Developing a mercury exposure profile for mink and river otter in Maine

(BRI 2004-09)

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(BRI 2003-05)

Submitted to:

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ABSTRACT

Anthropogenic releases of mercury into the environment for the past several decades have collected in aquatic ecosystems. The impact of this mercury build-up is of concern to regulators and policy makers. Maine and much of New England are especially at high risk because of local and regional emission sources, prevailing wind patterns, and certain hydrological and biogeochemical features. This study establishes an exposure profile for mercury in Maine's mink and river otter populations. A total of 69 otter and 92 mink carcasses have been collected. Mercury levels tend to be greater in otter vs. mink, interior vs. coastal populations, and females vs. males. Respective mean mercury levels in otter and mink fur, 25.88 and 20.69 ppm; based on other studies, fur mercury levels greater than 20 ppm indicate adverse effects. The proportion of sampled individuals exceeding 20 ppm in the fur was 59% for otter and 45% for mink. Otter and mink fur Hg levels ranged up to 234 ppm and 68.5 ppm, respectively. Brain and liver Hg levels were below published lethal levels. The strong and significant relationships among brain, liver, and fur Hg levels provide great flexibility in using one compartment for determining mercury exposure. Successful efforts with live-trapping are providing an ability to relate fur and blood Hg levels and also provide an effective way to target sampling areas. A total of 60 otter jaws were sent to Matson's Lab to determine age. Average age of trapped otters was 1.87 years old (the oldest was 9 years old). Age and fur mercury have a significant correlation ($p=0.0089$), while brain and liver did not. A total of 64 mink jaws were sent to Matson's Lab to determine age. Average age of trapped mink was 0.58 years old (the oldest was 5 years old). The brain, liver, and fur mercury and age did not correlate significantly in mink. No relationship was found with otter and mink corpora lutea and is likely explained by the majority of animals were under breeding age. Because of a small sample size in older individuals and the preponderance of individuals < 2 years of age, reproductive success and mercury levels cannot be significantly correlated.

INTRODUCTION

Mercury and other aquatic-based persistent bioaccumulative toxins are prevalent in Maine's freshwater and marine environments (Maine DEP 1998, NESCAUM 1998). Methylmercury (MeHg) availability to fish and wildlife varies inter-regionally (Evers et al. 1998b). Because its availability is strongly influenced by hydrology (Lucotte et al. 1999, Evers and Reaman 1998) and biogeochemical factors (Watras and Huckabee 1994) it also shows tremendous variation intra-regionally (Evers et al. 2004). To interpret environmental exposure in wildlife established benchmarks are needed. Standardized sampling of high-risk biosentinels provides a method for making informed comparisons and definitive interpretations, thereby helping assess risks to wildlife and allow landscape-level extrapolations of the hazards.

The mink (*Mustela vison)* and the river otter (*Lontra cannadensis*) are both widely distributed in New England and Maine. Both species have diets that include fish and crayfish, although mink are known prey generalists. Because of their high metabolism and piscivorous diet, both mink and river otters are highly susceptible to elevated levels of environmental MeHg (USEPA 1997).

Similar to the sampling time period of 2000-2002, our objective in 2003 was to further develop a mercury exposure profile for Maine's mink and river otter populations based on fur and tissues from carcasses provided by trappers. This profile serves as the basis for the mammal component of the Maine-based wildlife criterion value being developed by Evers et al. (2004).

Context – Comparison with other studies

Lab-based, dose-response studies of mink (Wobeser and Swift 1976) and otter (O'Connor and Neilson 1980) have shown that terminal total Hg concentrations occur at 25–20 ppm (ww) in the liver and kidney and 15–19 ppm (ww) in the brain. Dietary MeHg concentrations > 1.8 ppm (ww) are sufficient to cause mercury intoxication (Wobeser and Swift 1976, Thompson 1996).

Although fish fillet Hg levels > 1.8 ppm are rare in Maine (Stafford and Haines 1997), fish total Hg levels > 1.0 ppm are common and these (and lower) levels may contribute to sublethal impacts. Fish species with fillets > 1.0 ppm include smallmouth bass (*Micropterus dolomieu*), yellow perch (*Perca flavescens*), chain pickerel (*Esox niger*), and land-locked salmon (*Salmo salmar*) (Stafford and Haines 1997, Evers and Reaman 1998). Nearly all Hg in fish is in the toxic methyl form and is therefore biomagnified to the next trophic level.

Table 1. Concentrations of total Hg (ppm, ww) in river otter from various study sites. All values in parentheses are ranges and single values are arithmetic means. Studies are sorted by site.

Site	Sample Size	Muscle	Brain	Liver	Kidney	Fur[1]	Source
Britain	7	-	-	(0.2-4.3)	(0.08-2.02)	-	Mason 1988
Denmark	69	-	-	(0.03-12.4)	-	-	Mason and Madsen 1992
Georgia[3]		4.4C 1.5I		7.5 C		24.3C 15.2I	Halbrook et al. 1994
Ireland	32	-	-	(0.15-17.03)	-	-	Mason and Sullivan 1993
Maine	**69**	-	**0.55** (0.06–3.25)	**1.76** (0.24-8.66)	-	**25.9** (1.1–234)	BRI, This study
Manitoba	38		(0.04-9.5)	1.3-21.7	0.03-15.1		Kucera 1983
Mass.	96			1.9 (0.5-4.8			Organ 1989
New York	34	-	-	(0.01-6.95)	-	-	Foley et al. 1988
Nova Scotia	23		(0.07-1.8)C (0.5-10.2)I				Burgess et al. 2002
Ontario-1	1	36	30	96	58	47	Wren 1985[2]
Ontario-2	-	0.9	-	2.9	1.1	-	Wren et al. 1980
Ontario-3	84	(0.1-4.3)	(0.2-7.2)	(0.2-17.4)	(0.1-12.6)		Wren et al. 1986
Ontario-4	-	-	-	(1.0-3.5)	-	-	Wren and Stokes 1988
Ontario-5	130	-	2.0	6.7	-	13.8	Mierle et al. 2000
Vermont	21	-	-	-	-	13.58 (4.91-46.5)	BRI Unpub. data 2002
Wisconsin	49	1.4	0.7	3.3	8.5	6.5	Sheffy and St. Amant 1982

[1] Fresh weight

[2] Based on one individual from the English-Wabigoon River system that contained a recently operating chlor-alkali plant; this otter was found dead due to mercury exposure.

[3] Coastal samples=C and Interior samples=I

Empirical studies conducted by BioDiversity Research Institute (BRI) in New England wildlife (e.g., Evers et al. 2004, Shriver et al. 2002) and nationwide with the Common Loon (*Gavia immer*) (Evers et al. 1998, Evers et al. 2003) indicates elevated and potentially harmful Hg levels are present in aquatic environments. Comparisons with other mammalian studies (Table 1 and 2) further indicate that mink and river otter populations in Maine are likely exposed to sufficient quantities of dietary Hg to cause sublethal impacts.

