16 (0.18) [0.05-0.22]
Low dose	19.7±0.4	1.75±0.09*	4.3 [2-11.5]	0.13 [0.06-0.3]
High dose	17.9±0.7*	1.26±0.12*	2.3 [0.5-11]	0.02* [0-0.13]

* Means so marked are significantly different ($P < 0.05$) from controls; Student's t-test.

** Significantly different if corrected for body size.

In the trimethyl experiment one of the controls was mis-shapen. The figures in parentheses are the means without this bird included.

TABLE 20

Organ weights in starlings (Means ± S.E.) dosed with trialkyl lead compounds

	Liver wt (g)	Kidney wt (wt)
Triethyl experiment		
Controls	2.77±0.23	0.91±0.05
Low dose	2.89±0.13	0.98±0.03
High dose	1.78±0.08*	0.84±0.05
Trimethyl experiment		
Controls	2.80±0.05	0.90±0.03
Low dose	3.23±0.14*	0.95±0.05
High dose	1.47±0.13*	0.61±0.02*

*Means so marked are significantly different from the controls $P < 0.05$, Student's t-test.

The values for a mis-shapen bird did not alter these means importantly.

Figure 10

All birds from the Mersey were collected between September 1979 and December 1980 during the periods when mortalities were occurring or soon after.

Birds from other sites were collected specifically for comparison with Mersey data during the same time periods or were collected at earlier times and analysed for lead soon after collection.

Not all the data is from ITE analysis. Some of the casualty dunlin and almost all the casualty wildfowl have been analysed by industrial analysts, while MAFF laboratories analysed the Mersey casualty gulls.

Fig. 10. Liver lead levels mg kg^{-1} wet weight in waders, wildfowl and gulls from the Mersey and elsewhere.

