ENVIRONMENTAL CONTAMINANTS, POPULATION STRUCTURE, AND BIOLOGICAL CONDITION OF HARVESTED MINK IN THE WESTERN NORTHWEST TERRITORIES, 1991-92

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ABSTRACT

Mink are a top trophic level species that readily bioaccumulate environmental pollutants, and as such are considered to be a sensitive indicator of ecosystem health. In the first year of a study to examine levels of organochlorine and heavy metal contaminants in mink along the Mackenzie River drainage basin, carcasses were collected from Inuvik, Ft. Good Hope, and Ft. Rae during winter 1991-92. Tissue samples from 20 mink from each site were analyzed for a suite of 63 organochlorine residues in fat and liver samples, including 43 polychlorinated biphenyl (PCB) congeners and 20 pesticides, and residues of 10 heavy metals in liver and kidney samples. In an attempt to link contaminant levels to population effects, carcasses also were examined for sex, age, and body condition.

A total of 510 mink were collected. Over 60% of the harvest in all areas was composed of juveniles, and 62% were males. Inuvik mink were significantly larger and fatter than mink from the Ft. Good Hope area, which were in turn larger and fatter than Ft. Rae mink.

Overall, contaminant levels were low in comparison with other mink studies in North America, with total PCB residues ranging from a mean of 8.9 μg/kg (parts per billions [ppb]) in the livers of Inuvik mink to 95.5 ppb in mink from Ft. Rae. Heavy metal residues were also comparatively low, with the exception of mercury, which was at moderate levels (community means of 1.0-3.0 μg/g [parts per million] in liver samples). Many environmental factors may influence the intake of mercury. There was a general trend of decreasing contaminant levels with increasing latitude; Ft. Rae mink had slightly higher residue levels than mink from Ft. Good Hope, and Inuvik mink were significantly lower than other communities.

The population indices, coupled with comparatively low levels of contaminants, suggest little or no effects on mink reproduction or population health as a result of these contaminants. Collections and residue analyses will be continued for at least 2 years near Inuvik and other sites on the Mackenzie drainage system, to examine spatial and temporal trends in contaminant levels.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Little information is available on contaminant loads in terrestrial wildlife in northern Canada. The scarcity of heavy metal or organic residue data for terrestrial mammals has been identified as one of the major data gaps in arctic contaminant research (Wong 1989). The limited analyses that have been conducted on terrestrial species have indicated that a variety of contaminants are present (Smith and Armstrong 1975, Shaw and Gunn 1981), and warrant more comprehensive studies to establish baseline levels.

Mink (Mustela vison) are a top trophic level species that readily bioaccumulate environmental pollutants such as polychlorinated biphenyl (PCB), DDT and methylmercury residues. Small mammals and fish form the greatest components of mink diet in most areas (Eagle and Whitman 1987), thus the species is exposed to contaminants derived from both land and aquatic food webs. Mink are extremely sensitive to PCB contaminants, and are known to experience reproductive failure as a result of eating food contaminated with relatively low levels of PCBs (reviewed in Ringer 1981, Eisler 1986). Dietary doses of PCBs as low as 0.64 parts per million (ppm) fed for 160 days can result in nearly complete reproductive failure (Platonow and Karstad 1973). This unique susceptibility can result in population effects at low levels of environmental contaminants (Wren 1991). As such, mink may provide a sensitive indicator to assess short and long term trends in environmental contaminants and ecosystem health.

A number of organochlorine and heavy metal contaminants have been identified in freshwater fish in the Mackenzie River, providing a potential source of contaminants for mink (Muir et al. 1989a, 1989b). Studies on fish near Ft. Good Hope and Colville Lake

have detected the presence of PCBs, toxaphene and chlordane, as well as HCH, chlorobenzene, dieldrin and DDT (Kuhnlein 1991). The heavy metals copper, nickel, cadmium, mercury, selenium and zinc have also been identified. Furans, dioxins and toxaphene have been identified in fish in low but detectable levels in the Northwest Territories (NWT) portion of the Slave River and nearby lakes (K. Robertson pers. comm.)

