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Polychlorinated Biphenyls and Organochlorine Pesticides in the Australian Fur Seal, *Arctocephalus pusillus doriferus*

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Seals occupy a high trophic level in the marine ecosystem and have large reserves of subcutaneous fats. It is, therefore, not surprising that they accumulate high concentrations of lipophilic substances such as organochlorine pesticides. Seal tissue concentrations of pesticides are considered by some workers to be a good indication of local environmental loads (Holden 1978; Hidaka et al. 1983). The Australian fur seals at Seal Rocks occupy a breeding colony from which they can range into Bass Strait, Westernport Bay and Port Phillip Bay (Fig. 1). It is, therefore, reasonable that results obtained for local seals should provide an indication of pesticides and PCBs in local squid and schooling fish.

Richardson and Waid (1983) provide results indicating that biota in Port Phillip Bay and Bass Strait, adjacent to the colony are exposed to elevated concentrations of PCBs. We have determined PCB and pesticide levels in local seals.

MATERIALS AND METHODS

As part of an ongoing tagging project, Australian fur seals Arctocephalus pusillus doriferus from Seal Rocks, Victoria Australia (Fig. 1) were collected by scientists from the Arthur Rylah Institute for Environmental Research, Department of Conservation, Forests and Lands (Bacher 1985).

Seals were dissected in the field, samples were wrapped in Al foil and returned to the laboratory for PCB and organochlorine pesticide analysis. Samples (10g) were supplemented with an equal weight of anhydrous sodium sulphate and extracted three times into hexane (100 mL) using a high speed blender. The hexane extracts were

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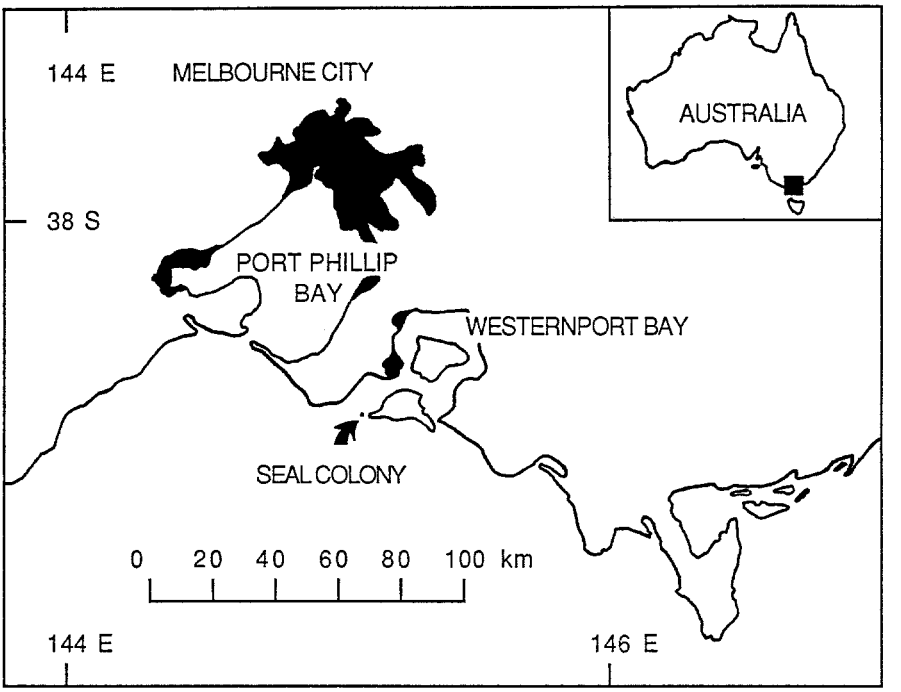

Figure 1. The seal breeding colony at Seal Rocks, Australia, adjacent to Phillip Island. The darkened areas on the western side of Westernport Bay are industrial estates.

combined and the volume reduced to 5 mL on a Kuderna Danish apparatus, the extract was partially cleaned up by column chromatography (10g alumina deactivated with 0.5g water) and eluted in 50 mL of hexane. The volume was again reduced to 5 mL and given a final cleanup using concentrated sulphuric acid.

Analysis was carried out using a Hewlett Packard model 5880 gas chromatograph. Samples (3 µL) were introduced onto a 25m bonded phase capillary column (equivalent to SE 54) using a split/splitless injection. The oven temperature program started at 65°C for 0.4 min and was then increased by 20°C min^{-1} to a final temperature of 220°C. Compounds were detected using electron capture. No baseline drift was detected under these conditions.

