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HEAVY METALS AND ORGANOCHLORINES IN MARINE MAMMALS FROM GREENLAND

by

Poul Johansen
Greenland Fisheries Investigations
Charlottenlund
Denmark

Finn O. Kapel
Greenland Fisheries Investigations
Charlottenlund
Denmark

Inge Kraul
Royal Veterinary and Agricultural College
Copenhagen V
Denmark

ABSTRACT

Information on the levels of heavy metals and organchlorines in different tissues of marine mammals (harp seal, hooded seal, ringed seal and minke whale) from Greenland waters is presented in order that data from such a "clean" environment may serve as "reference measurements" to similar data from areas receiving a considerable input of pollutants.

Levels of mercury in seals from Greenland are lower than levels reported for the same seal species elsewhere, but this may to some extent be caused by differences in age structure of the populations sampled.

Cadmium levels in liver and kidney of ringed seals were surprisingly high and much higher than in similar samples from grey seal and harbour seal from European waters, whereas lead levels in liver and kidney of ringed seal from Greenland seem to be lower than those reported from European waters.

Levels of total DDT and PCB in blubber of seals from Greenland in general are much lower than levels reported from the Canadian/US east coast, the North Sea, and the Baltic.

INTRODUCTION

At earlier Statutory Meetings of ICES it has been discussed if pollutants

may have had an impact on reproduction and survival of marine mammals in the Baltic and the North Sea (Otterlind, 1976; Duinker *et al.*, 1979). As this is much of a dispute it might be useful to compare the levels of pollutants in marine mammals in these areas with the levels found in areas where marine mammals live and bread successfully such as in Greenland waters.

Data on the level of pollutants in marine mammals in Greenland are, however, quite sparse. Therefore this paper should only be considered a first attempt to make such a comparison, and data from other "reference areas" should also be considered. In addition to the results presented here results for walrus have been submitted for publication (Born *et al.*, in prep.).

Different analytical techniques to measure heavy metals have been applied to obtain the results presented in this paper. This introduces some variability which, however, will only be discussed briefly.

MATERIALS AND METHODS

Samples were collected at different sites in connection with different research programmes in Greenland from 1972 to 1979. Tissue samples have been stored deep frozen from the time of collection until analysis. In most instances length, age, and sex of the seals were recorded.

Details on analytical methods are available but only a summary of these methods will be given in this paper.

Methyl-mercury was analysed by means of gaschromatography and total mercury by means of flameless Atomic Absorption Spectrophotometry (AAS) at the Royal Veterinary and Agricultural College in Copenhagen.

Cadmium, copper, lead, and zinc were measured by means of ASS, in some cases after extraction of the metals, at Sentralinstitutt for Industriell Forskning, Oslo. Some of the analyses for Cd, Cu, Pb, and Zn were conducted by means of Anodic Stripping Voltammetry (ASV) at the Greenland Geological Survey in Copenhagen.

DDE, DDD, DDT, and PCB were measured by means of gaschromatography at the Royal Veterinary and Agricultural College. "Total" DDT was expressed according to this formula:

$$\leqslant \text{DDT} = \text{DDT} + (\text{DDT}+\text{DDD}) \times 1.111$$

RESULTS

Results for mercury are presented in Table 1, results for cadmium, copper lead, and zinc in Table 2, and results for organochlorines in Table 3. Figure 1 shows areas of sampling.

Mercury (Table 1)

It is noticeable that the total mercury level in liver tissue is much higher than in muscle tissue of all three seal species studied, whereas the levels are

almost equal in muscle and liver in the minke whale as is also commonly found in fish. Furtermore it may be noted that the mercury level in liver of hooded seal is much higher than for the two other seal species.

Levels of the methylated part of total mercury are in the same order of magnitude in muscle and liver tissue of seals, while the percentage of methyl mercury in muscle are considerably higher than the corresponding liver values.

Cadmium, copper, lead, and zinc (Table 2)

Results are only available for one species, the ringed seal.

The level of cadmium is very low in blubber, quite low in muscle but very high in liver (mean values of 6.6 - 17.0 ppm Cd on a wet weight basis) and kidney (mean value of 37.4 ppm Cd on a wet weight basis). It is remarkable that differences of the Cd level in liver may be observed within rather a short distance in that the mean value from Upernavik is higher than the mean value from the Umanak area, whereas the mean value from the latter area corresponds to the mean value from an area very far apart at Daneborg, East Greenland, see Figure 1.