This study will evaluate the presence and establish baseline levels of organochlorine and heavy metal contaminants in mink along the Mackenzie River drainage basin, and will examine geographical and temporal trends in these contaminant levels. The baseline values established may identify specific contaminants that warrant further study, and provide the basis for a more specific ongoing monitoring program. In an attempt to link contaminant levels to population effects, the study also will examine samples of carcasses collected to determine age and sex structure of the harvest and body condition. Examination of age and sex ratios appears to be the only method, short of an intensive live-trapping study, to assess the reproductive performance of the population.

Specific objectives of the study are:

1. To assess the exposure of wild mink to organochlorine and heavy metal contaminants.
2. To determine baseline levels of organochlorine and heavy metal contaminants in several mink tissues.
3. To identify geographical and temporal trends of these contaminants in mink in the Mackenzie River drainage basin.
4. To evaluate the potential impact of organochlorine contaminants on mink reproduction.

5. To evaluate mink as a sensitive indicator species to monitor the effects of environmental contaminants on ecosystem health.

6. To examine age and sex ratios in the harvest, aging techniques, and body condition, morphometric differences, and diet among collection areas.

Some analyses and interpretation of the data have been conducted, but the information and conclusions presented here should be considered preliminary.

METHODS

With the assistance of Department of Renewable Resources (DRR) staff in Inuvik, Ft. Good Hope, Ft. Norman , Ft. Simpson, and Ft. Rae (Fig. 1), cooperative trappers were provided with carcass tags and plastic bags, and were asked to tag and bag all mink harvested, noting location and date taken. All carcasses were kept frozen during storage and transportation. Carcasses were examined in Yellowknife. Sex, body and tail length, weight, and fat indices (weight of fresh omental fat over fresh weight [minus stomach contents] of skinned carcass) (Buskirk and Harlow 1989) were recorded. Condylobasal length and zygomatic width were measured. The length of temporal muscle coalescence (Poole et al. in press) was recorded to examine its relationship with age in mink. Stomach contents, when present, were weighed and frozen, and sent to the Composition Analysis Laboratory, Fort Collins, Colorado, for diet composition analysis. Liver, kidney, and fat (inguinal pad) samples were collected for contaminant residue analysis from 20 mink from each community, and were stored at -20 C. An even distribution by sex was sampled at each site.