Because the prey base is similar to loons, we expected body burdens in Maine to be greater than those in other areas of the United States for river otter (Table 1) and mink (Table 2). Much of the comparative literature is based on liver total Hg levels. However, because much of the Hg in the liver is demethylated (Scheuhamer et al. 1998) the available toxicity of methylmercury is best measured in the brain, fur, or muscle tissue.

An Ontario study considered otter populations to have reduced survivorship in high Hg areas (considered > 20 ppm of Hg in the fur) (Mierle et al. 2000). While Foley et al. (1988) considered Hg exposure in New York otter and mink population did not pose a serious risk, Halbrook et al. (1994) concluded similar Hg exposure profiles in mink and otter populations from Georgia were associated with adverse effects. Irrelevant of what levels pose risk at the individual level, there is widespread agreement that these two species are subjected to elevated Hg levels (Thompson 1996, USEPA 1997). Although the otter forages at higher trophic levels, most authors note that mink appear to be more sensitive to Hg impacts.

Table 2. Concentrations of total Hg (ppm,ww) in mink from various study sites. All values in parentheses are ranges and single values are arithmetic means. Studies are sorted by site.

Site	Sample Size	Muscle	Brain	Liver	Kidney	Fur[1]	Source
CT	8	-	-	(1.1-8.5)	-	-	Major and Carr 1991
MA	4	-	-	(0.01-1.9)	-	-	Major and Carr 1991
ME	92	-	**0.55** (0.1-2.6)	**1.64** (0.1-8.0)	-	**20.92** (1.8-68.5)	BRI, This study
NY	60	-	-	(0.25-7.66)	-	-	Foley et al. 1988
OH	-	-	-	0.1	-	-	Lynch 1973
ON	94	(0.01-4.1)	(0.3-0.7)	(0.01-7.5)	(0.1-5.5)		Wren et al. 1986
PQ 1	-	1.9	0.8	9.2			Desai-Greenway and Price 1976
PQ 2	-	2.4 (0.41-6.2)	-	8.3 (2.2-20.0)	-	-	Langis et al. 1999
SK[2]	1	-	-	58.2	31.9	-	Wobeser and Swift 1976
WI	39	1.3	0.5	2.1	2.3	7.6	Sheffy and St. Amant 1982

[1]Fresh weight
[2] Mink found in wild alive but later died due to mercury exposure

STUDY AREA & METHODS

Study Area

Previous mercury-based studies in Maine provided information on "hotspots" (Welch 1994, Evers et al. 1998a), aquatic habitats prone to enhanced methylmercury availability (i.e., reservoirs with a river-based origin that have summertime water levels that fluctuate >1m; Evers and Reaman 1998), and species most at risk (Evers et al. 1998b).

We identified three focal areas for our carcasses collection efforts (Appendices 1-3): (1) Flagstaff Lake, the North Branch of the Dead River and its watershed including Chain-of-Ponds, and the Dead River outflow from the Flagstaff dam have some of the highest levels of biotic mercury in the country; (2) Seboomook and Canada Falls Lakes and neighboring areas have had reports of mink extirpations; and (3) Millinockett area was chosen because of elevated mercury levels found from 2001 opportunistic sampling. Carcasses were also opportunistically collected from other areas in the state.

Sample collection

We collected 69 river otter (8 in 2000, 18 in 2001, 10 in 2002, 33 in 2003) and 92 mink (24 in 2000, 23 in 2001, 26 in 2002, 19 in 2003) carcasses from licensed fur trappers during the 2000-03 trapping seasons. The logistics of carcass retrieval were discussed with the following trappers: Dave MacNeill of Millinocket, Dan Kusnierz of Old Town, Bobby Cercena of Eustis, Jerry Le Beau of North Anson, Lindsay Seeley of Orrington, Jim Carter of Ashland, Oscar Cronk of Wiscasset, Bruce Connery of Acadia National Park and Robert Chandler from Princeton. In 2000, the author met with trappers in the Boothbay area during a trapper safety course sponsored by Maine Inland Fisheries and Wildlife (where he received his trapping certificate # METS-025-00-006).

Sample Processing

Carcasses were labeled and stored in freezers. Brain, femoral muscle, liver tissue, and the lower jaw were removed using stainless-steel instruments and placed into sterilized I-CHEM® jars. The lower jaw was archived in a freezer so a canine tooth could be used in the future to accurately age individuals. Fur was taken from the foot of the animal using stainless-steel instruments, cleaned, and placed into sealed envelopes. The tissues, once harvested, were refrozen. The tissue samples and corpora lutea were harvested at the University of Southern Maine using techniques according to Tufts University Animal Wildlife clinic protocols (M. Pokras, pers. com.). Lower jaws from 52 otter and mink and ovaries from 22 females (7 mink and 15 otter) were submitted to Matson's Laboratory, LLC (P.O. Box 308, 8140 Flagler Rd., Milltown, MT 59851; 406-258-6286; www.MatsonsLab.com).

Sample Analysis

Fur, brain and liver tissues were analyzed for total mercury using Cold Vapor Atomic Absorption (CVAA) methods. Laboratory analysis was conducted by Texas A&M Trace Element Research Lab (TERL), College Station, Texas (2000, 2002 and 2003) and Maine Environmental Lab (MEL), Yarmouth, Maine (2001, 2002 and 2003). Femoral muscle tissues

were archived for future analysis. TERL and MEL have conducted BRI's mercury analysis for bird tissues (blood, feathers, and eggs), fish, and crayfish for the past three years. Mercury level results are given as fresh weight (fw) for fur and wet weight (ww) for liver and brain. Instead of analyzing methylmercury (MeHg) levels we focused on total Hg because it is (1) less costly, (2) generally correlated with MeHg in most tissues (Kucera 1983), and (3) reflective of fur Hg levels because >95% of the Hg is methyl (Thompson 1996).

Methods for Live Trapping

We attempted live-captures of river otter and mink at latrine sites from during the fall of 2001 and summer of 2002-03. One-and-one-half inch soft catch foothold traps were set at entrances and exits of the latrine sites. We sectioned off the entrance and exits of the latrine sites and set the traps where the otter and mink are forced to step on them while traveling to or from the latrine. Also, traps were set on crossing paths that otter and mink use while traveling from one water-body to another. The number of traps varied at latrine sites from two to four depending on how many entrances and exits were present.

