# Mercury in Canadian Seals

by
H. C. FREEMAN and D. A. HORNE
*Fisheries Research Board of Canada*
*Halifax Laboratory*
*1707 Lower Water Street*
*Halifax, Nova Scotia, Canada*

## Summary

The mercury concentration was determined in ringed and bearded seal claws, tissues from a harbour seal, tissues obtained from 6 gray seals of different sizes and ages, tissues from ten female harp seals and their pups, and a female gray seal and her fetus. It was suggested that the mercury concentration of the fur and claws of seals could be used as indicators of the degree of the seals' mercury contamination. Preliminary results indicate that mercury contamination in these species, from the same location, increases with size.

The methylmercury concentration of seal pups was lower than that of their mothers. The fetus of the seal did not show a preference for mercury over that of the mother's tissues. It was suggested that seals may possess enzyme systems that demethylate methylmercury.

## Introduction

Preliminary studies have shown that most tissues from Canadian seals are highly contaminated with mercury. The mercury content of the liver of one Canadian gray seal (estimated age, 25 years) was found to be 387 ppm (UTHE, 1972). Fish and shellfish, the principal diet of seals, are known to concentrate heavy metals including mercury, and appear to be able to tolerate them with no apparent ill effects; yet if these contaminated fish are eaten by man, the mercury is considered hazardous to human health. The Japanese mercury problem at Minamata Bay in the 1950's, where there were 111 human casualties resulting from the consumption of fish and shellfish contaminated with mercury, is well documented (BERGLUND *et al.*, 1971). A similar mercury poisoning incident occurred at Niigata, Japan in 1965, where 26 cases of poisoning resulted in 5 deaths (BERGLUND *et al.*, 1971).

It was thought essential to study mercury contamination in the seal since the seal is high in the marine food chain and appears to concentrate mercury from its fish and shellfish diet with no apparent harm to itself. It was hoped that since the seal, like man, is a mammal, a better understanding of mercury contamination in the seal would assist in understanding this problem in man.



Bulletin of Environmental Contamination & Toxicology,
Vol. 10, No. 3 © 1973 by Springer-Verlag New York Inc.

A number of species of seal were included in this study to provide preliminary views of mercury contamination in seals. It was also decided to carry out analyses of seal pups and their mothers in order to determine whether an increase in concentration of mercury occurs from mother to pup as has been reported in humans (WALLACE *et al.*, 1971). Methylmercury concentrations were also determined for a number of samples since some investigators (BACHE *et al.*,1971; UTHE, 1972) have found that mercury does not exist almost entirely in its toxic methylmercury form in seals and fish, as has been reported (WALLACE *et al.*, 1971.).

## Experimental

The seal tissues were obtained at various locations in Eastern Canada as indicated in the tables. The seal claws of the ringed (*Phoca hispida*) and bearded (*Erignathus barbatus*) seals were obtained from the Arctic Biological Station of the Fisheries Research Board of Canada, Ste. Anne de Bellevue, P.Q.

Total mercury was determined in duplicate on acid digests of homogenates of sections of tissue using a semi-automated flameless atomic absorption method as described by ARMSTRONG AND UTHE (1971). A model 403 Perkin-Elmer atomic absorption spectrophotometer equipped with a Perkin-Elmer Model 56 recorder was used. Sampling was performed by a Technicon Sampler II and a Technicon proportioning pump.

Methylmercury was determined in duplicate samples according to the semi-micro, gas liquid chromatography (GLC) method of UTHE *et al.*, (1972). Samples and standards were injected with Hamilton gastight (No. 1705N) syringes. A Packard Model 7831 GLC apparatus, fitted with a $^{3}$H-foil electron capture detector and 6' x 4 mm glass columns containing 7% carbowax 20 M on chromosorb W 80/100 mesh, treated with dimethyldichlorosilane, was used. The carrier gas ($N_2$) was maintained at a flow rate of 60 ml/min and the component temperatures were set at 180°, 190°, 200° and 200°C for the oven, inlet, detector and outlet respectively. Responses were recorded on an Electronik 16 Honeywell recorder.