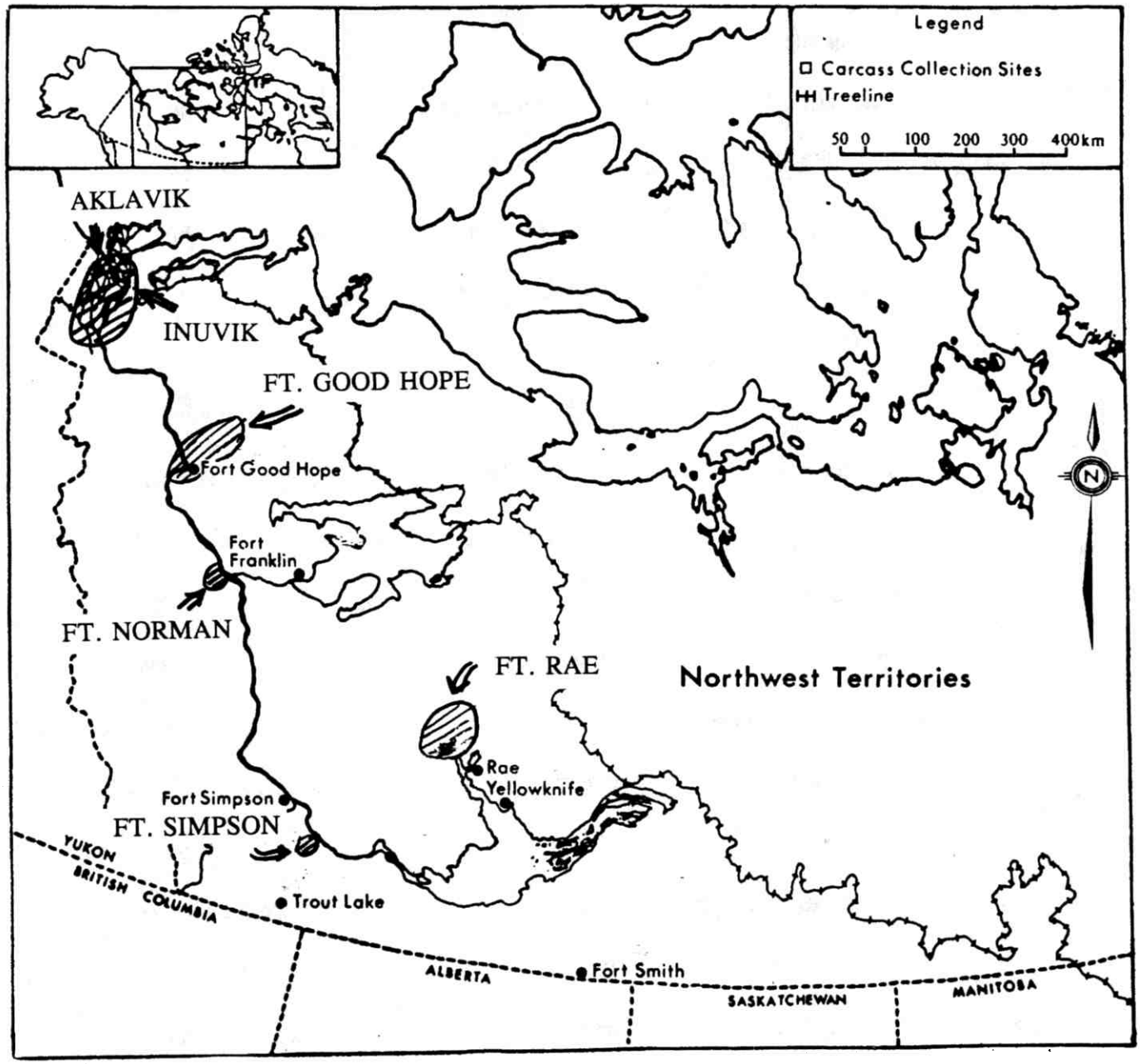

Figure 1. Location (shaded areas) of mink carcass collections in the western NWT, 1991-92.

Frozen tissue samples were forwarded to the Great Lakes Institute, Windsor, Ontario, for contaminant analyses. Using established laboratory techniques involving gas chromatography and an electron capture detector (G.D. Haffner, pers. comm.), analyses were conducted for residues of 20 organochlorine pesticides and 43 PCB congeners (Table 1) on individual fat and liver samples from each animal. Detection limits were 0.02 μg/kg (parts per billion [ppb]). Analyses for 10 heavy metals (Table 1) were run on individual liver and kidney samples.

Table 1. Organochlorine and heavy metal residues analyzed in mink tissues.

Organochlorine residue			Heavy metals
1,2,4,5-T4CB	PCB #52	PCB #129	Aluminum (Al)
1,2,3,4-T4CB	PCB #49	PCB #182/187	Cadmium (Cd)
QCB	PCB #44	PCB #183	Chromium (Cr)
a-HCH	PCB #42	PCB #185	Copper (Cu)
HCB	PCB #64	PCB #174	Iron (Fe)
b-HCB	PCB #74	PCB #171	Mercury (Hg)
g-HCH	PCB #70	PCB #200	Manganese (Mn)
OCS	PCB #66/95	PCB #172	Nickel (Ni)
oxy-Chlordane	PCB #60	PCB #180	Lead (Pb)
trans-Chlordane	PCB #101	PCB #170/190	Zinc (Zn)
cis-Chlordane	PCB #99	PCB #201	
trans-Nonachlor	PCB #97	PCB #203	
pp'DDE	PCB #87	PCB #195	
pp'DDD	PCB #110	PCB #194	
cis-Nonachlor	PCB #151	PCB #206	
pp'DDT	PCB #149	Arochlor 1254:1260	
photo-Mirex	PCB #118	PCB #77	
Mirex	PCB #146	PCB #126	
HCI Epox	PCB #153	PCB #169	
Dieldrin	PCB #105	PCB #189	
PCB #31	PCB #141		
PCB #28	PCB #138		