Pesticides were quantified against authenticated standards supplied by the Victorian Government Analytical Laboratory (Melbourne, Australia). The samples contained pesticide peaks which partially obscured some of the PCB peaks. A further alkaline

hydrolysis cleanup step was, therefore, required. The pesticides were hydrolysed in 1 mL of methanol:water:KOH (8:2:1, v:v:w) for 1 h at 60°C. PCBs were repartitioned into hexane and injected into the GC. PCBs (detection limits 50ng) were quantified against all the peaks in mixtures of commercial standards (Monsanto).

Pesticides analysed included both o,p' and p,p' isomers of DDT, (1,1 -(2,2,2-trichloroethylidene) bis [4-chlorobenzene]) its derivatives TDE, DDE, and (hexachlorobenzene) HCB, lindane, heptachlor, heptachlor-epoxide and aldrin (detection limits 10ng).

RESULTS AND DISCUSSION

All of the seals contained PCBs, DDT, DDE and some TDE (Table 1); some also contained trace amounts of hexachlorobenzene (γHCB) and hexachlorocyclohexane (HCH), particularly in the blubber. In all samples the DDT p,p' isomers were present in high proportions compared to the o,p' isomers.

Much attention has been given to describing the distribution of PCBs and pesticides within animals in an attempt to understand the mechanisms of accumulation, partitioning and depuration. There is now sufficient evidence to support the contention that PCB and DDT levels in the blubber of male seals increases with age (Addison and Smith, 1974) but reaching a plateau value in later life. Other researchers have also made this observation but have added the modifier that organochlorine concentrations are also inversely correlated with blubber thickness (Donkin et al., 1981).

Our sample contained only 7 males making it difficult to attempt any in depth statistical analysis. Indeed, very low correlations between age and PCB concentrations in blubber were indicated for males ($r = 0.09$) as well as the whole population ($r = 0.10$); that is to say, the population samples were relatively heterogeneous.

The breeding colony at Seal Rocks is very close (30 km) to a number of industrial complexes, which include two oil refineries, a steel mill and a naval dock yard. Results from tagging studies (Warneke, 1975) indicate that while immature pups remain close to the colony, older animals tend to range much further. It is quite conceivable that some individuals may spend time feeding in the vicinity of these sites and, therefore, be exposed to much higher levels than individuals which have fed outside Westernport Bay. The male seal (08) may be one of these as all of its organs contained

elevated concentrations of PCBs and DDT derivatives compared to the other animals (Table 1). In this study the large variance observed in the results does not support the contention that the seals are useful as indicators of local marine pollution.

The fact that lipophilic compounds can be partitioned into pups from their mothers through the placenta and in mother's milk has been indicated for seals (Donkin et al., 1981) and dolphins (Tanabe et al., 1981) thus also reducing loads in the mother. We also observed the same phenomenon in this study; the three pregnant females had consistently low concentrations of both PCBs and total DDT. There was, however, no statistically significant difference between males and females due to the large variance within the male population.

TABLE 1. Polychlorinated biphenyl and organochlorine pesticides in the organs of the Australian Fur Seal (ng g^{-1} wet weight).