All of the traps were set on land, using a drop of otter or mink lure. The traps were equipped with four swivels and a spring to minimize trauma to the animal's foot. One swivel at the base of the trap allowed the trap to rotate 360°. The traps were anchored to a nearby root or a three-foot stake. The traps were always set so the animal could not reach the water or a tree to pry itself free and to avoid the potential risk of injury. We dug the traps into substrate so they would be flush with the ground. We used wax paper over the pan to keep the trigger debris free. The trap was then covered by pine needles and dirt to camouflage them. We checked the traps every morning so the animals were not in the traps for more than one night.

Once the otter or mink was captured we used a catchpole to safely control the animal while placing it in a holding box for transport back to our field station. We hand injected the animals using a mixture or Ketamine (2.5 mg/kg) and Medetomidine (0.025 mg/kg). We used Atipamezole (0.100 mg/kg) as an antiseden to the Medetomidine. The maximum time the animals were anesthetized was 45 minutes before given the antiseden.

RESULTS AND DISCUSSION

A. Mercury exposure profile

Three compartments were analyzed for Hg on each individual collected in 2000-03.

1. River Otter

A total of 69 otter carcasses were collected from 2000-03. Mean (+/- SD) length and weight for males were 69.4+/- 7.2cm and 5,694.6 +/- 1,337.5g, respectively. For females mean (+/- SD) length and weight were 67.0+/- 5.2cm and 4,975.6+/- 898.3g.

We analyzed 33 fur, liver and brain samples in 2003. Fur Hg concentrations ranged between 1.4 ppm in otter from Round Pond, on Mount Desert Island, to 73.7 ppm on the Dead River, near Flagstaff Lake (Table 3). Otter fur Hg levels indicates individuals from several sites are elevated (>20 ppm) when compared with other studies (Table 1). Brain total Hg levels ranged from 0.06 to 3.25 ppm while liver total Hg levels ranged from 0.24 to 8.66 ppm (Table 3).

Wren (1985) showed that Ontario river otters with mean fur Hg levels of 47 ppm had on average 30 ppm and 96 ppm total Hg in the brain and liver respectively. Lethal levels are considered 25-30 ppm total Hg in the liver (Thompson 1996) and 15-19 ppm total Hg in the brain (O'Connor and Neilsen 1980, Mierle et al. 2000). Although fur Hg levels from Maine otter approach lethal levels, brain and liver Hg levels indicate lower exposure.

Table 3. Concentrations of total Hg levels (ppm, ww) in brain, liver, and fur* from river otters collected in Maine during 2000-03 trapping season.

Tissue	Year	Sample size	Mean	SD (+/-)	Range
Brain	2000	8	0.45	0.24	0.08 - 0.69
Liver	2000	7	3.00	1.61	0.24 - 4.74
Fur*	2000	8	21.60	11.28	4.99 - 33.7
Brain	2001	18	0.44	0.18	0.23 - 1.03
Liver	2001	18	1.53	1.01	0.32 - 3.47
Fur*	2001	18	18.69	7.62	1.14 - 32.0
Brain	2002	10	0.77	0.56	0.26 - 2.01
Liver	2002	10	1.31	0.44	0.68 - 2.16
Fur*	2002	10	21.4	5.41	13.3 - 28.6
Brain	2003	33	0.58	0.55	0.06 - 3.25
Liver	2003	33	1.95	1.54	0.26 – 8.66
Fur*	2003	33	20.94	13.02	1.4 – 73.7
Total Brain	2000-03	69	0.55	0.46	0.06 – 3.25
Total Liver	2000-03	69	1.83	1.36	0.24 – 8.66
Total Fur*	2000-03	69	25.88	35.78	1.14 – 234.0

*Fresh Weight

Fur Hg levels reflects the total body burden bioaccumulated over time, particularly for individuals with high exposure. Consequently the animal's age may be a confounding factor in interpreting fur Hg results. Mierle et al. (2000) found that Hg concentrations in fur changed with age. It increased during the first four years in Ontario otters, but then declined. However, fur Hg levels in the Ontario study did not exceed 15 ppm in known age otters, and it is likely the animals were able to demethylate their Hg body burden. In our study, several otters had relatively high fur Hg levels; therefore it is not clear if these animals would be able to effectively demethylate their body burden. Blood Hg levels reflect recent dietary uptake and would help explain fur Hg concentrations. Fur, brain and liver mercury levels (Fig 2) had very significant correlations ($P<0.001$).

2. Mink

A total of 92 mink carcasses were collected from 2000-03. Mean (+/- SD) length and weight for females were 33.84 +/- 2.36cm and 410.27 +/- 102.04g, respectively. For males mean (+/- SD) length and weight were 37.96 +/- 2.69 cm and 613.47 +/- 136.87 g.

We analyzed 19 fur, brain and liver samples in 2003. Mink fur Hg concentrations ranged from 1.78 ppm on Felts Brook near Orrington to 68.5 ppm on Flagstaff Lake (Table 4). Mink fur Hg levels indicates individuals from several sites are elevated (>20 ppm) when compared with other studies (Table 2). Not enough is known about mink behavior and reproduction, in regards to mercury exposure, to make a clear assessment about overall health of Maine's mink. Fur, brain and liver mercury levels (Fig 1) had very significant correlations ($P<0.001$).