Reproductive tracts from all females were dissected out and stored in 70% alcohol. It had been hoped that corpora lutea counts could be used to assess ovulation rates and *in utero* litter size in serially sectioned ovaries (Strickland and Douglas 1987). However, because mink generally breed in March with a greatly reduced period of delayed implantation compared with marten (Martes americana)(Mead and Wright 1983), corpora lutea or placental scars would not be visible during the collection period, and the attempt to assess reproductive indices from the carcasses was abandoned. Therefore, the reproductive performance of the populations were assessed indirectly by examining age and sex ratios in the harvest (Strickland and Douglas 1987).

To examine if the ratio of pulp cavity width:tooth width (percent pulp) (Dix and Strickland 1986) could be used to rapidly classify mink into juvenile and adult age classes, all lower canines were extracted by simmering lower jaws in hot water for 30-40 minutes. Following procedures outlined in Dix and Strickland (1986), the percent pulp, as determined from radiographs, was measured. Radiographs were taken at the Stanton Yellowknife Hospital using a Senograph 600T Mammo Unit and Kodak Mammography film exposed at 30 Kv and 7 Mas. Tooth and pulp cavity width were measured using a Canon microfiche reader, which projected images at 23.5X. Lower canines from all mink were aged by cementum analysis by Matson's Laboratory in Milltown, MT.

Data were examined using SAS (1988) software. In this report age class "0" (juvenile) denotes mink in their first winter of life; yearling mink (in their second winter of life) are designated by age class "1". Statistical significance is at the $P \leq 0.05$ level.

RESULTS

Carcass collections

A total of 510 mink carcasses were collected: 337 from Inuvik (90% of the community harvest), 48 from Aklavik (6%), 68 from Ft. Good Hope (80%), 52 from Ft. Rae (20%), 3 from Ft. Simpson, and 2 from Ft. Norman. The Aklavik and Inuvik mink were combined for analyses because most of these mink were taken from the Mackenzie Delta. The Fts. Simpson and Norman samples were excluded from many of the analyses.

The age distributions of harvested mink were similar among the 3 main collection areas (Fig. 2). Juveniles made up over 60% and yearlings comprised 13-14% of the sample from each community. The oldest mink was 9 years of age. The age and sex ratios from the collection areas also were similar (Table 2). Overall, 62% of the harvest were males (1.69 M:1 F).

There were no significant differences in omental fat among 0, 1, 2, and 3+ age classes for both males and females ($P > 0.11$), therefore all age classes were combined to examine among community differences. Ft. Good Hope and Inuvik mink were significantly fatter than Ft. Rae mink for males (ANOVA, $P < 0.0001$) and females ($P = 0.002$)(Table 3).

Examining condylobasal length, zygomatic width, and body length, mink from the Inuvik area were significantly larger in all variables than Ft. Good Hope mink, which were in turn larger than Ft. Rae mink (males and females, ANOVA, all $P < 0.001$)(Table 4).

