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Mercury Concentrations in the Australian Fur Seal *Arctocephalus pusillus* from SE Australian Waters

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During the last two decades, increasing awareness and concern about metal contamination in the environment has led to many investigations of the distribution and concentration of mercury in biological material. Of particular concern are the high concentrations of mercury reported in the tissues of marine fish.

Marine carnivores such as seals and sea lions, as well as porpoises and dolphins, occupy an important position in the upper trophic level of the marine food web and this, together with their longevity, makes these marine mammals useful indicators of mercury accumulation in the marine environment.

High concentrations of mercury have been reported in the tissues of pinnipeds (Freeman and Horne 1973: Gaskin *et al.* 1973: Heppleston and French 1973: Sergeant and Armstrong 1973: Buhler *et al.* 1976) and cetaceans (Gaskin *et al.* 1972: Gaskin *et al.* 1974: Koeman *et al.* 1975) inhabiting waters of the northern hemisphere. Little information exists on mercury concentrations in marine mammals from the southern hemisphere.

This paper reports total mercury concentrations in the tissues of the Australian Fur Seal *Arctocephalus pusillus* from south-eastern Australian waters.

MATERIALS AND METHODS

Breeding colonies of *A. pusillus*, occur on islands in Bass Strait and adjacent eastern Australian waters. Specimens for this study were collected from a breeding colony located on Seal Rocks ($145^{o}06'E$, $38^{o}32'S$) a rocky basalt outcrop about 1.5 km from the western entrance to Western Port Bay (Figure 1).

Sixteen tagged seals of known age were collected from the Seal Rocks colony, and samples of brain, hair, kidney, liver, muscle and spleen were taken from each animal. Tissues were packed in polythene bags, frozen and stored at $-20^{o}C$ until analysis.

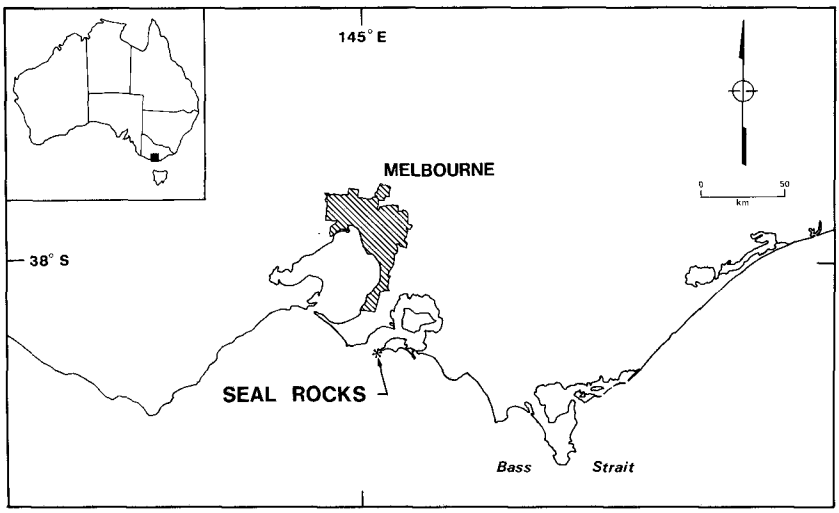

Figure 1. Location of sampled *A. pusillus* colony

Total mercury was determined on acid digests of tissues by cold vapour atomic absorption spectrophotometry (Beumer and Bacher 1982). All concentrations are expressed as microgram per gram (ug g^{-1}) wet weight. Concentrations in hair are expressed on a dry weight basis. Determination of each animal's age, to the nearest month, was possible because they had all been marked with a numbered tag when 2-8 weeks old.

RESULTS AND DISCUSSION

The concentrations of total mercury in tissues of *A. pusillus* are presented in Table 1; the large standard deviations of the means reflect the wide range in age of the animals.

The highest concentrations of mercury were found in liver, and the highest value, 170 ug g^{-1} in a 12-year-old female, is comparable to the 180 ug g^{-1} reported in the liver of a 14-year-old grey seal *Halichoerus grypus* (Heppleston and French 1973), but is considerably less than the 387 ug g^{-1} reported in the liver of a 25-year-old grey seal from eastern Canada (Sergeant and Armstrong 1973). Concentrations of mercury in brain were less than 1 ug g^{-1} except in one 8.5-year-old female and one 12-year-old male. Both these animals also showed the highest concentrations of mercury in the spleen.

Regression analyses of untransformed data (Table 2) showed that mercury concentration in liver, spleen, brain and hair were significantly correlated with age ($P < 0.005$), suggesting that mercury accumulates in these tissues. The significant positive correlation ($r=0.9745$; $P<0.001$) between mercury concentration in the liver and age suggested that mercury accumulates in this

Table 1. Mercury concentrations in the tissues of *Arctocephalus pusillus*.