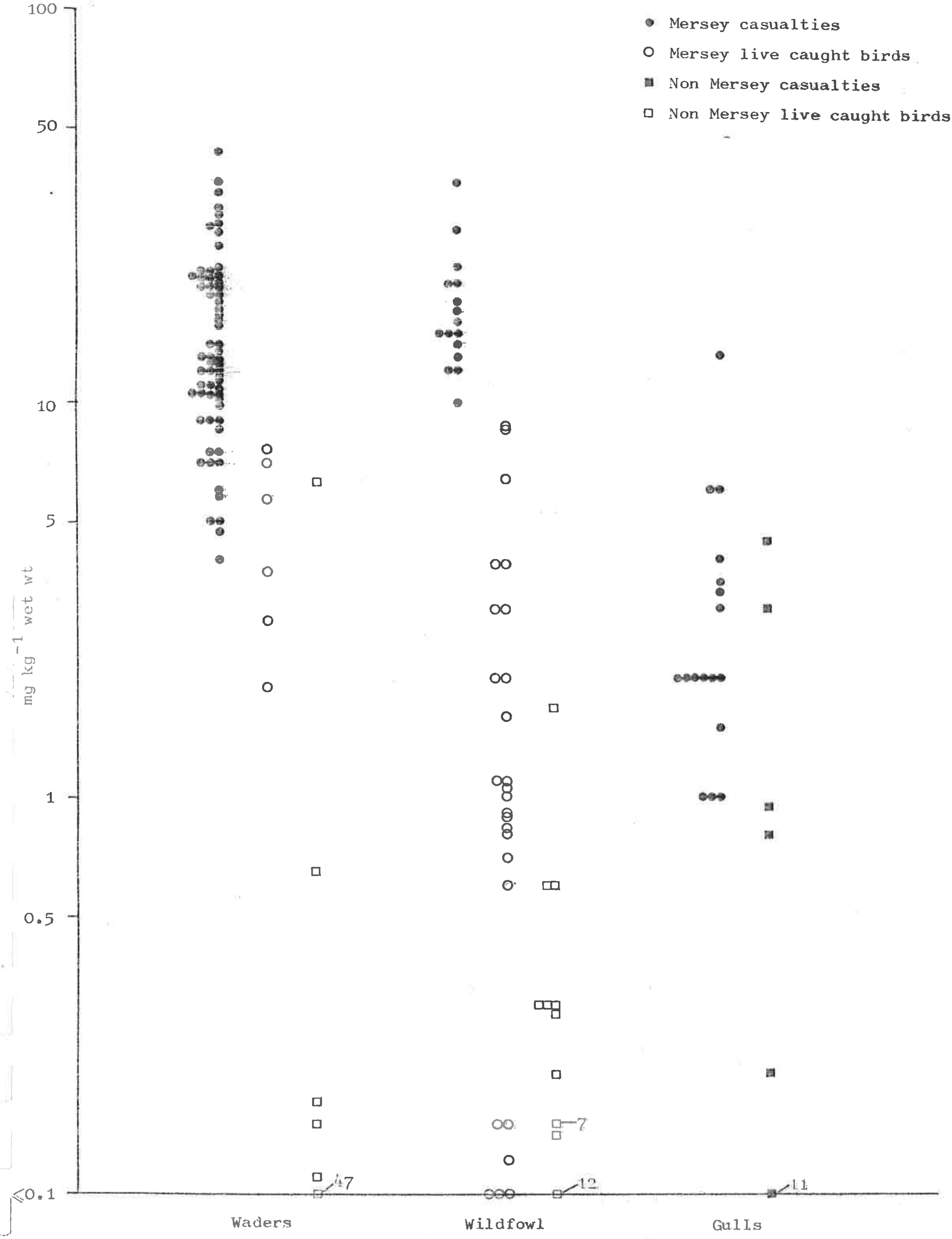
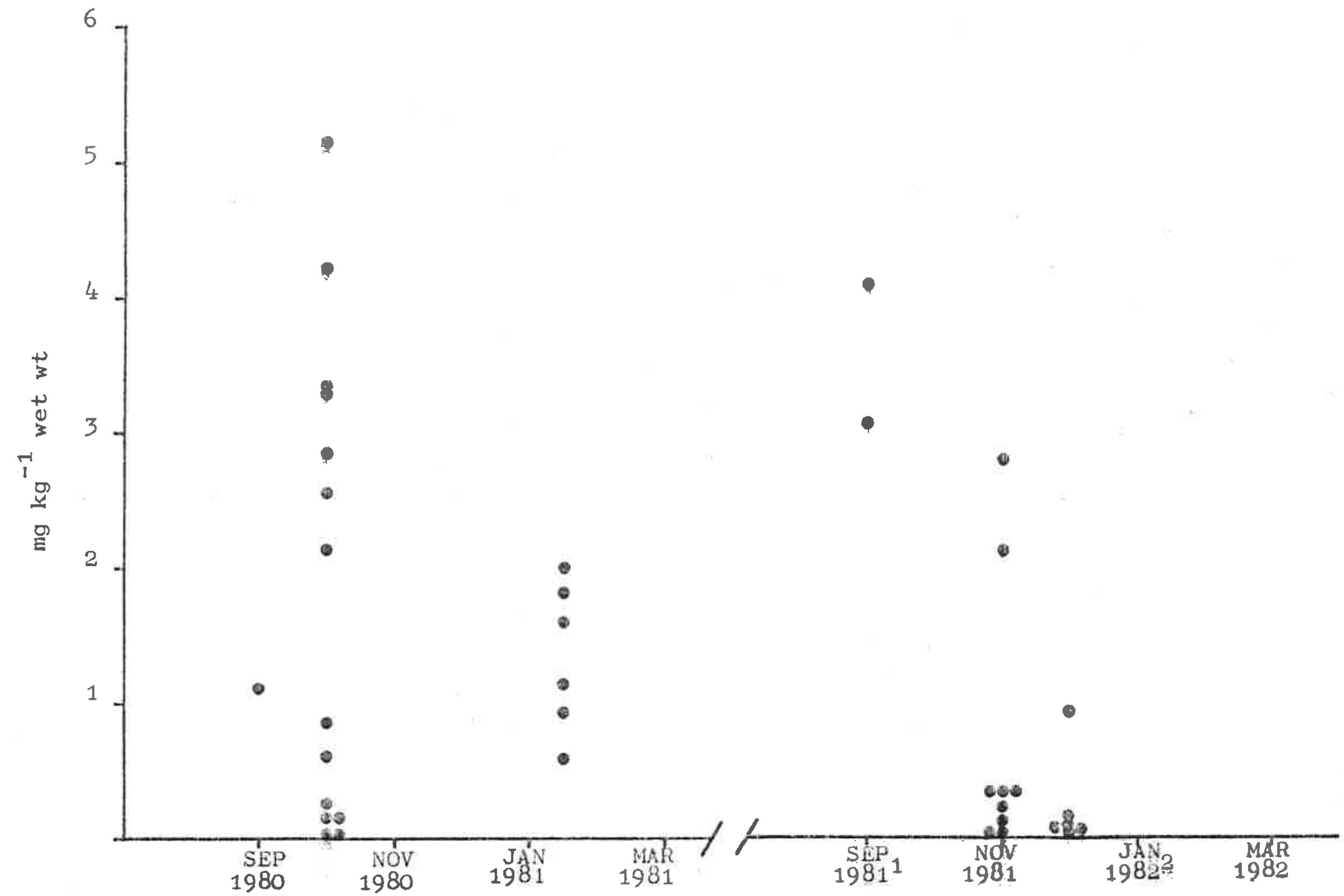