Up to 90% overlap of temporal muscle length between juvenile and older animals precluded use of this technique to estimate age class of the carcasses. Percent pulp,

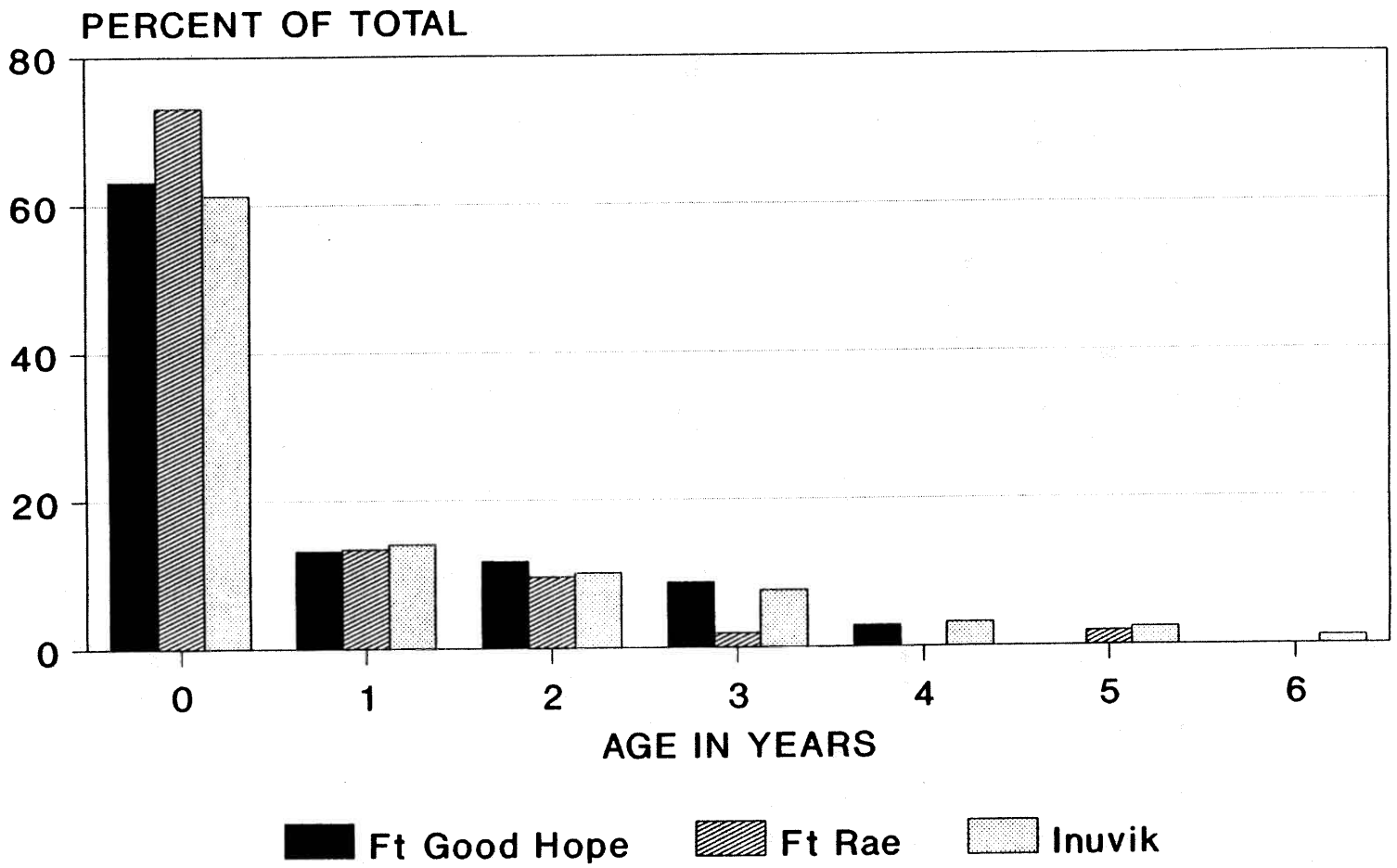

Figure 2. Age structure of mink carcasses collected from 3 NWT communities, 1991-92: Inuvik (n = 385), Ft. Good Hope (n = 68), and Ft. Rae (n = 52).

Table 2. Age and sex ratios from mink carcasses, 1991-92.

Community/ Trapper	Sample Size	Ratios	
		Juv:2+Fem	Male:Female
Inuvik	385	8.21	1.77
Ft. Good Hope	68	6.14	1.43
Ft. Rae	52	12.67	1.48

Table 3. Mean body fat index (SD)[n] of mink carcasses by sex and community[a].