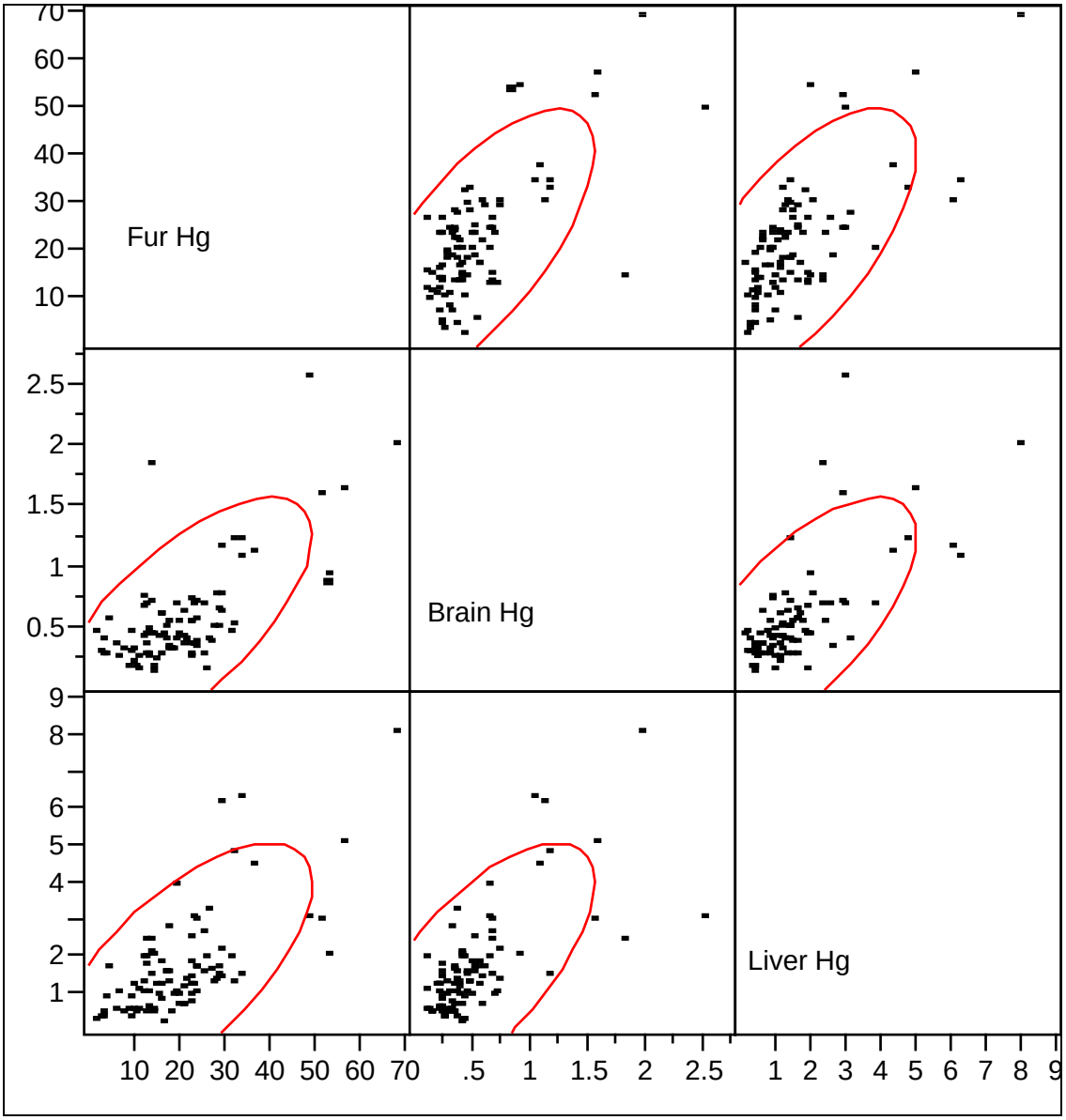
Table 4.. Concentrations of total Hg levels (ppm, ww) in brain, liver, and fur* from mink collected in Maine during 2000-03 trapping season.

Tissue	Year	Sample size	Mean	SD	Range
Brain	2000	25	0.63	0.46	0.13 - 2
Liver	2000	25	2.46	1.92	0.49 - 8.03
Fur*	2000	25	24.32	14.24	9.2 - 68.5
Brain	2001	23	0.59	0.56	0.22 - 2.55
Liver	2001	23	1.61	1.43	0.27 - 6.13
Fur*	2001	23	19.09	13.53	1.78 - 51.8
Brain	2002	25	0.51	0.33	0.16 - 1.84
Liver	2002	25	1.24	0.73	0.16 - 2.96
Fur*	2002	25	18.56	10.27	3.7 - 53.8
Brain	2003	19	0.43	0.19	0.11 – 0.83
Liver	2003	19	1.06	0.45	0.47 – 1.94
Fur*	2003	19	21.9	10.42	7.8 – 52.8
Total Brain	2000-03	92	0.57	0.45	0.11 - 2.55
Total Liver	2000-03	92	1.76	1.49	0.16 - 8.03
Total Fur*	2000-03	92	20.69	12.76	1.78 - 68.5

*Fresh Weight

B. Relationship between Tissues

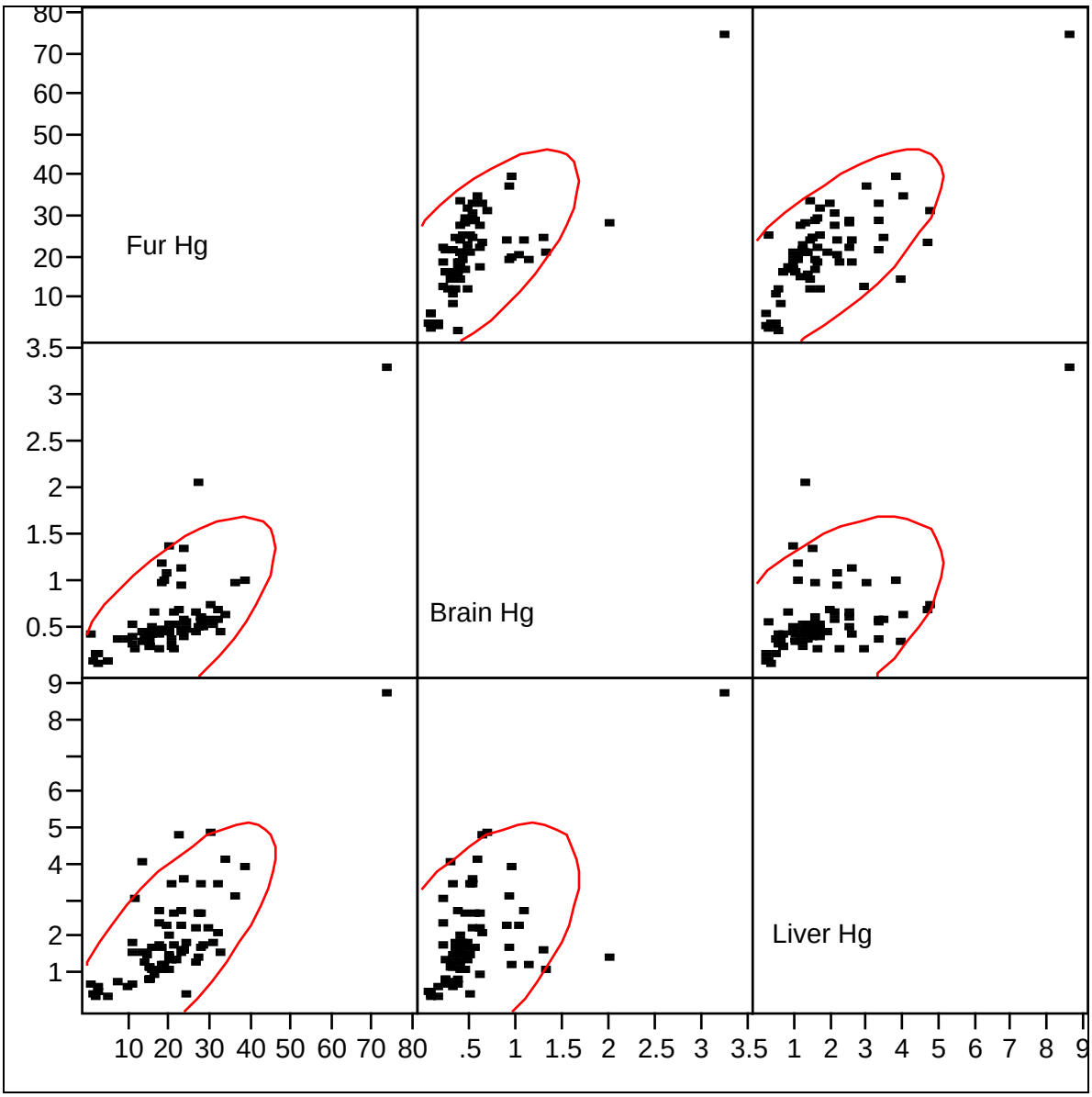
Fig. 1 Mink Multivariate Scatterplot Matrix for Brain, Liver and Fur 2000-03 in Maine