Copper and zinc values will not be discussed here.

All mean lead values are low and many single values are below the detection limit. It is a well known fact that the chamical analysis for lead causes many analutical problems, *e.g.* contamination of samples. Therefore single high lead values should perhaps be discarded and some of the mean values of Table 2 changed according to the notes of the table.

Organochlorines (Table 3 and Figure 2)

Residues of the lipophilic compounds DDT, DDD, DDE, and PCB are in all species studied as expected highest in the blubber tissue. The distribution between blubber, liver, and muscle are illustrated in Figure 2. It is noticed that levels of PCB and $\leq$ DDT are of the same order of magnitude, especially in blubber.

DISCUSSION

In order to compare the levels of metals and organochlorines in marine mammals from Greenland with levels from other areas such levels are listed in Table 4 (metals) and Table 5 (organochlorines).

Cadmium

It is striking that cadmium values are much higher in liver and kidney of ringed seal from Greenland than in grey seal from West Scotland or grey seal and harbour seal from areas of the North Sea receiving a considerable input of pollutants.

The reason for these very high values is not known. Similar results are known from Arctic Canada in both ringed seal and narwhal (Fallis, personal

communication). Most animals from Greenland analysed have been aged, and almost all of them are very young, *i.e.* younger than two years, and many of them even not one year old. This means that accumulation of cadmium has taken place during a very short period, and not during many years as usually seems to be the case for the accumulation of Cd in the liver and kidney of seals (Roberts *et al.*, 1976; Drescher *et al.*, 1977). The difference between the Cd level in ringed seal from Greenland and grey seal or harbour seal from the North Sea may be caused by species differences but this should be studied further by analysing tissue from the same species in different areas.

Copper and zinc

In liver Cu and Zn levels are similar in ringed seal from Greenland and in harbour seal from the North Sea whereas Cu and Zn levels in grey seal from the North Sea are somewhat higher. In kidney Cu and Zn levels are higher in ringed seal from Greenland than in harbour and grey seals from the North Sea. These differences could be due to species differences.

Mercury

Mercury levels in seals from the Arctic have already been compared to those in areas exposed to large inputs of industrially produced mercury waste (Smith and Armstrong, 1975).

Our results of Hg levels in both liver and muscle tissues of harp, hooded, and ringed seals from Greenland are lower than levels reported for the same species elsewhere including Canadian Arctic (see Table 4). For ringed seal this probably mainly is caused by the fact that the animals analysed from Greenland are younger than seals analysed from other areas, as an age correlated increase in Hg concentration in tissues of seals has been demonstrated by several authors (*e.g.* Smith and Armstrong, 1975; Drescher *et al.*, 1977). Whether this explanation holds true for harp and hooded seal also is not known as the correlation between mercury values and age has not yet been carried out.

A comparison of the few results (ringed seal, 1974) from Daneborg in East and Upernavik in West Greenland indicates a difference in mercury level from coast to coast in Greenland.

As reported from other seal studies (Koeman *et al.*, 1973; Smith *et al.*, 1975) the methyl mercury content exceeded only a minor fraction of total Hg in livers (from 5 to 30%) compared to muscle tissue (from 57 to 86%). In whales where the concentrations of total mercury in liver and muscle are small and comparable the percentage of methyl mercury shows the same pattern.

Lead

The Pb levels in liver and kidney samples of ringed seal from Greenland

seem to be lower than those reported in harbour seal from the German North Sea coast, and in muscle, liver and kidney much lower than those reported in harbour seal from West Scotland. Some of these differences are probably caused by difficulties with the chemical analysis for lead.

Organochlorines

The results of organochlorines show as in the case of Hg a marked difference between the level in ringed seals in East and West Greenland. The level of total DDT and PCB in ringed seal blubber from Upernavik district is in the same order of magnitude as the levels from ringed seals in Arctic Canada. Levels in blubber from harp seal are lower in Greenland than those from the Gulf of St. Lawrence (see Table 5). Compared to harbour and grey seals from the North Sea DDT values in blubber of seals from Greenland are somewhat lower. In blubber of harbour seal DDT and PCB levels from the Canadian/US east coast, and PCB levels from the North Sea are much higher than values in blubber of seals from Greenland. But all figures of organochlorines in marine mammals in Greenland are very small compared to those found in ringed seals of the Baltic where the PCB content has been suspected to cause pathological changes in the uteri followed by failure in production of pups (Helle *et al.*, 1976).