Age (month)	Sex	Mercury Concentration (ug g^{-1} wet weight)					
		Muscle	Liver	Kidney	Spleen	Brain	Hair*
6	M	0.21	1.11	0.21	nd	0.04	1.07
6	F	0.09	0.97	0.13	nd	nd	1.99
20	M	0.52	7.90	0.65	0.79	0.12	1.23
32	M	0.43	42.7	0.42	1.21	0.64	3.94
32	M	0.16	39.6	0.83	0.94	0.59	5.42
44	M	0.92	30.1	0.67	1.63	0.36	9.36
56	F	1.44	49.8	0.49	1.02	0.95	13.2
66	M	1.90	69.8	1.71	1.45	0.50	17.7
66	M	1.23	67.4	0.56	0.78	0.42	11.7
80	M	0.75	70.5	0.23	1.32	0.74	10.3
80	F	1.31	78.3	0.56	0.78	0.32	6.50
80	M	0.68	68.4	1.00	1.46	0.64	9.56
90	F	0.72	83.0	0.37	1.96	0.58	12.4
102	F	0.85	88.6	0.55	2.33	2.20	19.8
126	F	0.64	128	0.31	1.36	0.59	17.2
144	M	1.78	170	1.42	3.80	2.53	12.0
	Mean	0.91	62.3	0.63	1.29	0.70	9.59
	SD	0.52	44.7	0.43	0.92	0.70	5.89

* Expressed on a dry weight basis.
nd - not detected.

Table 2. Correlation coefficients (r) for mercury concentrations in the tissues of *Arctocephalus pusillus*.

	Age	Muscle	Liver	Kidney	Spleen	Brain
Muscle	0.5102					
Liver	0.9745**	0.5644				
Kidney	0.3334	0.7661**	0.4047			
Spleen	0.7992**	0.5284	0.8144**	0.5400		
Brain	0.7114*	0.4637	0.7325*	0.3836	0.8692**	
Hair	0.7603**	0.5617	0.6901*	0.3539	0.5849	0.5687

** $P<0.001$
* $P<0.005$

tissue throughout life. Mercury concentration in brain appeared to reach a plateau in early life; this agrees with the observations of Heppleston and French (1973) who noted that mercury in brain reaches a ceiling level in animals 12-18 months old. In contrast, mercury concentrations in brain of the common seal *Phoca vitulina* appeared to reach a maximum in 10-year-old animals (Koeman *et al.* 1975).

Concentrations of mercury in muscle and hair reached a plateau in juvenile *A. pusillus* 4-5 years old. Concentrations in muscle were significantly correlated with age in juveniles ($r=0.9142$; $P<0.001$), but not in adults ($r=0.0053$); similarly, mercury concentrations in hair showed a positive correlation with age in juveniles ($r=0.9313$; $P<0.001$), but not in adults ($r=0.2041$).

These differences in mercury accumulation in juvenile and adult seals may be due to the onset of sexual maturity. *A. pusillus* attains sexual maturity at 3-6 years of age (Warneke 1979) at which time increasing hormonal activity and consequent biochemical changes may alter the metabolic processes responsible for the uptake and distribution of mercury by various tissues.

A significant positive correlation was found between mercury concentrations in brain and spleen ($r=0.8692$; $P<0.001$). Although concentration in both these tissues were significantly correlated with age (Table 2), partial correlation ($r=0.7116$; $P<0.005$) between mercury concentrations in brain and spleen, with age constant, suggested a significant relationship in mercury accumulation between these tissues. A similar relationship based on partial correlation was found between the concentrations of mercury in muscle and kidney ($r=0.7350$; $P<0.001$).

Mercury concentrations in the tissues of pinnipeds have been shown (Sergeant and Armstrong 1973) to depend on the position of their prey in the marine food web, as well as their residence time in coastal waters. The east coast of Australia lies in a mercuiferous belt (Jonasson and Boyle 1972), and industrial and urban development around Port Phillip Bay and Western Port may contribute appreciable quantities of mercury to the immediate coastal environment. Unfiltered surface waters in Port Phillip Bay and Bass Strait contain 0.1 to 0.3 ug mercury per kilogram (Smith 1983). Pelagic fish from Port Phillip Bay and adjacent coastal and offshore waters in Bass Strait have high concentrations of mercury in their tissues (Walker 1976, 1981, 1982).

A 12-year study (Warneke 1975 and pers. comm.) of the Seal Rocks seal colony has shown that the population is non-migratory although some seals move to and from distant colonies. Pups up to 1 year old are totally dependent on their mothers and juveniles 2-4 years old appear to remain at the natal colony until their recruitment into the breeding population. Limited observations of feeding behaviour (Warneke pers. comm.), as well as extensive tagging data suggest that juveniles feed in on-shore coastal waters, whereas the adults' feeding range probably extends to the edge of the continental shelf. Thus the seals from this area, which feed almost exclusively on cephalapod molluscs and pelagic fish are exposed to a high dietary intake of mercury which is reflected in their tissue concentrations.

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