Pairwise Correlations

Variable	by Variable	Correlation	Count	Signif Prob
Brain Hg	Fur Hg	0.6991	89	<0.00001
Liver Hg	Fur Hg	0.6777	89	<0.00001
Liver Hg	Brain Hg	0.6878	89	<0.00001

Fig. 2 Otter Multivariate Scatterplot Matrix for Brain, Liver and Fur 2000-03 in Maine



Pairwise Correlations

Variable	by Variable	Correlation	Count	Signif Prob
Brain Hg	Fur Hg	0.6966	69	<0.00001
Liver Hg	Fur Hg	0.7462	69	<0.00001
Liver Hg	Brain Hg	0.5596	69	<0.00001

C. Live Capture

Because few trappers operate in the Flagstaff and Seboomook regions we live trapped these of know, high Hg risk. Capturing a live animal also permits blood sampling. Analysis of blood samples allow more meaningful comparisons among different sites and regions, because (1) blood Hg levels reflect a recent or short term Hg exposure of a piscivorous mammal and (2) should be independent of age. Because >95% of Hg in the blood is in the methyl form, measuring total Hg provides insight into the recent dietary uptake of MeHg. Collecting blood samples from recently killed animals is difficult because blood rapidly loses moisture after death; therefore, blood clots and whole blood Hg likely do not correlate (based on studies with loons, M. Pokras, Tufts Univ., pers. com.). Conversely, much of the Hg in organs is inorganic. By sampling and analyzing fur and blood from live individuals we hope to establish a relationship between the two matrices that can be applied to future studies for Hg interpretation of live or dead animals. Because animals can be live-trapped in areas of low density, we avoid potential population impacts and provide a comparative template for other studies that cannot afford removing animals.

Live trapping also adds another matrix of Hg measurement that can be related to other compartments such as fur, liver, kidney, and brain. Each matrix provides different information. Mercury levels in fur are an indicator of long-term body burden and organs generally demethylate Hg and do not necessarily provide an accurate assessment on toxicity to the individual. There is now evidence that the brain can demethylate Hg (particularly in the otter, D. Evans, Trent Univ., pers. com.) so that compartment may not be helpful for chronic Hg loads. Sampling certain matrices, such as muscle or fur (since fur would likely reflect remobilization of MeHg in the muscle) can provide better insights into the lifetime body burden for the animal. This is crucial part of this investigation because the bioaccumulation rate of MeHg is one of the most important aspects of toxicity to a population.

1. Capture efforts in 2003

BRI set a total of 5 leg-hold traps in the Flagstaff Lake area during July and August (Appendix 4). The traps were set out for a total of 14 nights, resulting in the successful live-capture of four otter. We had a total of 70 trap nights (Table 5) and our success was 0.06 otters per night (Table 5). In a study by Blundell G.M. et al. (1999) the trapping efficiency for river otters using leg-hold traps was 0.048.

Table 5. Live leg-hold trapping results for 2001-03.

	2001	**2002**	**2003**
Efficiency (captures/trap night)	0.001 otter/trap-night	0.07 otter/trap-night	0.06 otter/trap-night
Trapping Effort (# of traps x # of nights trapping)	952 trap-nights	45 trap-nights	70 trap-nights

We live-trapped four otters, one adult female and three adult male otters, they were captured at Flagstaff Lake, located in Eustis, Maine. First, the otters were removed from the trap with the aid of a catchpole and placed into a catch box, enabling transportation back to the field station to take a blood and fur sample. Once the animal was anesthetized we examined it for any obvious injuries that it may have sustained from the trapping process (no visible damage to the otters was observed).

A mixture of Ketamine (2.5 mg/kg) and Metetomidine (0.025 mg/kg) sedative was administered via hand injection to the rump of the animal. Approximately three to five minutes following injection, the animal was fully sedated. The otter was removed from the catch box and placed upon a padded blanket where the sampling of tissue (blood and fur) and basic measurements (weight and length) were collected. A small patch of fur was clipped from the area located just above the animal's hind foot. Using a 1cc syringe, approximately 8.0cc of whole blood was hand-drawn from the jugular vein. The animal was then placed back into the catch box and was administered the antiseden Atipamezole (0.10 mg/kg). Approximately 8 minutes preceding the injection of Atipamezole was required for the otter to fully recover. The total time the otters was anesthetized was approximately 45 minutes.

The animals were kept overnight at the field station where it was monitored for any health irregularities and then was released the following morning at the trapping site.