The percentage of unmetabolized DDT in seals from Greenland (mean (n=88) = 35%, range = 19-45%) is not significantly different from the percentage seen in harbour seal (*Phoca vitulina*) from the Wadden Sea of South Jutland (mean (n=19) = 29%, range 15-45%).

For whales only few analyses from Greenland are available and only for the minke whale. Organochlorine levels for this species from other areas have not been found in the literature but may be compared with blubber analyses of baleen whales as given by Taruski *et al.*,(1975) also citing other authors:

Species	No. of animals (sample type)	$\leq$ DDT ppm	PCB ppm
Humpback wahle	4 (wet)	1.4 - 23.1	1.3 - 6.0
Grey whale	23 (wet)	ND - 0.68	-
Fin whale	6 (oil)	4.24- 32.33	ND - 7.0
Fin whale	12 (wet)	0.667- 2.557	0.012-0.185
Blue whale	1 (oil)	0.18	ND
Sei whale	1 (oil)	0.31	ND
Minke whale (this study)	6 (wet)	1.38	o.61

Heavy metal intake and human health

The implications of the high levels of cadmium and mercury in marine mammals to human health in Greenland have been studied as seals in some areas constitute the most important food item. The results of this study conducted within the last few years have not yet been published, and will be reviewed briefly here. Lead was also included in the study, not because of concerns that lead in marine food could impair public health but to use the results as a reference point to similar studies in European countries.

The first step of the study were calculations of metal intake by humans based on knowledge of the composition of food and concentrations of metals in the food. The result of these calculations are shown in Figure 3. The calculations were made under different assumptions reflecting variability in food intake and metal concentrations as shown in the figure, which also shows the metal levels considered as "provisional tolerable weekly intake" by FAO/WHO Expert Committee on Food Additives, April 4-12, 1972, Geneva. The figure finally distinguishes between four sources of metals, namely seal liver and meat, fish liver and meat, considered to be the most important sources at least for mercury and cadmium. It is seen that the calculated intake of Hg and Cd in all cases are well above what is considered tolerable intake, whereas the intake of Pb from marine food is much lower than the tolerable intake. It should be noted that the results are representative only for the hunting districts in Greenland, and not for the fishing districts in which seals constitute only a minor part of the food.

As a follow-up to the calculations an investigation of the levels of Cd, Hg, and Pb in blood and hair samples from the Greenland population was conducted. Preliminary results from this investigation have confirmed high levels of mercury in humans, whereas cadmium levels in humans were surprisingly low and probably not reflecting the composition of food items. This indicates that cadmium in marine food is not well absorbed in man, but it should also be taken into account that it is to some degree disputed whether blood and hair are appropriate targets for the monitoring of cadmium, and it has been recommended to analyse kidney tissue from humans for cadmium. Finally the investigation showed unexpected high levels of lead in blood and hair in people from Greenland, but the reason for this is not known.

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Figures in brackets refer to reference numbers in Table 4-5.

Table 1. Mercury in muscle and liver of seals and whales sampled in Greenland during the period 1972-78. Results of total mercury (total Hg) and methyl-mercury (CH_3Hg) calculated as Hg in mg/kg on wet weight basis, range and arithmetic mean.