Fig. 11. Alkyl lead concentrations (mg kg^{-1} wet weight) in livers of wildfowl shot on the Mersey September 1980-March 1982.



(1) We hope to obtain more liver samples from the Liverpool University Veterinary Centre for September 1981.

(2) No samples as shooting restricted due to bad weather.

Fig. 12a. Daily food consumption in starlings receiving 200 µg trimethyl lead chloride per day.

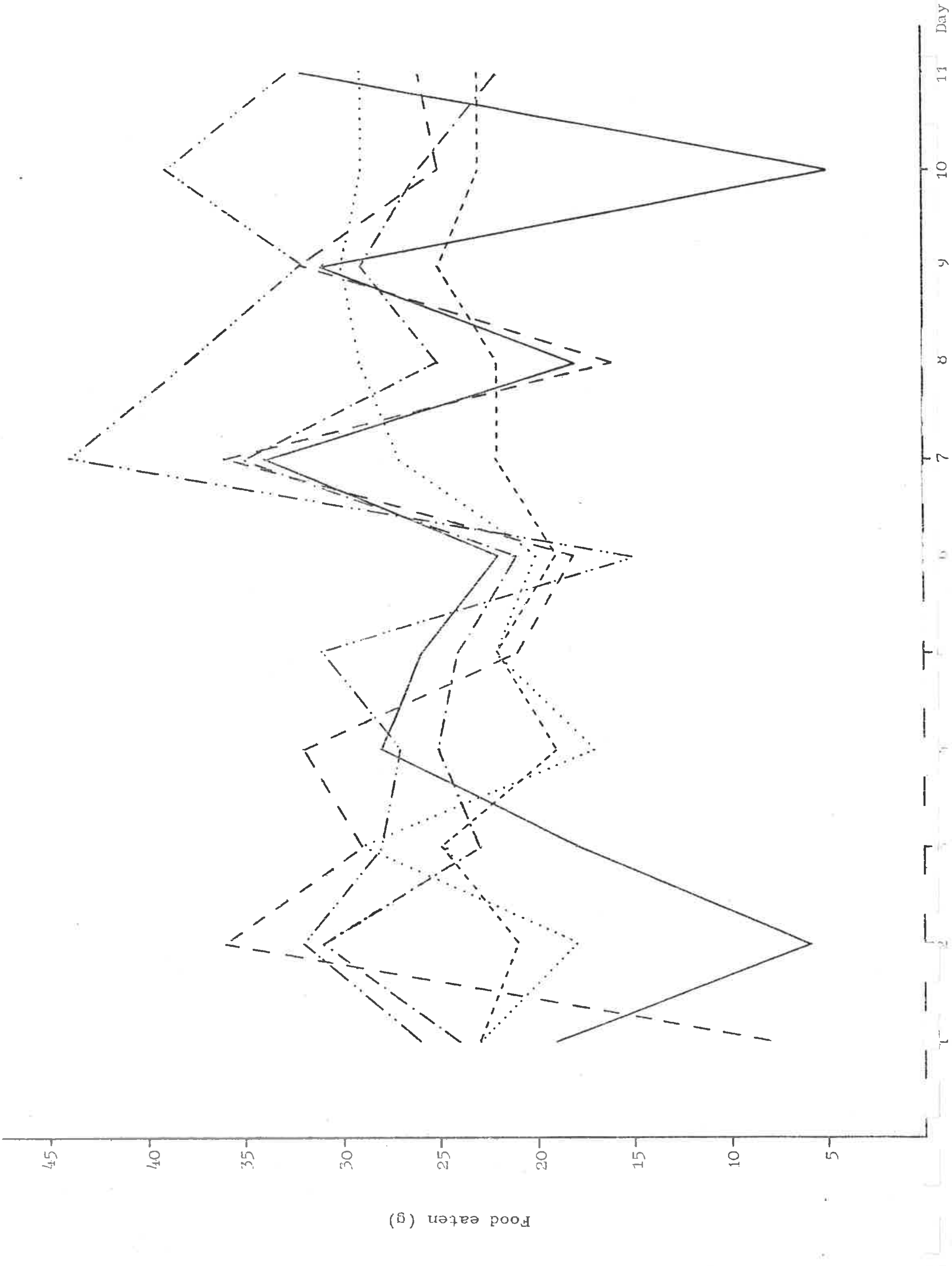
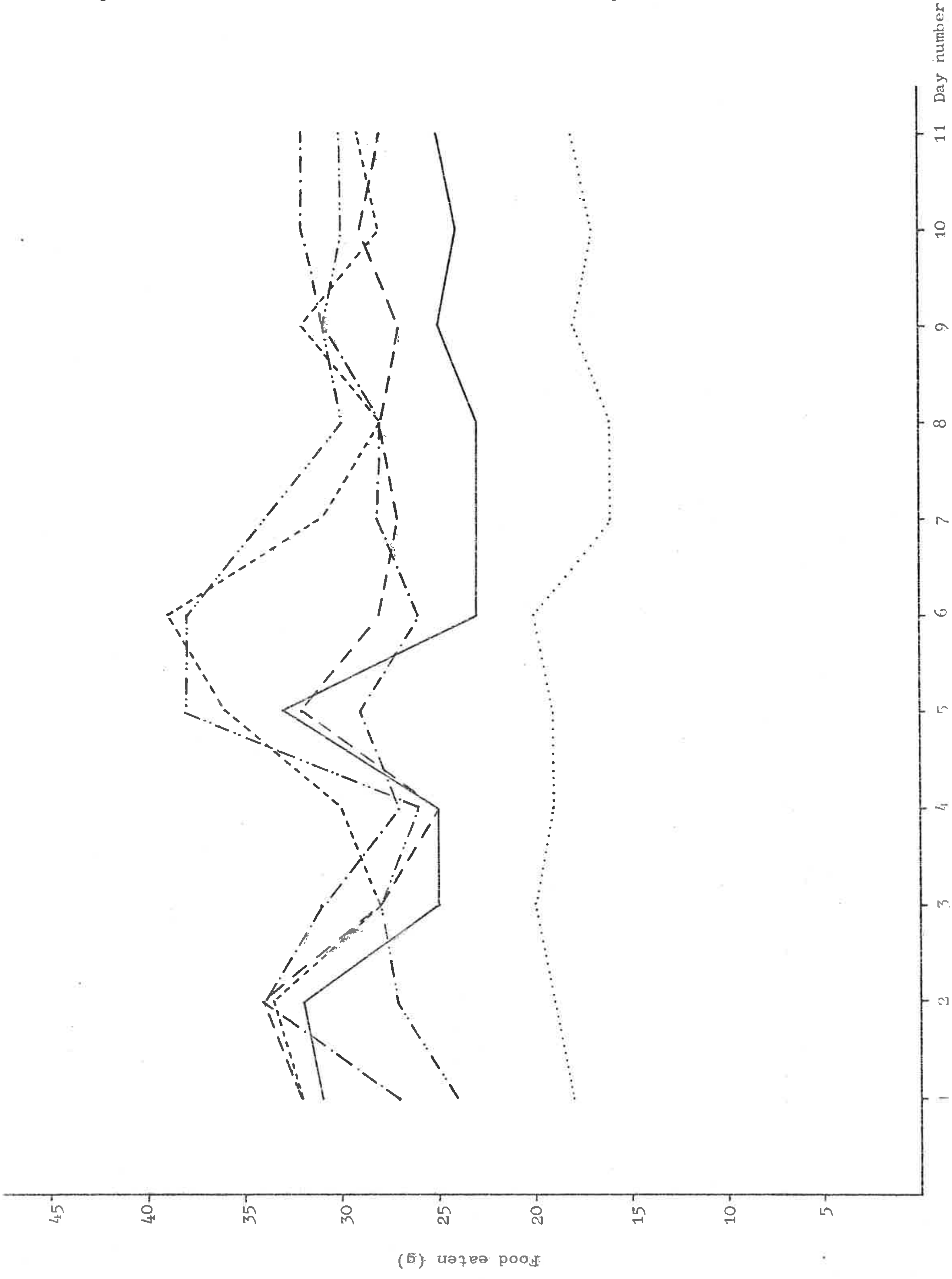