## Results and Discussion

Table 1 shows the total mercury analyses of claws obtained from Canadian Arctic ringed and bearded seals. Samples were removed from the distal (outer), middle and proximal (growing) sections of claws of each seal. It was hoped that the claws might indicate periods of high and low mercury contamination as demonstrated by areas of high and low mercury concentration in the claw. It is noted (Table 1) that there is some variation in mercury concentration in some claws indicating times of varying mercury intake; however, in most cases, the mercury was distributed fairly evenly in the three sections of the claws demonstrating a constant mercury state in the animal.

TABLE 1

Total Mercury Content of Claw Sections of Ringed (*Phoca hispida*) and Bearded Seals (*Erignathus barbatus*)

| Species | Sex | Length (cm) | Total mercury (ppm) | | | |
|---|---|---|---|---|---|---|
| | | | Distal Section | Middle Section | Proximal Section | Mean |
| Ringed | M | 101 | 1.5 | 1.1 | 0.77 | 1.1 |
| " | M | 101 | 1.1 | 2.0 | 2.7 | 1.9 |
| " | M | 101 | 1.5 | 0.95 | 0.88 | 1.1 |
| " | M | 109 | 1.2 | 1.4 | 1.4 | 1.3 |
| " | M | 111 | 1.3 | 1.1 | 1.3 | 1.2 |
| " | F | 113 | 1.8 | 1.6 | 1.4 | 1.6 |
| " | M | 116 | 2.4 | 1.8 | 2.2 | 2.1 |
| " | M | 116 | 2.8 | 3.6 | 2.3 | 2.9 |
| " | M | 117 | 2.0 | 2.7 | 2.8 | 2.5 |
| " | M | 119 | 1.6 | 1.4 | 1.6 | 1.5 |
| " | F | 121 | 3.0 | 4.2 | 3.9 | 3.7 |
| " | F | 123 | 1.8 | 2.2 | 2.6 | 2.2 |
| " | M | 124 | 1.6 | 2.0 | 2.0 | 1.9 |
| " | M | 126 | 1.6 | 1.9 | 1.8 | 1.8 |
| Bearded | F | 147 | 1.7 | 1.7 | 1.4 | 1.6 |
| " | M | 155 | 0.94 | 1.4 | 1.1 | 1.1 |
| " | M | 158 | 2.0 | 2.3 | 1.4 | 1.9 |
| " | F | 165 | 0.99 | 0.95 | 0.95 | 0.96 |
| " | F | 171 | 1.5 | 2.0 | 2.2 | 1.9 |
| " | M | 173 | 0.85 | 0.42 | 0.65 | 0.64 |
| " | F | 177 | 1.3 | 0.91 | 1.0 | 1.1 |
| " | M | 176 | 0.47 | 0.41 | 0.69 | 0.52 |
| " | F | 203 | 0.85 | 0.88 | 0.057 | 0.47 |

Total mercury and methylmercury analyses are given in Table 2 for tissue of 2 gray seal pups, 2 young gray seals, and 2 large adult seals of each sex. Mercury contamination increased with size and age of seals in most tissue. The mercury levels in the fur, claws, liver and kidney of the two large adults (Table 2) are high, yet the seals appeared to be healthy, although no pathological study was carried out.

TABLE 2

Total and Methylmercury in Gray Seals (*Halichoerus grypus*)[1]

| Number & Sex | 1♂ | 2[2] ♀ | 3♂ | 4♀ | 5♂ | 6♀ |
|---|---|---|---|---|---|---|
| Weight (kg) | 59 | 50 | 148 | 130 | 363 | 227 |
| Length (cm) | 132 | 122 | 155 | 153 | 226 | 183 |