SPECIES	LOCALITY/YEAR	TISSUE	n	Total Hg range	Total Hg mean	CH_3Hg range	CH_3Hg mean	Percent CH_3Hg of total Hg
HARP SEAL	UMANAK/1972	muscle	12	0.11 - 0.26	0.20	0.07 - 0.15	0.11	57
		liver	7	0.21 - 3.6	1.2	0.11 - 0.26	0.19	30
(Pagophilus groenlandicus)	UPERNAVIK/1973	muscle	11	0.11 - 0.48	0.24	0.05 - 0.34	0.16	65
		liver	11	0.37 - 5.8	2.3	0.09 - 0.69	0.31	20
	UPERNAVIK/1976	muscle	4	0.16 - 0.26	0.20	-	-	-
		liver	4	0.54 - 1.3	0.86	-	-	-
HOODED SEAL	UPERNAVIK/1974	muscle	4	0.16 - 0.24	0.20	0.10 - 0.17	0.14	68
		liver	4	1.9 - 11.2	6.5	0.061 - 0.45	0.27	4.8
(Cystophora cristata)	UPERNAVIK/1976	muscle	10	0.21 - 0.47	0.33	-	-	-
		liver	10	2.8 - 44.4	16.7	-	-	-
RINGED SEAL	UPERNAVIK/1973	muscle	10	<0.05 - 0.51	0.23	0.02 - 0.34	0.15	64
		liver	10	0.32 - 4.9	2.4	0.03 - 0.55	0.30	15
(Phoca hispida)	UPERNAVIK/1974	muscle	7	<0.05 - 0.12	0.088	0.003 - 0.10	0.036	72
		liver	7	<0.05 - 1.2	0.34	0.006 - 0.22	0.085	27
	DANEBORG/1974	muscle	7	0.25 - 0.68	0.42	0.23 - 0.56	0.36	86
		liver	7	1.4 - 8.1	2.9	0.31 - 0.96	0.58	20
	UPERNAVIK/1976	muscle	31	0.02 - 0.55	0.18	-	-	-
		liver	31	0.14 - 11.9	2.1	-	-	-
MINKE WHALE	UMANAK/1972	muscle	9	0.06 - 0.21	0.11	0.03 - 0.09	0.06	56
		liver	4	0.10 - 0.21	0.17	0.05 - 0.09	0.08	47
(Balaenoptera acutorostrata)	DISKO BAY/1978	muscle	6	0.09 - 0.25	0.15	0.08 - 0.16	0.11	60
		liver	6	0.07 - 0.41	0.18	0.03 - 0.13	0.06	43

Table 2. Cadmium, copper, lead, and zinc in ringed seal *(Phoca hispida)*, range and arithmetic mean (ppm wet weight). n = number of samples.

LOCALITY/YEAR	TISSUE	n	Cd range	Cd mean	Cu range	Cu mean	Pb range	Pb mean	Zn range	Zn mean
UMANAK/1979	blubber	29	<0.02 - 0.03	<0.02	0.08 - 0.18	0.12	<0.05 - 2.38	0.12[a]	0.66 - 1.16	0.84
	muscle	29	0.02 - 0.42	0.07	1.03 - 1.55	1.27	0.02 - 0.10	0.04	14.2 - 39.5	22.2
	liver	29	2.71 - 14.9	7.32	4.48 - 22.3	11.6	<0.01 - 0.03	0.01[b]	30.7 - 67.3	46.0
	kidney	29	9.01 -146.2	37.4	4.95 - 21.8	10.6	<0.004 - 0.48	0.05[c]	27.9 - 78.0	46.2
DANEBORG/1974	liver	7	1.8 - 18.2	6.6	1.3 - 14.6	8.1	<0.03 - 0.04	<0.03		
UPERNAVIK/1974	blubber	7	<0.02 - 0.04	<0.02	<0.2 - <0.2	<0.2	<0.02 - 0.15	0.05[d]	0.1 - 2.3	1.4
+1976	muscle	7	0.09 - 0.24	0.15	2.0 - 4.7	3.2	<0.05 - 0.35	0.16[e]	37 - 84	55
	liver	12	2.3 - 31.6	17.0	2.8 - 16.9	7.6	<0.03 - 0.06	<0.03	18 - 46	37

a) 26 out of 29 values were below the detection limit (0.05 ppm Pb). In computing the mean value values below the detection limit have been fixed to half this value, *i.e.* 0.025 ppm Pb. This procedure has been applied in similar cases mentioned below. In the actual case the mean value for lead in blubber probably is better expressed as less than 0.05 ppm Pb, see the text.

b) 15 values were below the detection limit (0.02 ppm Pb).

c) 12 values were below the detection limit (0.02 ppm Pb).

d) 4 values were below the detection limit (0.02 ppm Pb). The mean is probably better as less than 0.02 ppm Pb, see the text.

e) 1 value was below the detection limit (0.05 ppm Pb).

Table 3. Organochlorine residues in blubber of seals and whales sampled in Greenland during the period 1972-76. Arithmetic mean and range in mg/kg on wet weight basis.

