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The Polar Bear as a Biological Indicator of the Environmental Mercury Burden

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ABSTRACT. 128 fresh (current) and 18 preserved (museum) polar bear hair samples were subjected to mercury analysis. Mercury levels ranging from <0.5-44.3 ppm were observed in the fresh samples with a geographic distribution showing higher levels in the western Arctic and substantially lower levels in the eastern Arctic and in Hudson's Bay. A similar geographic range and distribution was found in the museum specimens. No correlation can be demonstrated between observed levels and industrial releases of mercury. There is no real indication of increase in general levels over time. The source of observed high levels of mercury in arctic marine fauna appears to be geologic rather than industrial.

Key words: mercury, polar bear

RÉSUMÉ. Des analyses de mercure ont été effectuées sur des échantillons de poils provenant de 128 ours polaires en vie et de 18 ours polaires préservés dans des musées. Les niveaux de mercure variaient entre <0.5 et 44.3 p.p.m. dans les échantillons d'ours en vie, les niveaux étant plus élevés dans l'ouest de l'Arctique et beaucoup moins élevés dans l'est de l'Arctique et la baie d'Hudson. Les spécimens de musées présentaient des statistiques semblables quant à la portée et la distribution géographique. Aucune corrélation n'a pu être établie entre les niveaux observés et les émissions industrielles de mercure. Il ne s'est présenté aucune indication d'une augmentation à la longue des niveaux en général. La source des niveaux élevés de mercure semble donc être géologique plutôt qu'industrielle.

Mots clés: mercure, ours polaire

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INTRODUCTION

Mercury has been perceived as an environmental contaminant with potential for adverse health consequences, especially since the two catastrophic epidemics of methyl mercury poisoning which occurred in Niigata and in Minamata in Japan in the late 1950s and early 1960s (Tsobaki and Irukayama, 1977). Since that time the potential for organic mercury salts to accumulate in the biota and to be concentrated in the food chain has been recognized (Stopford and Goldwater, 1975), and strict standards for mercury content of fish offered for sale have been introduced in many countries (Berglund *et al.*, 1971).

In the course of investigations into the possible risks from environmental mercury to Canadian native populations it was discovered that observed high mercury levels in coastal-dwelling Inuit appeared to be linked not to the inclusion of fish in the diet, but to the consumption of sea mammals — especially seal (Wheatley, 1979).

A number of papers have been published which confirmed the seal as a significant accumulator of mercury, primarily in the liver, with levels averaging about 27 ppm in ringed seal, but reaching up to 420 ppm in older bearded seal (Smith and Armstrong, 1975, 1978).

The polar bear feeds almost exclusively on seal and hence was seen as the top of the natural food chain. The opportunity arose to analyze polar bear hair samples from a variety of locations across the Canadian Arctic. The results of those analyses are the subject of this paper.

MATERIALS AND METHODS

Clipped polar bear hair samples were obtained mainly from trapped live bears on which other biological investigations were being carried out, through the courtesy of wildlife officers with the N.W.T. Fish and Wildlife Service and the Canadian Wildlife Service of Environment Canada. Each sample was identified as to place of capture and individually was labelled so as to permit subsequent identification as to age and sex (though no use has been made of this last piece of information).

A few samples were obtained from hides of shot animals. No information as to age or sex of these animals was available except that all were adult. Each sample was packed in an individual roll-top plastic bag.

A further group of samples was obtained through the courtesy of the Mammalogy Section of the Canadian National Museum of Natural Sciences. These samples were clipped from museum specimens and were dated from 1910 to 1927. They were subjected to soaking in 1% Triton X-100 for 24 hours followed by repeated rinsings until the washings gave no mercury content on analysis. The quoted analyses are of hair samples after washing in this manner.

All samples were analyzed by atomic absorption at the facilities of Health and Welfare Canada's Industrial Hygiene laboratory using the method of Farant *et al.* (1981).

RESULTS

A total of 122 fresh samples was collected from six major areas (Fig. 1). Levels of mercury in the hair of cubs from all areas were uniformly low (less than 1 ppm) which might be expected since their hair was laid down while on a diet of milk. Accordingly readings of cubs are omitted from all tabulated means. The levels of mercury in the hair of all adult and subadult bears (109) are expressed as group means in Table 1. It is to be noted that the highest levels