| | Concentration of Hg and MeHg (ppm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MeHg | Hg | MeHg | Hg | MeHg | Hg | MeHg | Hg | MeHg | Hg | MeHg | Hg |
| Fur | 0.20 | 1.6 | 0.24 | 1.8 | 0.35 | 1.4 | - | 3.1 | 2.8 | 12. | 2.5 | 16. |
| Claw | - | 4.4 | - | 3.2 | - | 5.0 | - | 8.4 | - | 9.8 | - | 8.6 |
| Liver | 0.27 | 4.1 | 0.26 | 2.8 | 0.41 | 10. | 0.29 | 11. | 0.65 | 30. | 0.62 | 26. |
| Kidney | 0.16 | 1.5 | 0.035 | 1.5 | 0.23 | 3.0 | 0.24 | 2.8 | 0.36 | 5.7 | 0.32 | 5.0 |
| Flipper | - | - | - | - | 0.30 | 0.91 | 0.45 | 0.94 | - | - | - | - |
| Dorsal Muscle | 0.42 | 0.77 | 0.12 | 0.58 | 0.30 | 0.85 | 0.56 | 0.86 | 0.83 | 1.6 | 0.90 | 1.6 |
| Heart | 0.10 | 0.40 | 0.27 | 0.28 | 0.15 | 0.43 | 0.12 | 0.40 | 0.26 | 0.75 | 0.27 | 0.65 |
| Gonad | <0.01 | 0.18 | <0.01 | 0.37 | 0.089 | 0.23 | 0.088 | 0.33 | 0.16 | 0.42 | 0.11 | 0.60 |
| Blubber | 0.055 | 0.062 | <0.01 | 0.036 | 0.034 | 0.055 | 0.076 | 0.10 | <0.01 | 0.086 | <0.01 | 0.11 |
| Brain | - | 0.26 | - | 0.19 | <0.01 | 0.30 | 0.024 | 0.33 | - | 0.45 | - | 0.43 |

[1] Seals were obtained at Fourchu Bay, Nova Scotia, Canada during the summer of 1972.

[2] Seals 1 and 2 were pups.

In Table 3 are given the total mercury analyses of tissues obtained from ten harp seals and their pups from day 1 to day 5 post partum. It is noted as for the gray seals when comparing the means of the mercury assays (Table 3) that the fur, the claws, the livers and kidneys are more contaminated with mercury than the other tissues assayed. It is also shown that the tissues from the pups are not as highly contaminated as the corresponding tissues from their respective mothers. This observation was confirmed (Table 4) when the total mercury concentration was determined in tissues from a highly contaminated female gray seal and its fetus. These observations are contrary to what has been reported for man where mercury is concentrated in the fetus (BERGLUND *et al.*, 1971); however, more studies are required in both species to determine if differences do occur. Much information on this subject, in man, was obtained from results of the Japanese epidemics but detailed data on the magnitude of the exposure during pregnancy of the mothers of the contaminated children were entirely lacking (BERGLUND *et al.*, 1971).

In Table 5 are given the total mercury concentrations of tissues obtained from a young female harbour seal (*Phoca vitulina*) which is not highly contaminated with mercury. It was noted that mercury values in kidney, liver, fur and claws were relatively high compared to values for other tissue.

It is apparent from the mercury levels in claws from six gray seals (*Halichoerus grypus*) of varying sizes and ages (Table 2), from harp seals (*Phoca groenlandica*) (Table 3) and others (Tables 4 and 5) that the claws are good indicators of the degree of mercury contamination of other tissue. The seal fur is likewise a good indicator of the extent of contamination. Claws, fur, hair and feathers are epidermal tissue derived from the embryonic ectoderm (ROMER, 1970); hair in man, and feathers in birds are good indicators of the degree of mercury contamination in these species (BERGLUND *et al.*, 1971).

Methylmercury content was determined in tissues of female harp seals and their pups (Table 6), and in all tissues, as found previously for total Hg content (Table 3), it was found to be much lower in pups than in their mothers. The percent methylmercury relative to the total mercury was lower in all tissues in the pups except the livers. This was unexpected for it is thought that methylmercury passes through the placental barrier to the fetus in man but this does not appear to be the case with seals. It is also noted that the stomach and stomach content (milk) contain 45.5% and 70.5% methylmercury respectively indicating that the mother's milk is contaminated mostly with methylmercury.