SPECIES	LOCALITY/YEAR	n	Extractable fat %	Mean mg/kg DDE	DDD	DDT	∑ DDT	PCB	Range ∑ DDT	PCB
HARP SEAL	UMANAK/1972	8	90.3	3.3	0.16[a]	0.91	4.9	1.9	0.82-17.2	0.74-4.0
(Pagophilus groenlandicus)	UPERNAVIK and DISKO BAY /1974	3	93.7	0.91	0.11	0.42	1.5	1.7	0.92- 2.6	1.2 -2.8
	UPERNAVIK/1976	3	93.3	1.9	0.15	0.55	2.8	1.6	0.93- 5.1	0.74-2.7
HOODED SEAL *(Crystophora cristata)*	UPERNAVIK and DISKO BAY /1974	4	89.6	1.7	0.086	1.4	3.5	3.9	2.1 - 6.5	2.2 -8.2
RINGED SEAL	DANEBORG/1974	7	92.6	1.4	0.13	1.4	3.1	3.2	1.1 - 7.2	1.9 -5.8
(Phoca hispida)	UPERNAVIK/1974	9	96.0	0.54	0.069	0.53	1.2	1.2	0.43- 2.0	0.62-1.9
	UPERNAVIK/1975	31	92.0	0.36	0.032	0.34	0.76	0.87	0.31- 3.4	0.28-3.1
	UPERNAVIK/1976	17	88.6	0.78	0.031	0.47	1.4	0.99	0.35- 6.2	0.28-3.6
MINKE WHALE *(Balaenoptera acutorostrata)*	UMANAK/1972	6	59.8	0.60	0.14	0.55	1.4	0.61	0.21- 2.6	0.14-1.1

a) Two values were below the detection limit (0.001 ppm DDD).

Table 4. Mean values of cadmium, copper, mercury, lead, and zinc in marine mammals from the North Atlantic and Arctic Canada. ppm on wet weight basis

Species	Locality	Tissue	Sex/age	n	Cd	Cu	Hg	Pb	Zn	Ref.
Grey seal	Farne Islands	Liver	♂	24	0.31	12.6	43.0	<2.5	51.6	1
			♀	38	0.91	28.9	141.5	<2.5	55.3	1
		Kidney	♂	27	2.29	3.23	4.12	<2.5	27.5	1
			♀	37	5.94	2.97	4.32	<2.5	28.4	1
Harbour seal	German North Sea coast	Liver	o- 6 mths	27	0.018	6.1	3.5	0.23	39.4	2
			7-12 -	11	0.024	7.0	6.7	0.23	39.6	2
			13-18 -	11	0.028	5.7	15.3	0.17	42.2	2
			19-24 -	4	0.032	10.6	11.2	0.23	37.3	2
			6- 8 years	4	0.135	10.7	96.0	0.46	36.0	2
		Kidney	7-12 months	9	0.10	3.3	3.3	0.32	22.2	2
			19-24 -	4	0.22	3.2	3.9	0.38	26.5	2
			6- 8 years	3	0.31	2.5	7.9	0.46	18.8	2
Grey seal	Sable Island Eastern Canada	Muscle	8 years	11			1.13			3
		Liver	8 -	11			88.2			3
Harbour seal	Sable Island Eastern Canada	Muscle	3 years	8			0.71			3
		Liver	3 -	8			8.86			3
Hooded seal	Magdalen Is. Quebec	Muscle	10 years	3			1.21			3
		Liver	10 -	3			37.2			3
Harp seal	Escoumins, Quebec	Muscle	7 years	19			0.38			3
		Liver	7 -	20			3.63			3
Ringed seal	Victoria Is., NWT, Canada	Muscle		80			0.72			4
		Liver		80			27.5			4
Bearded seal	Victoria Is., NWT, Canada	Muscle		3			0.53			4
				6			143			4
Harbour seal	Gulf of Maine, and Bay of Fundy	Muscle	103 cm	11			0.59			5
		Liver	103 -	10			8.75			5
Harbour seal	West Scotland	Muscle		12	0.13		1.4o	1.2		12
		Liver		6-17	0.2-1.1[a]		1.05-1.13[a]	2.31		12
		Kidney		6-15	0.1-1.9[a]		0.2 -4.7[a]	1.17		12