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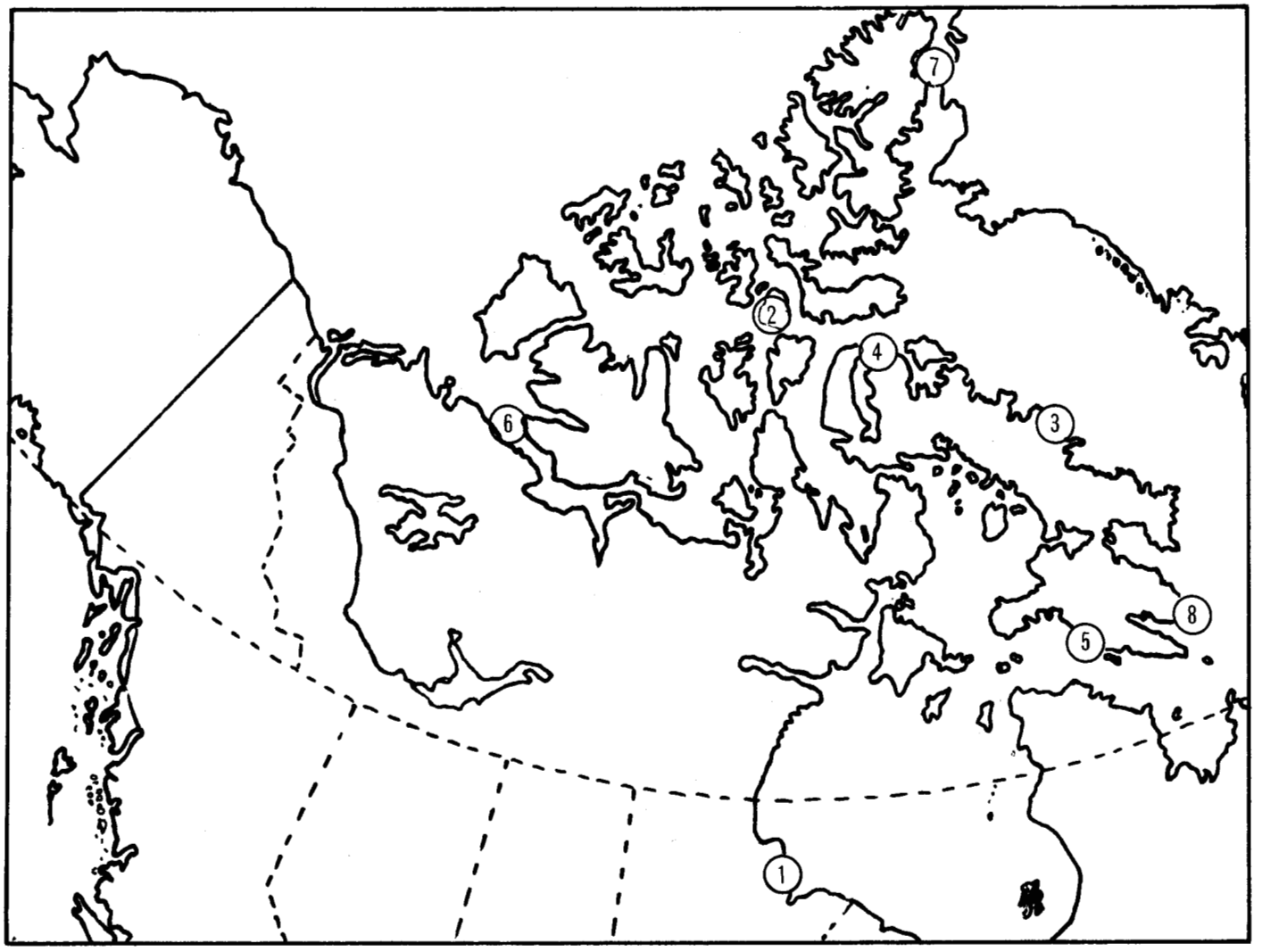

FIG. 1. Location of capture of bears sampled (see Tables 1 and 3).

are found in the northern and western Arctic while the lowest levels are in the most southerly part of the polar bear range. The overall difference between high and low levels is approximately fivefold and there is a steady gradient in the intermediate areas.

TABLE 1. Total mercury (ppm) in polar bear hair samples by geographic area of capture, 1977-1980

Location	Date	Map Ref	(n) Sample Size	Mean	S.D.	Range
Amundsen Gulf	1977	6	5	18.54	14.52	9.3-44.3
Cornwallis Island	1980	2	7	7.85	4.49	3.6-17.3
North Baffin Island	1980	4	27	6.93	1.80	4.5-11.8
Cornwallis Island	1977	2	7	6.59	1.72	4.5- 9.2
Clyde River	1980	3	9	4.92	0.63	4.0- 5.8
South Baffin Island	1977	5	13	3.53	0.77	2.7- 5.7
Southern shore of Hudson Bay	1980	1	41	2.54	1.00	1.1- 6.3

Smith and Armstrong (1978) reported on mercury levels in seals from various parts of the Canadian Arctic and concluded that there was no significant difference between geographic areas. Using the published figures of these authors, it can be shown that there is a geographical gradient in the rate of accretion of mercury in the liver (where it is stored more or less indefinitely) of both seal species (Table 2). This rate varies from region to region, with the highest accretion rate in the Amundsen Gulf area being roughly double the rate in the Cornwallis area and about four times the rate in the East Baffin area. In other words, these accretion rates match closely the different hair levels in the equivalent polar bear populations. (It must be remembered that while the mercury in seal liver is cumulative with age (Koeman *et al.*, 1975), the mercury in polar bear hair (or any other hair) is not cumulative but merely reflects the current blood level at the time that particular hair cell was being laid down.)