Community	Males	Females
Inuvik	0.45 (0.23) [233]	0.44 (0.23) [132]
Ft. Good Hope	0.55 (0.36) [38]	0.33 (0.22) [25]
Ft. Rae	0.27 (0.22) [27]	0.27 (0.21) [20]

[a] Body fat derived from the following formula from Buskirk (1983) for marten: Body fat = 603 x (omentum wt/carcass wt) + 0.87.

Table 4. Mean condylobasal length, zygomatic width, and body length of NWT mink.

Sex/ Community	n	Condylobasal length (mm) (SD)	Zygomatic width (mm) (SD)	Body length (mm) (SD)
Males				
Inuvik	240	76.2 (2.26)	45.6 (1.77)	457 (20.4)
Ft. Good Hope	40	71.3 (2.42)	41.7 (2.14)	429 (21.4)
Ft. Rae	30	69.1 (2.52	39.7 (1.78)	406 (20.4)
Females				
Inuvik	136	69.2 (1.96)	40.5 (1.70)	407 (17.5)
Ft. Good Hope	27	65.2 (1.66)	37.3 (1.32)	386 (22.2)
Ft. Rae	20	62.8 (1.27)	35.6 (1.13)	360 (17.7)

however, provided a reliable and relatively rapid method of distinguishing juvenile from older animals (Table 5). Over 97% of juvenile and 1+ year age and sex classes could be identified correctly using this technique.

Stomach contents from 77 mink are presently being analyzed.

Contaminant analyses

Organochlorine contaminant levels generally were lower in Inuvik mink compared with animals taken near Ft. Rae and Ft. Good Hope, although for many compounds the differences were not significant (Table 6). Contaminant levels in Ft. Rae samples generally were slightly higher than those from Ft. Good Hope. Results are presented in this report

Table 5. Percent pulp cavity ([pulp width/tooth width] x 100) of lower canine teeth in juvenile and adult mink, 1991-92.

Sex	Age class	n	Mean	SD	Dividing point	% Aged correctly
M	0	188	50.71	5.45	36.6	99.5
	1+	103	21.57	5.81		97.1
F	0	106	44.73	4.25	32.4	100
	1+	68	19.55	4.41		100

only for liver samples because of strong correlations between contaminant burdens in liver and fat from the same animal, and most other studies in North America examining organochlorine contaminants in mink have used livers, facilitating comparisons. Many of the pesticides and PCB congeners examined were found at very low levels and are the less toxic compounds. Data from some of the more toxic compounds, and those with higher levels are given here (Table 6). Data from other compounds not listed are available from the authors. The level of Aroclor mixture (1242:1254:1260) provides a reliable estimate of total PCB (log[Aroclor] = 0.28 + 1.01 log[total PCB], r^2 = 0.94). Aroclor 1260 represented over 86% of the total PCB levels found at all sites in liver samples, and over 90% in fat samples.

Preliminary analyses conducted by the Great Lakes Institute (G.D. Haffner pers. comm.) found no significant differences in organochlorine contaminant burdens between the sexes, with body size, or with age. Relatively small samples from each site (20) may have masked true differences among these variables.

Table 6. Mean (SD) levels (wet weight) of selected organochlorine contaminants (μg/kg [ppb]) from livers of mink taken near 3 communities in the western NWT, 1991-92.[a,b,c]

Community	% lipid	Oxychlor	DDE	DDT	Dieldrin	PCB118	PCB153	PCB138	PCB126	PCB189	Aroclor[d]
Ft. Rae	6.9	3.3 (2.87)	6.2 (9.30)	0.03 (0.10)	0.6 (1.52)	1.5 (1.91)	6.2 (7.83)	7.1 (9.89)	ND	0.2 (0.54)	95.5 (113.62)
Ft. Good Hope	7.2	3.5 (3.68)	5.3 (7.73)	ND	0.4 (0.46)	1.0 (1.58)	7.1 (19.09)	5.8 (13.75)	0.02 (0.06)	0.2 (0.87)	78.0 (185.84)
Inuvik	5.2	1.4 (2.18)	0.8 (0.63)	ND	0.7 (2.03)	0.1 (0.11)	0.6 (0.62)	0.7 (0.70)	ND	ND	8.9 (9.41)