a) Range of values

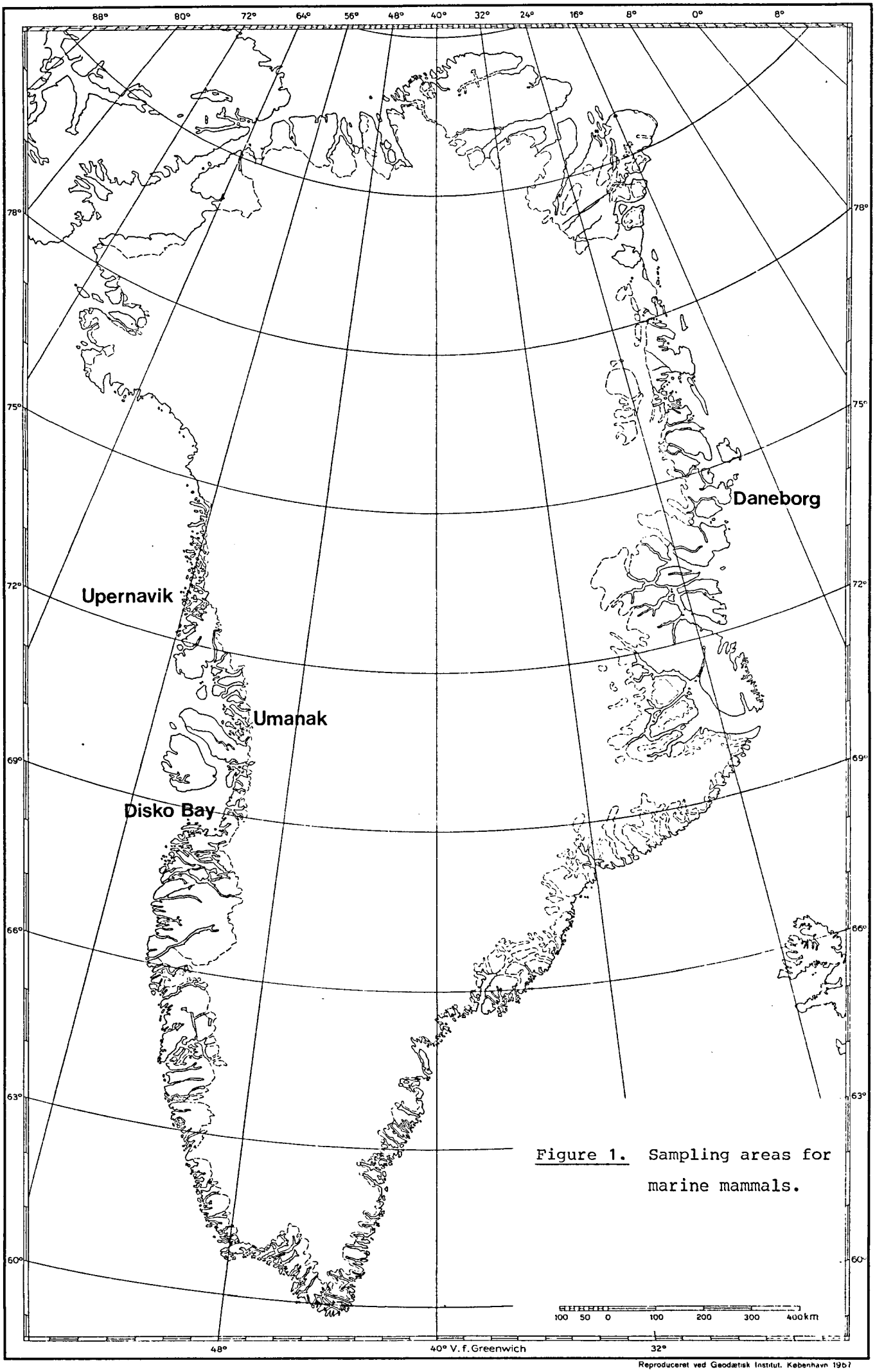

Figure 1. Sampling areas for marine mammals.

Table 5. Mean values of total DDT and PCB in marine mammals from the North Sea, the Baltic, the Canadian/US east coast and the Canadian Arctic. Results are expressed in ppm on wet weight basis.

SPECIES	LOCALITY	TISSUE	Age/length/sex	n	% fat	Σ DDT	PCB	REF.
HARBOUR SEAL	German North Sea coast	blubber	0-6 months	24	87.1	10.3	167.8	2
			7-12 "	12	93.9	7.7	135.5	2
			13-18 "	11	88.3	8.8	162.8	2
			19-24 "	4	98.2	6.0	87.3	2
			6-8 years	4	96.3	6.3	164.6	2
GREY SEAL	Farne Island	blubber	(3-27 years) ♂	26		8.97	48.7	6
			(1-36 ") ♀	33		4.26	35.4	6
HARBOUR SEAL	Dutch Wadden Sea	blubber	4 years	7	85.6	10.7	189.4	7
		liver	10 "	5	5.24	0.55	17.0	7
HARBOUR SEAL	Gulf of Maine & Bay of Fundy	blubber	99 cm	10	90.7	51.6	71.9	5
		muscle	100 cm	10	1.71	0.45	0.77	5
		liver	103 cm	10	3.31	1.03	1.84	5
HARP SEAL	Gulf of St.Lawrence	blubber	6 years	18	91.0	9.36	8.17	8
RINGED SEAL	Arctic Canada	blubber		7	91.0	1.02	0.87	9
		muscle		4	2.3	0.021	0.020	9
		liver		6	3.5	0.046	0.042	9
RINGED SEAL	Holman Island, NWT, Canada	blubber	14.5 years ♂	15		1.31	4.1	10
			10.9 " ♀	13		0.61	2.0	10
RINGED SEAL	Bothman Bay, Baltic	blubber	♂	24		130	100	11
			♀	8-29		88-130[a]	73-110[a]	11