Fig. 12b. Daily food consumption in control starlings.



INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

NCC/NERC CONTRACT HF3/03/199
ITE PROJECT 181
Annual Report to Nature Conservancy Council

BIRDS OF PREY AND POLLUTION

Part III Incident investigations

D OSBORN & W J EVERY

Monks Wood Experimental Station
Abbots Ripton
Huntingdon
Cambs. PE17 2LS

June 1982

3 INCIDENT INVESTIGATIONS

Four incidents have been investigated in the past year, involving the unusual behaviour or deaths of birds.

3.1 Whooper swans *(Cygnus cygnus)* from Possil Marsh

This investigation was conducted in association with Barry Pendlebury (NCC) who supplied tissues, gizzard contents and one whole carcass for examination. He also sent tissues elsewhere and so this report contains only part of the information available on the incident.

Analytical results and other details for 4 gizzards and 4 livers and from the carcass 6018 are given in Table 21. There is no relationship between the amount of shot in the gizzard and the lead concentration in the liver.

All the lead in the gizzards was in the form of cartridge shot, rather than fishing weights.

Apart from bird no. 81/44/6, lead liver levels were high enough to have caused death.

Carcass 6018 had the clean shrunken organs that have previously been noted in ducks supposedly poisoned by lead effluent from a pottery factory. This internal appearance is very different from that of animals killed by exposure to alkyl lead compounds.

3.2 Black-headed gulls *(Larus ridibundus)* from Ravenglass

The Ravenglass colony showed poor breeding success in 1980 and 1981. Some birds from 1981 were sent to Monks Wood for analysis. Nothing unusual was found in terms of organochlorine or metal residues, except for one gull which had a high concentration of lead in its tissues (Table 22). This bird is currently being analysed for alkyl lead.