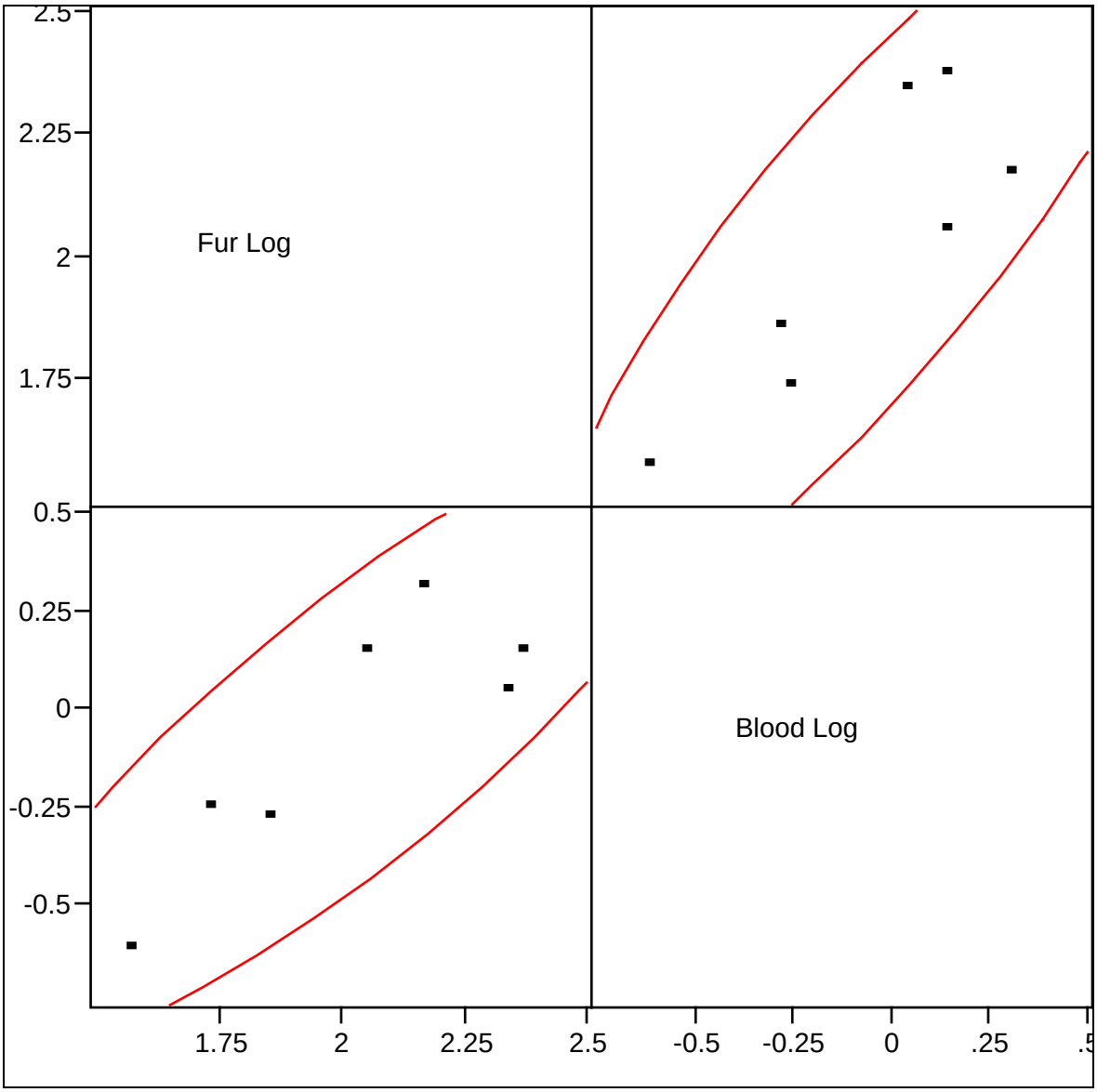
2. Tissue Analysis

The otter whole blood and fur sample were analyzed for total Hg at Texas A&M University, College Station, Texas. The fur mercury levels (Table 6) are well above published lethal levels (Mierle et al. 2000). The otter blood and fur mercury (Fig. 3) showed a significant correlation (r^2=0.86, p=0.0134). Existing studies investigating levels of Hg within otter blood, which is needed in order to make a comparison with our live-trapped otter sample, have not been found. However, the total Hg value of 234 ppm found in the otter fur is significantly higher than the existing mean of 25.88 ppm (+/-35.78) in the 69 otter carcasses collected and analyzed from Maine in 2000-03 (Table 1).

Table 6. Live Trapping Hg Results

Lake	Species	Gender	Blood Hg (ppm)	Fur Hg (ppm)
Flagstaff/ North Branch	Otter	Female/Adult	1.39	234
Flagstaff/ Trout Brook	Otter	Female/Adult	1.11	218
Flagstaff/ Trout Brook	Otter	Female/ Juvenile	0.176	8.95
Flagstaff/ North Branch	Otter	Female/Adult	0.557	54.6
Flagstaff/ Reed Brook	Otter	Male/ Adult	2.03	147
Flagstaff/ Trout Brook	Otter	Male/ Adult	1.4	113
Flagstaff/ Meyers	Otter	Male/ Adult	0.528	71.6
Chain of Ponds / Lower	Otter	Male/ Adult	0.224	37.6

Fig. 3 Otter Live Trap Multivariate Scatterplot Matrix for Blood and Fur 2000-03



Pairwise Correlations

Variable	by Variable	Correlation	Count	Signif Prob
Blood Log	Fur Log	0.8585	7	0.0134

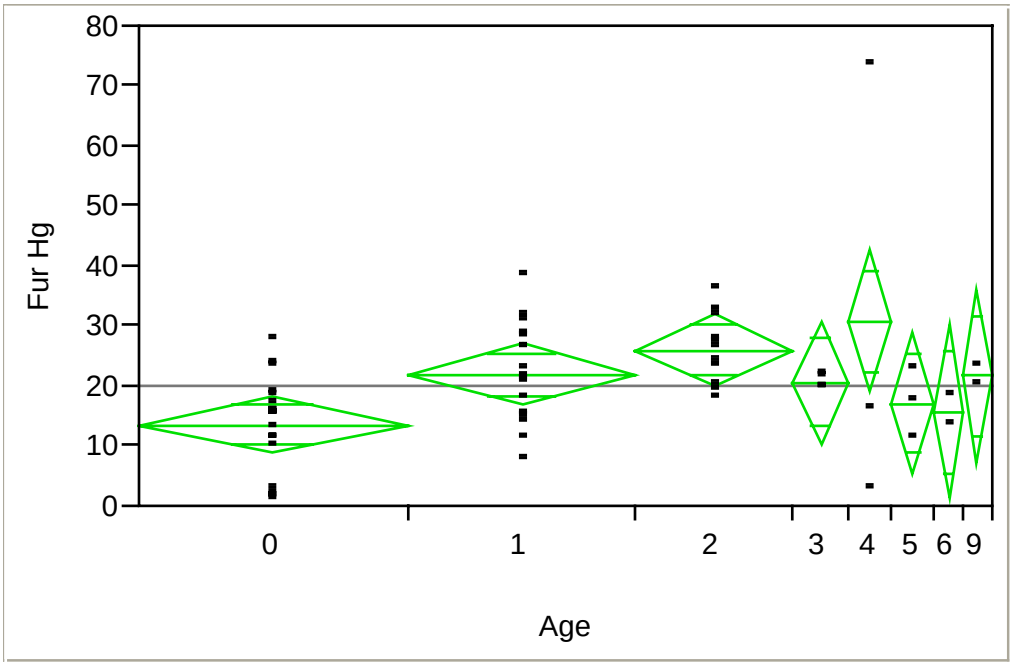
D. Other measurements

1. Animal age

A. Otter Aging

A total of 60 otter jaws were sent to Matson's Lab to determine age. Average age of trapped otters was 1.87 years old (the oldest was 9 years old). Age and fur mercury have a significant correlation (p=0.0089), while brain and liver did not.