The methylmercury content of the gray and harp seal tissues (Tables 2 and 6) ranged from 2.2-96% of the total mercury, with the kidney and liver tissues containing the smallest percentages of methylmercury. The methyl and total mercury content of these two tissues increased with increasing size and age of the seals but the percentages of methyl mercury actually decreased. Such low concentrations of methylmercury are surprising since it is thought

TABLE 3

Total Mercury (ppm) in Tissues of Harp Seals (*Phoca groenlandica*) (Mothers and Their Pups)

| Adult No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Mean ± S.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tissue | | | | | | | | | | | |
| Fur | - | - | 3.5 | 3.0 | 2.1 | - | - | 3.8 | 3.7 | 3.4 | 3.2 ± 0.25 |
| Claws | - | - | 2.2 | 5.4 | 3.4 | - | 2.7 | 3.3 | 4.2 | 4.4 | 3.7 ± 0.41 |
| Liver | 5.4 | 1.9 | 2.8 | 5.7 | 2.3 | 9.3 | 2.0 | 3.7 | 9.4 | 3.7 | 4.6 ± 0.89 |
| Flipper | 0.32 | 0.30 | 0.55 | 0.41 | 0.57 | 0.36 | 0.27 | 0.48 | 0.66 | 0.84 | 0.48 ± 0.054 |
| Dorsal Muscle | 0.37 | 0.28 | 0.54 | 0.42 | 0.55 | 0.33 | 0.28 | 0.50 | 0.60 | 0.70 | 0.46 ± 0.044 |
| Heart | 0.16 | 0.13 | 0.43 | 0.25 | 0.33 | 0.24 | 0.20 | 0.26 | 0.41 | 0.40 | 0.28 ± 0.031 |
| Blubber | - | - | 0.078 | 0.16 | 0.23 | - | 0.063 | 0.17 | - | - | 0.14 ± 0.00 |
| Light Muscle | - | - | - | 0.23 | - | - | - | 0.32 | 0.39 | - | 0.31 ± 0.044 |

| Pup No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Mean ± S.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 1 da | 1 da | 2 da | 2 da | 3 da | 3 da | 4 da | 4 da | 5 da | 5 da | |
| Fur | 2.0 | 1.9 | 1.4 | 1.1 | 1.5 | 0.86 | 0.63 | 2.3 | 3.6 | 1.5 | 1.7 ± 0.26 |
| Claws | 1.6 | 1.1 | 2.1 | 0.80 | 2.2 | 0.86 | 1.14 | 2.3 | 3.6 | 2.1 | 1.8 ± 0.27 |
| Liver | 0.83 | 0.70 | 0.52 | 0.37 | 0.44 | 0.53 | 0.21 | 0.18 | 0.35 | 0.43 | 0.46 ± 0.054 |
| Kidney | 0.43 | 0.48 | 0.29 | 0.26 | 0.34 | 0.25 | 0.27 | 0.31 | 0.51 | 0.40 | 0.35 ± 0.00 |
| Flipper | 0.32 | 0.22 | 0.30 | 0.24 | 0.20 | 0.20 | 0.16 | - | 0.24 | 0.19 | 0.23 ± 0.00 |
| Dorsal Muscle | 0.29 | 0.22 | 0.29 | 0.24 | 0.20 | 0.22 | 0.14 | 0.16 | 0.22 | 0.20 | 0.22 ± 0.00 |
| Heart | 0.22 | 0.21 | 0.21 | 0.18 | 0.14 | 0.12 | 0.12 | 0.11 | 0.23 | 0.13 | 0.17 ± 0.00 |
| Stomach | 0.17 | 0.13 | 0.15 | 0.11 | 0.12 | 0.089 | 0.12 | 0.097 | 0.13 | 0.13 | 0.13 ± 0.00 |
| Stomach Content | 0.04 | - | - | 0.070 | - | 0.066 | 0.13 | 0.070 | 0.075 | 0.17 | 0.088 ± 0.00 |
| Brain | 0.17 | 0.14 | 0.14 | 0.15 | 0.11 | 0.14 | - | - | 0.18 | 0.16 | 0.15 ± 0.00 |

TABLE 4

Total Mercury of Tissues from Mother[1] and Fetus[2]
Gray Seal No. 6 (Table 3)

| Tissue | Mercury (ppm) Mother | Fetus |
|---|---|---|
| Claw | 8.6 | 2.9 |
| Liver | 26. | 0.50 |
| Kidney | 5.0 | 0.37 |
| Dorsal Muscle | 1.6 | 0.19 |
| Heart | 0.65 | 0.62 |
| Umbilical Cord | - | 0.40 |

[1] Weight was 227 kg. and the length was 183 cm.