[a] n = 20 from each community.
[b] PCB77 and PCB169 not detected (ND) in any samples.
[c] Samples below detection limit were assigned one half the limit (0.01 ppb) for calculation of means.
[d] Aroclor 1242:1254:1260 is equivalent to Total PCB.

Baseline levels of heavy metal burdens were obtained for all 10 metals, and most were found to be low; results for cadmium and mercury are presented (Table 7). Again, there was a general trend of diminishing heavy metal burdens the further north the samples originated. Statistically, there were no differences in cadmium levels among sites, but mercury levels in Ft. Rae and Ft. Good Hope were significantly higher that those found in Inuvik. Cadmium burdens in females were higher than males ($\underline{P} = 0.028$).

Table 7. Mean (SD) levels (wet weight) of cadmium (Cd) and mercury (Hg) (μg/g [ppm]) from kidneys and livers of mink taken near 3 communities in the western NWT, 1991-92.[a,b]

	Kidney		Liver	
Community	Cd	Hg	Cd	Hg
Ft. Rae	1.0 (1.58)	1.7 (0.92)	0.4 (0.57)	3.0 (2.45)
Ft. Good Hope	0.9 (0.86)	1.2 (0.66)	0.2 (0.17)	2.2 (1.28)
Inuvik	0.8 (1.23)	0.7 (0.36)	0.3 (0.39)	1.0 (0.58)

[a] $\underline{n} = 20$ from each community.
[b] Outliers removed (liver $\underline{n} = 3$, kidney $\underline{n} = 1$).

DISCUSSION

Several factors are evident from the contaminant levels observed. First, while organochlorine residues are present in mink in the NWT, the observed burdens generally are low in comparison with mink from other areas of North America. NWT community means for total PCBs ranged from 9-95 ppb, while mink from Southern Ontario had total PCB levels which ranged from 34-1800 ppb, and DDE levels of 2.2-170 ppb (G.D. Haffner pers. comm.). Mink from Lake Ontario had levels of total PCB which ranged from 80-1020 ppb (D. Weseloh, unpubl. data, cited in Wren 1991). PCB levels in mink from New York ranged from 30-7900 ppb (Foley et al. 1988), and Oregon mink contained an average of 400 ppb PCB in liver tissue (Henney et al. 1981).

Almost all individual organochlorine and heavy metal residue levels were lowest in Inuvik mink, significantly so in many cases. Although further collections from other sites in the western NWT are required to confirm this trend, it appears that lower residue burdens may be associated with increasing latitude. Three likely sources for contaminants in NWT mink are global drift (long-range atmospheric movement), long-range aquatic movement through the Mackenzie drainage basin, or a local source. Local collection sites were up to 100 km apart within each community and residue levels were relatively uniform within each site, therefore it is unlikely that local contamination sources contribute much to the overall burden. Mink movements, with the exception of dispersing juveniles, generally are restricted to small areas (<2 km^2, Eagle and Whitman 1987). Although most Inuvik mink were trapped in the Mackenzie Delta where they would have direct access to contaminants transported down the river system, mink from the other 2 sites, with considerably higher

residue burdens, generally were taken from areas not directly associated with the river. This would suggest that the Mackenzie River system (i.e., contaminants washed downstream from northern British Columbia and Alberta) does not contribute a significant amount to the overall burden. Therefore, global drift may be the main source for the contaminants accumulated in NWT mink.