Sample	Sex	Age (years)	PCB	HCB	HCH	DDT	DDE	TDE	Total DDT
02 muscle	male	1.75	10.9	ND	0.6	2.6	16.1	1.7	20.5
liver			77.1	ND	ND	77.7	199.2	5.5	282.5
blubber			294.0	0.3	ND	1302.8	1457.1	16.5	2776.5
testes			55.0	ND	ND	26.2	54.2	3.2	83.7
09 muscle	male	1.75	7.5	ND	ND	3.0	21.1	1.4	25.5
liver			37.4	ND	0.6	3.9	126.3	6.0	136.2
blubber			418.3	ND	4.9	1565.9	4207.6	23.7	5797.2
testes			31.8	0.4	2.5	22.7	41.1	ND	63.8
08 muscle	male	3.75	40.6	0.1	ND	0.5	41.4	0.1	42.1
liver			114.5	0.2	0.8	0.3	239.4	2.7	242.5
blubber			3876.8	1.0	4.1	642.1	11411.5	ND	12053.0
testes			22.6	ND	ND	0.4	42.8	0.6	43.9
03 muscle	female	4.75	5.7	0.1	ND	0.6	14.9	1.3	16.8
liver	pregnant		17.4	ND	ND	0.8	52.0	2.1	54.9
blubber			535.5	0.4	0.2	678.1	3399.8	19.4	4097.4
01 muscle	male	5.75	12.0	ND	ND	1.3	21.6	2.3	25.3
liver			31.2	0.1	ND	1.9	60.4	2.5	64.9
blubber			782.9	0.9	ND	6813.7	2864.7	ND	9678.4
testes			12.7	ND	ND	1.2	19.2	0.6	21.1
10 muscle	female	7.75	3.0	ND	ND	2.2	15.4	1.0	18.6
liver	pregnant		4.4	0.1	ND	5.2	12.9	2.3	20.4
blubber			53.4	0.3	ND	232.4	226.2	7.3	466.4
06 muscle	male	0.75	5.3	0.1	0.1	3.3	9.6	2.1	15.1
liver	pup of		49.7	ND	ND	31.4	93.3	5.7	130.4
blubber	05		181.3	ND	ND	1105.6	966.3	ND	2072.0
testes			29.3	ND	ND	31.4	39.0	5.8	76.3
05 muscle	female	11.75	3.4	0.1	ND	1.6	11.4	1.3	14.5
liver	pregnant		26.4	0.1	ND	3.1	44.6	2.3	50.0
blubber			294.5	0.6	ND	623.2	981.7	9.9	1615.0
07 muscle	male	0.75	11.6	ND	0.1	3.7	23.7	2.0	29.5
liver			19.4	ND	ND	2.8	25.8	2.3	30.9
blubber			327.8	0.3	ND	1214.8	1355.9	28.7	2599.4
13 muscle	male	9-11	3.7	ND	ND	1.7	14.8	1.5	18.2
liver			26.3	0.4	ND	7.1	47.2	2.0	56.3
blubber			398.4	ND	2.4	482.6	1254.2	ND	1736.8
testes			2.1	ND	0.2	3.6	17.4	0.2	21.2
14 muscle	female	16.75	7.2	ND	ND	1.2	4.2	ND	5.5
liver	barren		20.0	ND	ND	4.8	57.9	3.3	66.1
blubber			501.4	0.8	ND	427.9	993.5	ND	1421.5

ND = Not detected (limit is about 50 ng PCBs, 10 ng pesticides)

TABLE 2. A comparison of PCB and total DDT concentrations ($\mu g\ g^{-1}$ wet weight) in pinniped blubber, (mean values with ranges).

Latitude		N	Total PCB	Total DDT	Sample	Reference	
Arctic	76°N	28	$\bar{x}$=0.23 (0.06-1.10)	$\bar{x}$=0.06 (0.01-0.40)	Atlantic Walrus	Born et al.	1981
Temperate N	53°N	7	$\bar{x}$=189.42 (22.00-576.00)	$\bar{x}$=10.85 (0.51-25.40)	Harbor Seal	Druinker et al.	1979
	48°N	22	$\bar{x}$=4.00 (1.00-11.00)	$\bar{x}$=1.70 (0.60-3.10)	Harp Seal	Addison et al.	1984
	48°N	8	$\bar{x}$=15.70 (±5.80)	$\bar{x}$=3.50 (±1.00)	Gray Seal	Addison et al.	1984
	33°N	4	$\bar{x}$=17.10 (12.00-25.00)	$\bar{x}$=103.20 (51.00-203.00)	California Sea Lion	DeLong et al.	1973
Tropical							
Temperate S	38°S	11	$\bar{x}$=0.69 (0.05-3.87)	$\bar{x}$=4.03 (0.03-12.05)	Australian Fur Seal	This study	
	69°S	1	0.04	0.17	Weddell Seal	Hidaka et al.	1983
Antarctic	70°S	20	$\bar{x}$=0.09 (0.01-0.76)	$\bar{x}$=0.07 (ND-0.15)[a]	Ross Seal	McClurg	1984

a ND not detected.

Several reports have drawn attention to the high concentrations of DDT and PCBs in marine mammals from the Northern Hemisphere (Table 2). For example, Tanabe et al. (1983) presented evidence that dolphins from the Northern Hemisphere contain higher levels of organochlorines than dolphins from the Southern Hemisphere. This pattern probably reflects the lower number of industrial point sources of PCBs and lower usage of DDT in the Southern Hemisphere. The presence, however, of organochlorine compounds in mammals from the Southern Pacific and the Antarctic (McClurg, 1984) adds weight to suggestions that much of the organochlorine load in the Southern Hemisphere originates in the Northern Hemisphere and is transported to the south in the atmosphere (Platt and Mackie, 1981).

Our results for Australian fur seals are compared in Table 2 with those of a variety of seal species from other latitudes. While the results presented are by no means exhaustive, it is clear that there is little recent information on organochlorine levels in marine mammals from the Southern Hemisphere. These results indicate that PCB concentrations in the Australian fur seals we sampled are low by world-wide standards. Total DDT levels on the other hand are at least as high as some reported for the Northern Hemisphere, indicating that previous DDT use on adjacent farmlands may be having a localised effect.

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