[2] Weight of the fetus was 431 g. and the length was 25.4 cm.

TABLE 5

Total Mercury in a Harbour Seal[1] (*Phoca vitulinus*) Tissue

| Tissue | Total Hg (ppm) |
|---|---|
| fur | 1.8 |
| claws | 1.8 |
| liver | 0.99 |
| kidney | 0.67 |
| dorsal muscle | 0.55 |
| heart | 0.23 |
| stomach | 0.22 |
| brain | 0.17 |
| blubber | 0.076 |
| gonad | 0.31 |
| spleen | 0.24 |
| eye | 0.095 |
| lung | 0.17 |
| pancreas | 0.27 |
| large intestine | 0.17 |
| small intestine | 0.26 |

[1] The weight of the seal was 28.4 Kg. and the length was 104 cm. The seal was shot at Ecum Secum, Nova Scotia in 1972.

that seals derive most of the mercury from their diet of fish where mercury is generally in the toxic methyl form. This suggests that seals may have enzyme systems capable of demethylating methylmercury. Such mercury demethylating systems were suggested for both seals and mink by UTHE (1972). If this is the mechanism by which methylmercury is being eliminated, the process is likely taking place in the liver and kidney tissue since these are the tissues lowest in the percentage of methylmercury. The question arises whether such an enzyme system is present in other mammals including man. The chemical composition and toxicity of the demethylated methylmercury bears investigation.

TABLE 6

Methylmercury in Tissue of Harp Seals[1] (*Phoca groenlandica*)

| Tissue | Mothers | | Pups | |
|---|---|---|---|---|
| | MeHg (ppm) Mean ± S.E. | % of Total Hg | MeHg (ppm) Mean ± S.E. | % of Total Hg |
| Liver | 0.26 ± 0.068(8)[2] | 5.6 | 0.059 ± 0.00(9) | 13. |
| Kidney | - | - | 0.057 ± 0.00(9) | 16. |
| Flippers | 0.22 ± 0.044(10) | 46. | 0.045 ± 0.00(8) | 20. |
| Dorsal Muscle | 0.13 ± 0.00(10) | 28. | 0.058 ± 0.00(10) | 27. |
| Heart | 0.20 ± 0.070(8) | 70. | 0.030 ± 0.00(8) | 18. |
| Stomach | - | - | 0.057 ± 0.00(8) | 46. |
| Stomach Content | - | - | 0.062 ± 0.00(5) | 71. |

[1] Seals were taken off ice floes in Gulf of St. Lawrence, Canada.

[2] Number of animals.

Acknowledgement

We thank Mrs. M. McMenemy, Mrs. B. McTague and Miss P. Michalik for their skilled technical assistance, and Dr. A.W. Mansfield of the Arctic Biological Station for providing the seal claw samples.

## References

ARMSTRONG, F.A.J., AND J.F. UTHE: Atomic Absorption Newsletter 10(5), 101 (1971).

BACHE, C.A., W.H. GUTENMANN, AND D.J. LISK: Science 172, 951 (1971).

BERGLUND, F., M. BERLIN, G. BIRKE, R. CEDERLOF, U. von EULER, L. FRIBERG, B. HOLMSTEDT, E. JONSSON, K.G. LUNING, C. RAMEL, S. SKERFVING, A. SWENSSON, AND S. LEJNING: Methyl mercury in fish. Nordisk Hygienisk Tidskrift, Supp. 4, Stockholm (1971).

ROMER, A.S.: The vertebrate body, 4th ed. W.B. Saunders Co., Philadelphia (1970).

UTHE, J.F., J. SOLOMON, AND B. GRIFT: J. Ass. Offic. Anal. Chem., 55(3), 583 (1972).

UTHE, J.F.: Fish. Res. Bd. Canada Manuscript Report Series #1167, 161 (1972).

WALLACE, R.A., W. FULKERSON, W.C. SHULTS, AND W.S. LYON: Mercury in the Environment, The Human Element, Oak Ridge National Laboratory, Oak Ridge, Tennessee. (1971).