3.3 Mute swans *(Cygnus olor)* from Mistley

A report was received that a large number of swans on the Stour estuary were behaving in a manner consistent with lead poisoning. However, subsequent investigations suggest that relatively few birds were involved. Two swans from the area were examined. These contained 1.3 and 1.0 mg Pb kg^{-1} dry liver tissue, and thus were unlikely to have been suffering from lead poisoning. Samples of material that the swans may have eaten were also taken for analysis. A starch-like material contained lead at 277 mg kg^{-1} wet wt and some grain husks contained 29.6 mg kg^{-1} wet wt. The faeces of a bird that was caught contained 55.6 mg kg^{-1} wet wt, but the toxicological significance of this is unknown.

We have been unable to find what caused the unusual behaviour, but have not yet investigated the effluent from a nearby brewery. Meanwhile, no further reports of unusual behaviour have been received.

3.4 Shetland auk wreck

In the second half of February and in early March 1982, about 600 auks were washed-up on the coast of Shetland. Local NCC representatives hold more precise details of where the birds were found.

Four birds were sent to Monks Wood for analysis. The results did not suggest that the birds had suffered from metal or organochlorine poisoning (Table 23). However, γ-BHC was found in the liver, and this chemical is not normally detected in seabird livers.

Post-mortem examination revealed wasted breast muscles and the absence of most of the normally thick layer of subcutaneous fat.

We concluded that these birds encountered adverse weather conditions and starved. It is likely that γ-BHC accumulated in the liver following loss of the fat in which γ-BHC is perhaps normally present at very low or undetectable concentrations.

TABLE 21

Summary of results of analyses of whooper swans

Bird code	Gizzard contents	Lead (mg kg^{-1} wet wt) Liver	Kidney	Probable cause of death
81/44/1	Very little vegetation. 44 pieces of lead shot (various sizes) weighing 2.72 g.	25.0		lead poisoning
81/44/2	Packed with grass etc. One very small piece of lead shot found weighing 0.002 g.	13.6		" "
81/44/5	Packed with grass etc. No shot found. Very little grit.	11.6		" "
81/44/6	Packed with grass etc. One piece of lead shot weighing 0.04 g found.	ND*		unknown
6018	Packed with grass etc. Lead shot weighing 0.31 g found.	15.5	25.8	lead poisoning

NOTE: * This liver was an unusual slate blue colour and contained about 0.05 mg Pb kg^{-1}, as alkyl lead.

ND - none detected.

TABLE 22

Ravenglass gulls : Analytical results

	mg kg^{-1} wet weight					
Bird No.[4]	DDE	HEOD	PCB	Pb[1]	Cd	Hg
1	ND	ND	0.03	c.0.8	0.84	0.07
2	ND	0.10	0.02	ND	0.41	0.09
3	0.20	0.08	0.03	c.2	0.63	0.07
4	ND	ND	0.02	c.0.5	0.54	0.04
5	ND	0.20	0.05	ND	1.54	0.12
6	0.11	0.08	0.03	ND	0.61	0.13
7	0.26	0.05	0.02	19.8[2]	0.42	0.07
8	0.05	ND	0.02	ND	0.97	0.10

NOTES:

1. Lead levels < 2 mg kg^{-1} are at the limits of detection of the equipment used.
2. Analysis in progress for alkyl lead.
3. Zn and Cu values were in the normal range, Cu possibly a little low.
4. Birds were not identified in any way.

Although some of the lead levels appear to be slightly elevated they would not seem to be sufficient to explain the observed problems. If alkyl lead is proved to be present, however, this view might need revision.

ND - none detected.

TABLE 23

Residues in auk livers from the early 1982 Shetland wreck

Bird	mg kg^{-1} wet weight			
	DDE	HEOD	γ-BHC	PCB
Razorbill	4.54	ND	0.46	4.33
Guillemot	2.92	0.47	0.34	2.00
"	3.31	ND	0.50	3.89
"	1.03	ND	0.27	0.29

ND - none detected.