The mercury levels in hair from museum specimens are given in Table 3. It should be noted that both total Hg and inorganic Hg levels are quoted. The presence of high levels of inorganic mercury in a few of these samples probably indicates the use of mercuric compounds in the

TABLE 2. Mean annual increment of mercury in ringed and bearded seal livers in different arctic locations

	Location	Mean Hg (ppm)	Mean age (yrs)	Hg/Age	N
Ringed Seal (*Phoca hispida*)	Holman 1972-73	27.50	12.81	2.15	81
	Holman 1977	25.54	8.08	3.16	112
	Barrow Strait	16.14	10.20	1.57	27
	Pond Inlet	3.76	5.17	0.73	33
Bearded Seal (*Erignathus*) *barbatus*)	Holman Island	143.00	8.50	16.80	6
	Belcher Islands	26.2	4.90	5.30	56

Source: Smith and Armstrong, 1978.

preservation process, especially in those samples showing a major preponderance of the inorganic fraction.

Unfortunately, apart from the 13 samples from the general area of Amundsen Gulf, there are only one or two samples from each location, which makes comparison unwise. But at least in these we can observe that mercury levels in the western Arctic seemed to be higher than those in the east and south (at Fort Churchill) where reported levels approximate those of today.

DISCUSSION

We have indicated that the immediate source of mercury for polar bears is the seal, while seals obtain their mercury from the consumption of fish and benthic invertebrates. The sources of mercury for the fish and the reasons for the discrepancies in mercury accumulation between the different areas remain obscure.

The most obvious conclusion to be drawn from this study is that the ultimate source of the observed mercury is not industrial. Were this the case the highest mercury levels would be expected in the southern Hudson Bay area, since the marine outfall from the contaminated river system upstream (Wabigoon-English River system) and also much of the prairie grain-growing area (which has been subjected to years of use of mercury-containing seed dressings) would cause more elevated levels in bears there than elsewhere.

A factor which perhaps plays a part is the regional variation in species of seal making up the bears' diet. According to Stirling and Archibald (1977), western bears tend to eat more bearded seal (*Erignathus barbatus*) than do eastern bears. Smith and Armstrong (1978) have demonstrated higher liver levels of mercury in bearded than in ringed seal (*Phoca hispida*). There are basic differences in the diets of these seal species with bearded seal acquiring a greater proportion of its food from benthic invertebrate fauna.

A somewhat similar observation of regional disparities in mercury level was made in polar bear livers by Lentfer (1976). He observed a greater-than-chance variation, which could not be accounted for by age, between the liver mercury level in bears from the area of Point Barrow and a discrete population of bears from the Chukchi Sea.

The ratio of inorganic to total mercury observed in the museum specimens (Table 3) deserves mention. In all hair samples analyzed for mercury we find a proportion of the total appearing in the inorganic fraction. We have not separated this out in the fresh specimens, since there was no opportunity for direct contamination by mercury compounds between sampling in the field and analysis in the laboratory. As a general rule in our experience inorganic mercury constitutes about 15% of total in hair samples and this is true for human as well as polar bear hair. Occasional samples have been observed in which the proportion of inorganic is higher than average (15%) and quite compati-

TABLE 3. Mercury levels in museum specimens (1910-1927) of polar bear hair

Location	Map ref.	Age	Total Mercury ppm A	Inorganic Mercury ppm B	Organic Mercury ppm A-B
Fort Churchill	1	Adult	2.8	0.7	2.1
Clinton Point	6	"	6.4	3.9	2.5
Cape Kellett, Banks I.	"	<1 yr.	5.1	2.2	2.9
" " " "	"	Adult	4.0	2.4	1.6
Cape Bathurst	"	"	6.9	2.7	4.2
" "	"	Juvenile	12.1	7.4	4.7
" "	"	"	13.1	10.1	3.0
" "	"	Adult	5.2	3.5	1.7
" "	"	"	12.4	6.0	6.4
" "	"	"	10.0	6.3	4.7
" "	"	"	21.1	16.6	4.5
" "	"	"	10.9	4.9	6.0
" "	"	Juvenile	53.6	53.3	0.3
" "	"	"	11.1	6.6	4.5
Smith Sd., Ellesmere I.	7	Adult	2.6	2.0	0.6
Cape Mercy, Baffin I.	8	Juvenile	2.0	1.4	0.6
Davis Strait	8	c.o.y.	1.5	0.9	0.6
" "	8	"	3.4	1.9	1.5

ble with the proportions evidenced in Table 3, but even looking only at the organic fraction of mercury the levels in the Amundsen Gulf area are markedly in excess of those further east and south, and approximate present-day figures.

In our view these findings support a contention that observed high mercury levels in the Canadian Arctic reflect geologic sources and are not connected with anthropogenic release.

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