Fig. 4 Otter one-way ANOVA for Fur and Age from 2000-03



1-way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
18.7757	7	0.0089

B. Mink Aging

A total of 64 mink jaws were sent to Matson's Lab to determine age. Average age of trapped mink was 0.58 years old (the oldest was 5 years old). The brain, liver, and fur mercury and age did not correlate significantly in mink. Since trappers provide carcasses the young animals are most likely to be trapped so this does not prove or disprove aging and mercury levels.

2. Corpora lutea

A. Otter Ovaries

A total of 26 otter ovaries were sent to Matson's Lab to quantify corpora lutea scars. Scars indicate reproductive success over time. Trapped female otters averaged 1.7 years of age (the oldest was 9 years old). Brain, liver and fur mercury and corpora lutea counts do not significantly correlate. Due to a small sample size and young animals, reproductive success and mercury levels cannot be significantly correlated.

B. Mink Ovaries

A total of 22 mink ovaries were sent to Matson's Lab to quantify corpora lutea scars. Trapped female mink averaged 0.37 years of age (two mink was a two-year-old, one three-year old, 4 were one-year-olds, and the remainder were < one-year of age). No scars were detected for the 22 mink ovaries. Mink are sexually mature at 10 months of age (Chapman and Feldhammer 1982), however, known of the seven individuals of breeding age showed evidence of reproductive success.

RECOMMENDATIONS

1. Expand live capture efforts in particularly high Hg sites, including the Flagstaff Lake and Seboomook Lake areas
2. Add a biomarker assay (e.g., comet assays to detect genetic fragmentation) to provide insight on potential impacts from Hg with an emphasis on individuals with fur Hg levels over 20ppm;