INSTITUTE OF TERRESTRIAL ECOLOGY
(NATURAL ENVIRONMENT RESEARCH COUNCIL)

NCC/NERC CONTRACT HF3/03/199
ITE PROJECT 181
Annual Report to Nature Conservancy Council

BIRDS OF PREY AND POLLUTION

Part IV PCB residues in PCB-dosed puffins

M P HARRIS & D OSBORN

Monks Wood Experimental Station
Abbots Ripton
Huntingdon
Cambs. PE17 2LS

June 1982

4 PUFFINS AND PCB

4.1 PCB residues

Monitoring has continued to follow the elimination of PCB from the dosed birds, six dosed birds were collected in March 1981. More birds were collected recently but have yet to be examined.

Only fat contained any PCB in either the dosed or control birds, but, again, the concentrations were higher in the dosed birds than in the controls.

Concentrations of PCBs in the 4 control birds were much lower than those seen in previous years, but, on such a small sample, little weight could be put on the result.

We cannot explain this sudden apparent drop in PCB concentrations in puffin fat.

The monitoring exercise continues to produce information on a number of other topics concerned with the pollutant content and physiology of puffins.

TABLE 24

Levels (mg kg^{-1} wet weight) of PCB in tissues of puffins killed at various times after implantation of PCB (dosed) or sucrose (control)

	Months after implantation	Fat	Liver	Kidney	Muscle	Brain
Dosed	1	301	43.1	ND	6.9	ND
	1	299	24.5	2.6	3.9	ND
	1.5	251	9.9	ND	7.3	ND
	3.5	280	ND	ND	ND	ND
	3.5	347	48.4	ND	21.1	50.9
	3.5	612	16.4	9.9	20.4	4.0
	3.5	610	21.5	12.5	20.1	ND
	3.5	516	24.0	11.3	25.2	ND
	3.5	451	23.1	11.6	17.8	13.0
	9	654	6.3	4.7	2.3	<1.0
	9	371	2.1	<1.0	2.6	<1.0
	9	429	14.0	<1.0	6.3	1.2
	12	284	10.0	4.5	8.1	ND
	12	105	3.5	2.6	4.0	ND
	12	294	17.3	2.8	10.2	4.5
	12	141	9.8	2.7	3.4	1.0
	12	457	10.5	8.2	14.8	6.0
	16	341	ND	ND	ND	ND
	16	200	ND	ND	ND	ND
	16	128	<1.0	ND	ND	ND
	16	211	30.3	14.1	12.4	8.2
	16	214	ND	ND	ND	ND
	16	118	1.2	1.0	7.7	2.7
	34	–	7.7	1.6	3.2	7.6
	34	93.5	2.4	ND	ND	ND
	34	124	3.2	ND	2.0	ND
	34	82.2	ND	ND	ND	ND
	34	97.1	2.6	ND	ND	ND
	34	97.1	1.0	ND	ND	ND
	48	7.81	ND	ND	ND	ND
	48	12.2	ND	ND	ND	ND
	48	8.64	ND	ND	ND	ND
	48	0.59	ND	ND	ND	ND
	48	1.27	ND	ND	ND	ND
	57	0.62	ND	ND	ND	ND
Control	3	ND	ND	ND	ND	ND
	24	25.7	ND	ND	ND	ND
	24	69.9	1.3	1.9	1.0	1.4
	24	34.5	ND	ND	ND	ND
	26	49.4	ND	ND	ND	ND
	28	38.5	ND	ND	ND	ND
	34	57.0	ND	ND	ND	ND
	34	73.6	ND	ND	ND	ND
	34	28.7	ND	ND	ND	ND
	34	28.1	ND	ND	ND	ND
	48	0.37	ND	ND	ND	ND
	48	0.59	ND	ND	ND	ND
	48	0.25	ND	ND	ND	ND
	48	2.95	ND	ND	ND	ND

NOTE: ND - none detected; –, no fat present at sampling site.