a) Range of means

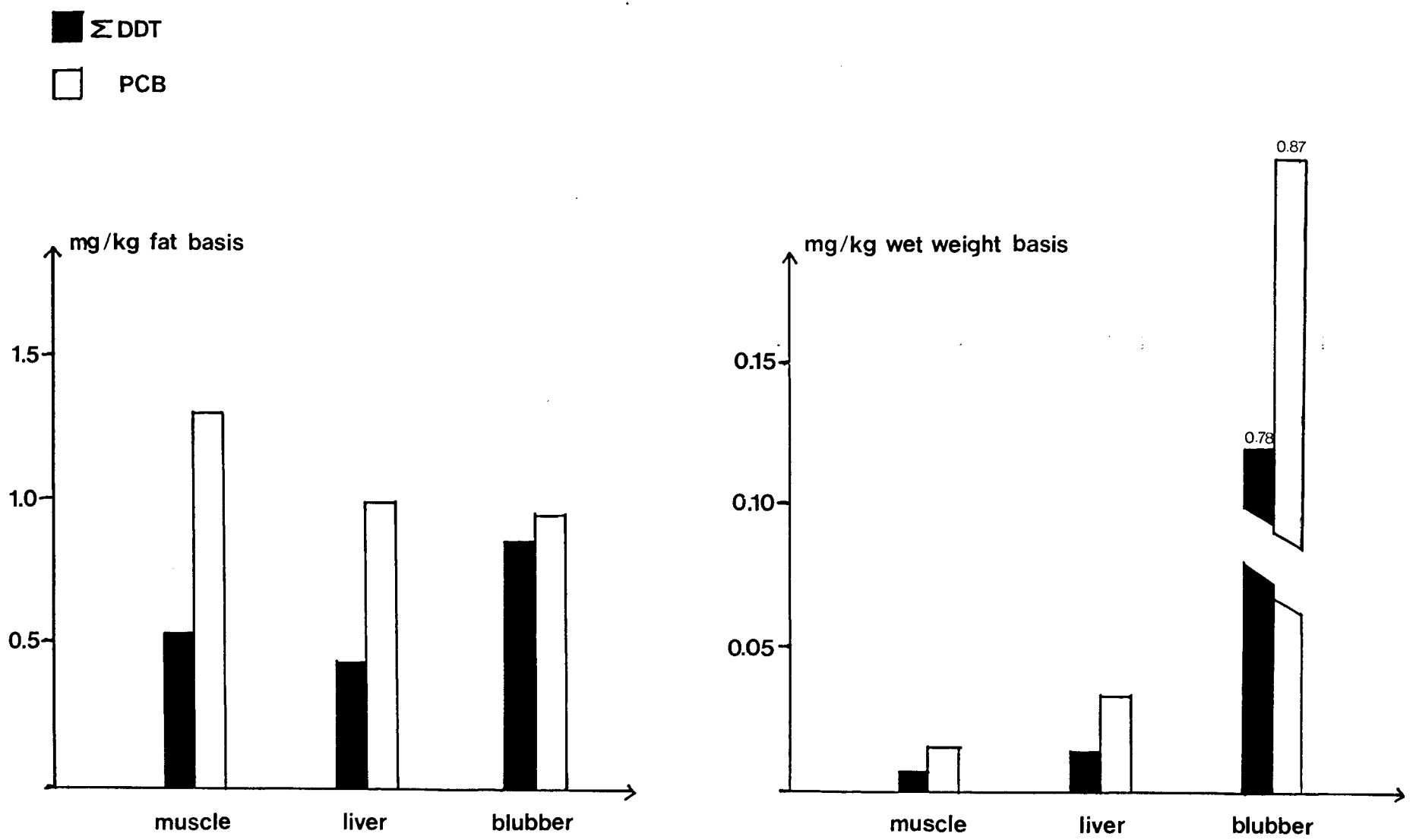

Figure 2. Distribution of total DDT and PCB in muscle, liver and blubber of 31 ringed seals.