One factor that does not support the global drift argument is the high proportion of Aroclor 1260 in the mink tissues. This heavier compound (compared to Aroclor 1242 and 1254) does not lend itself to long-range atmospheric or aquatic transportation, and a sample high in Aroclor 1260 suggests a local source of PCB (G.D. Haffner pers. comm.). Further examination of the possible sources for the contaminants observed will be possible after mink diet analyses are completed, and further collections are conducted from other sites in the NWT.

Cadmium levels generally were low and uniformly distributed, as would be expected for this relatively mobile metal. Mercury levels, however, were moderate compared with other studies of wild mink, which ranged from 0.14-5.05 parts per million (ppm) (Kucera 1983, Wren et al. 1986). Many factors influence tissue levels of mercury in mink, including acidity (pH) of the water, calcium and selenium levels, bedrock and soil composition, proportion of fish in the diet, and proximity to source of mercury pollution (Kucera 1983, Wren et al. 1986).

Attempts have been made to identify cause-effect links between presence of contaminants and health effects in the mink population of study (Wren 1991). A recent effort examined mink harvest levels over time in the Great Lakes area (Wren 1991).

However, many factors affect harvest levels, including trapper effort. We have attempted to relate contaminant levels observed in NWT mink with possible effects on mink reproduction or population health by examining the age and sex structure of the harvested population. We were unable to identify a direct indication of reproductive performance of the mink harvested. However, population indices as obtained from carcass analyses may provide an indication of harvest impact and, indirectly, reproductive performance and population status.

In discussions about marten harvesting Strickland and Douglas (1987:541) stated "the differences in vulnerability between males and females, and between juveniles and adults, are reflected in the sex and age ratios of trapped animals, and these ratios form the bases of indices of overharvest." A marten harvest with a low proportion of juveniles and a high proportion of adult females indicates that the population may be overharvested (Strickland and Douglas 1987, Thompson and Colgan 1987). Strickland and Douglas (1987) suggest that a healthy harvest has occurred in a marten population if the ratio of juveniles to adult females 2+ years old is twice, or more, the fecundity rate (based on corpora lutea counts in the previous winter). Sex ratios will similarly indicate potential overharvest, although less strongly; sex ratios that are nearly even or are dominated by females may indicate overharvest (Strickland and Douglas 1987, Thompson and Colgan 1987).

No data are available that examine sex and age biases in mink harvests. However, if we assume that the harvest biases for marten generally apply to mink, then the evidence from the 3 harvest areas suggests light harvesting and healthy reproductive performance. A harvest favouring older animals or males would suggest either heavy harvesting or poor reproduction. Over 60% of the harvest in each areas consisted of juveniles, and males

predominated each harvest. Although data are lacking, mink litters in the NWT may average 4 kits (Eagle and Whitman 1987), thus the age and sex ratios in the harvest are within the bounds of healthy harvest levels. These indices, coupled with the generally low levels of organochlorine contaminants and heavy metals, suggest little or no effect on mink reproduction or population health.

The collections reveal a general trend towards larger and fatter mink with increasing latitude. Inuvik mink were 10-15% larger than mink from the Ft. Rae harvest in the 3 body parameters examined, with Ft. Good Hope mink roughly midway in size between these two populations. It is unclear whether diet or climatic influences are the causes of these differences. The Inuvik Delta is well known for its high numbers of muskrats (Ondatra zibethicus), likely an important regional food source for mink.

Three sites will again be sampled during winter 1992-93. Inuvik will be resampled to examine temporal changes in contaminant levels. Mink carcasses will be collected from the NWT portions of the Slave River (Ft. Smith and Ft. Resolution), and the Liard River (Ft. Liard and Ft. Simpson). Sampling protocol will be changed slightly. Mink livers will be examined for organochlorine residues; fat will be dropped. Three pooled liver samples from each site will be examined for dioxins, furans, and toxaphene levels, chemicals which have been associated with fish in many parts of the drainage system. Banked samples from the 1991-92 Ft. Good Hope and Ft. Rae collections also will be analyzed for these 3 chemicals if funding permits. Heavy metal analyses will remain unchanged.

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