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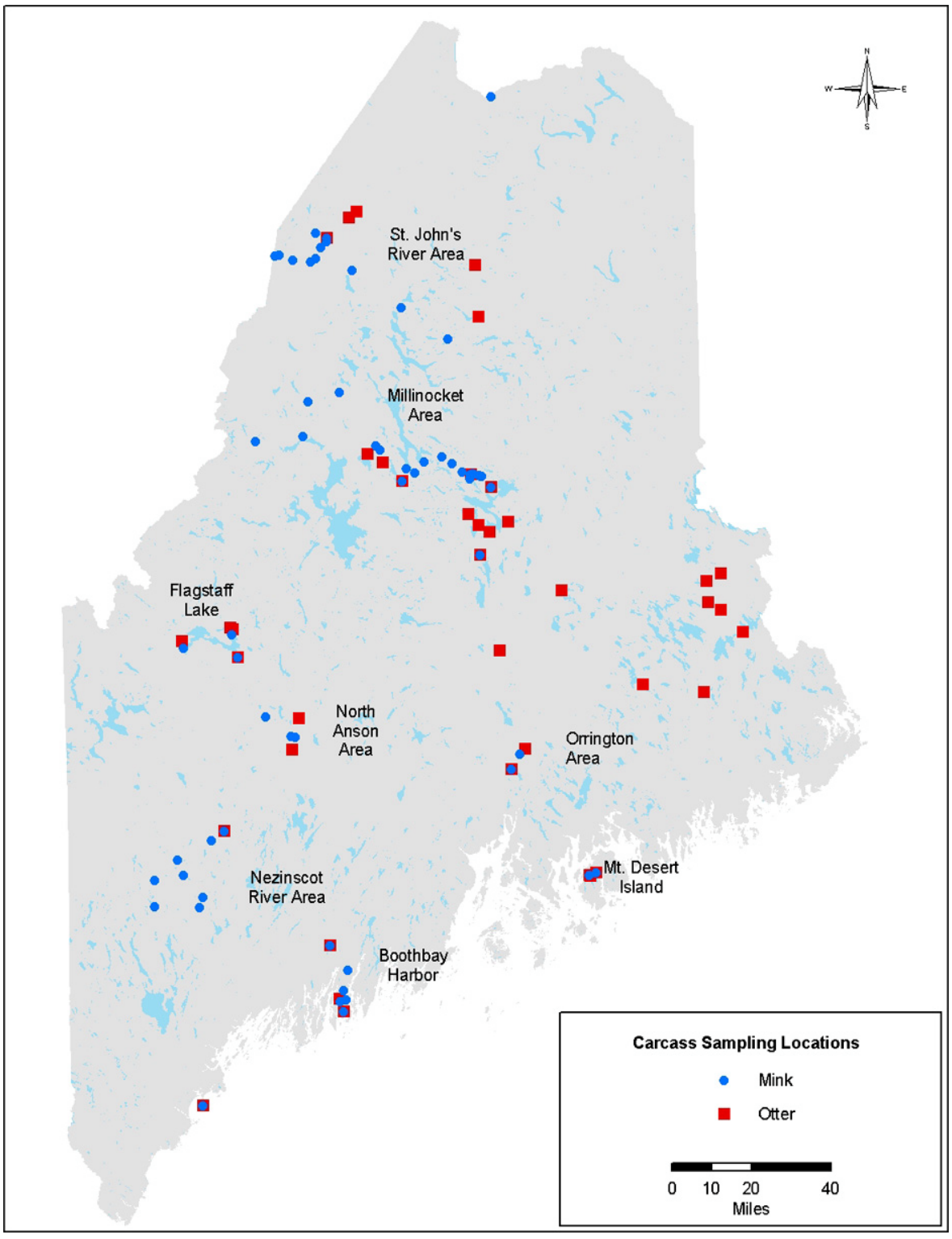
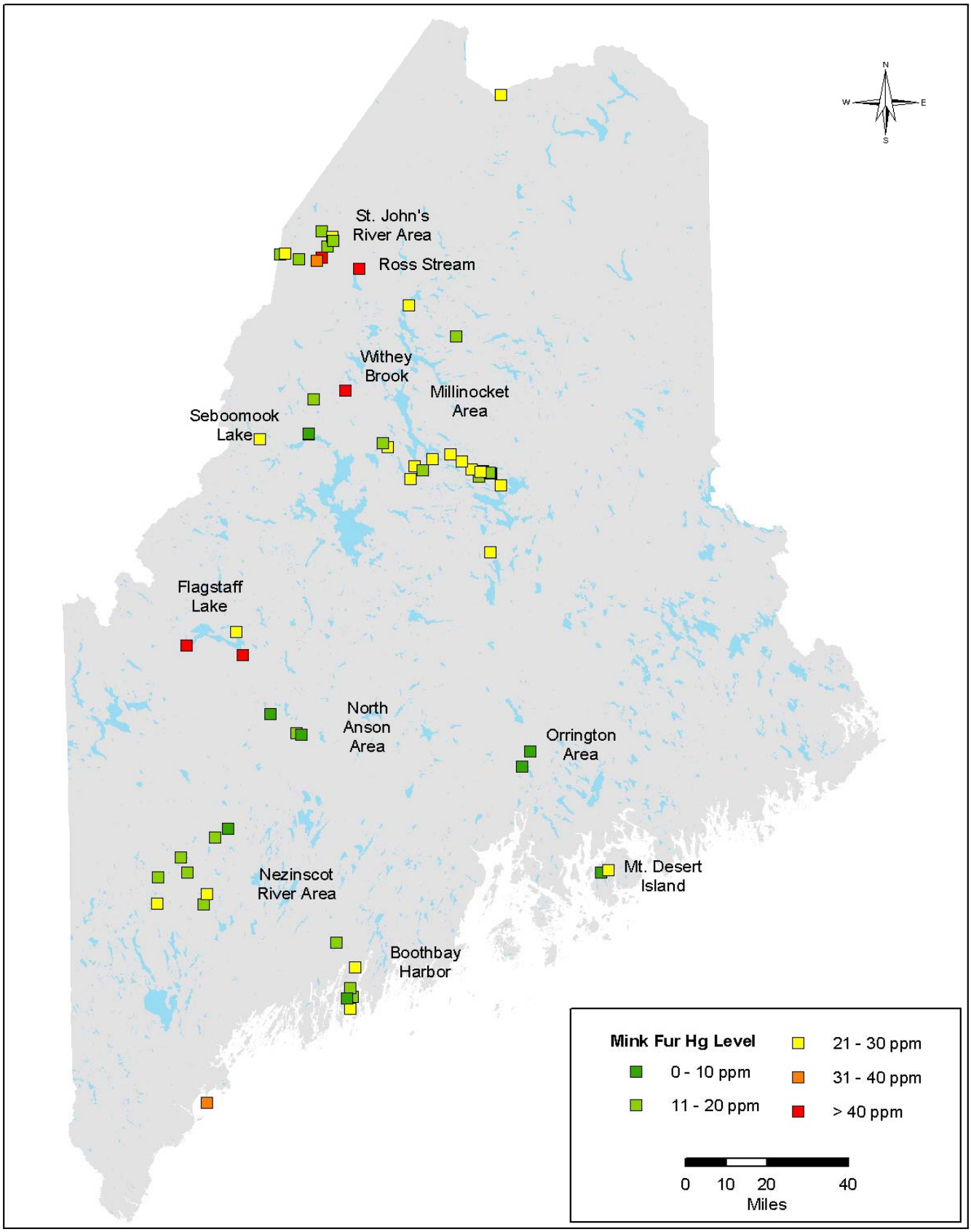
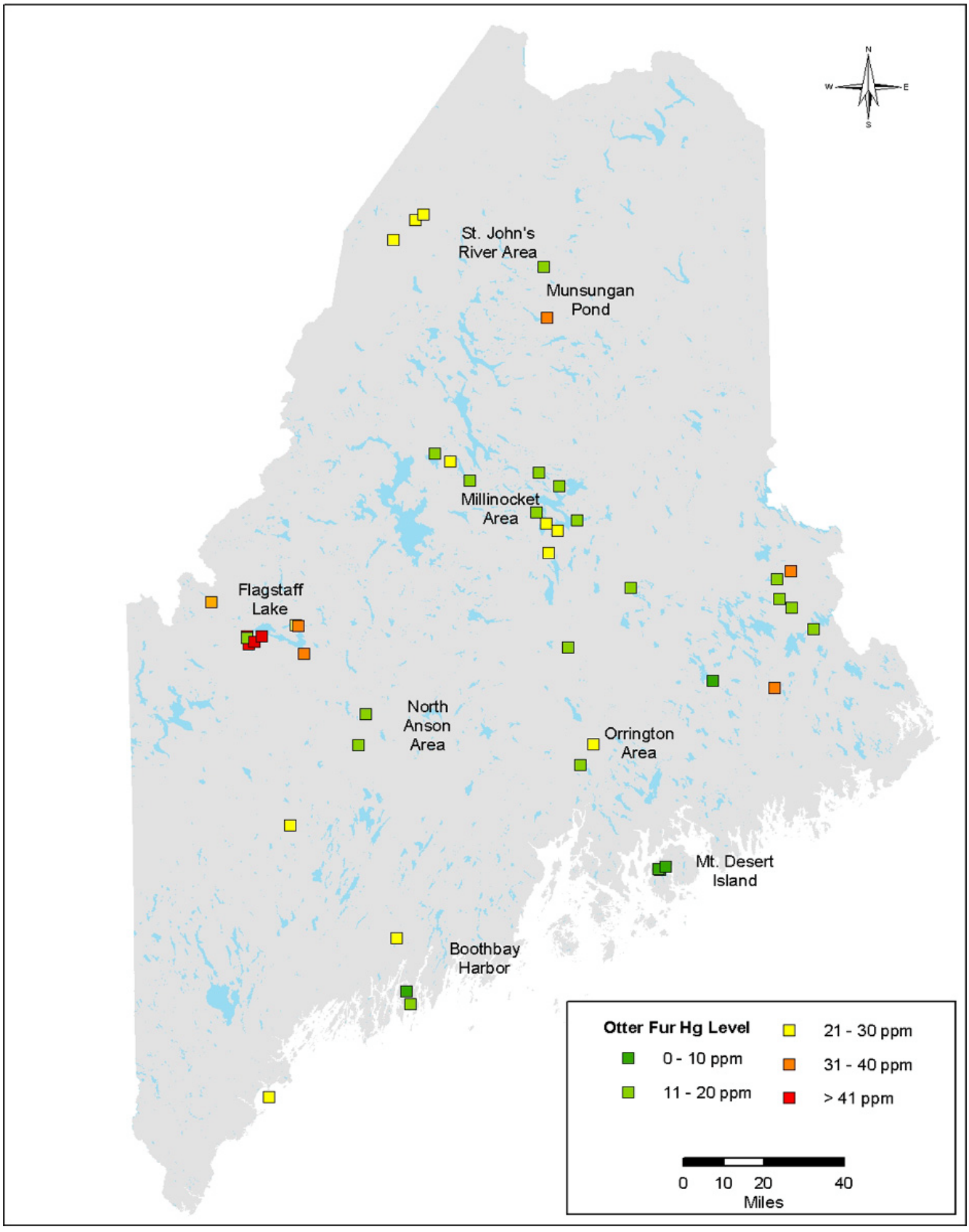
Appendix 1: Mink and River Otter carcass sampling locations, 2000-2003.



Appendix 2: Mercury exposure profile for Mink based on fur, 2000-2003.



Appendix 3: Mercury exposure profile for Otter based on fur, 2000-2003.



Appendix 4: Mink and River Otter live-trapping sites, 2001-03.