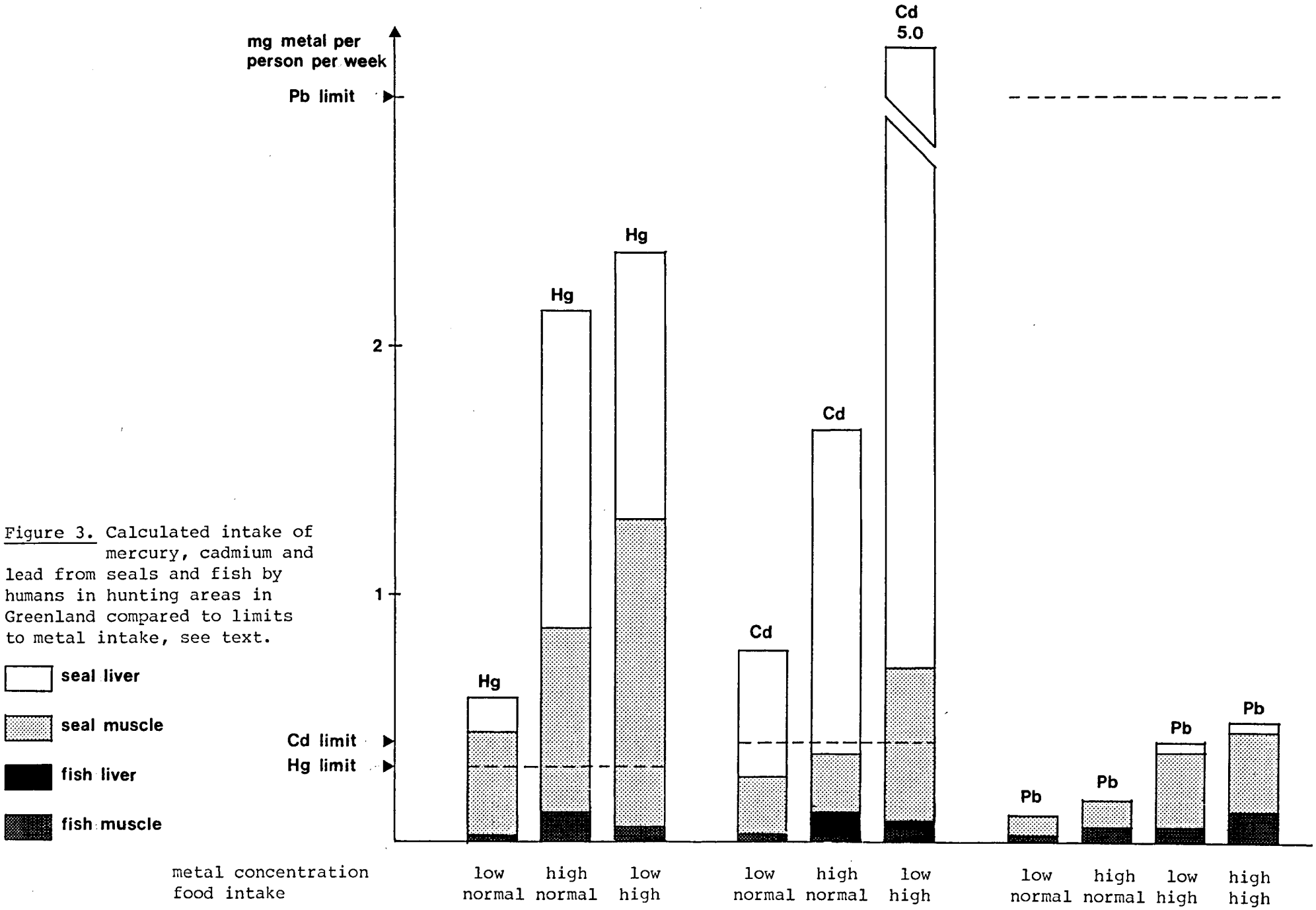

Figure 3. Calculated intake of mercury, cadmium and lead from seals and fish by humans in hunting areas in Greenland compared to limits to metal intake, see text.