MODULE 2 LAKES

2.1

FISH CONSUMPTION ADVISORIES

FISH CONSUMPTION ADVISORIES

General Statewide Mercury Advisory -Lakes -DEP

We had hoped we could identify an indicator fish species and avoid the need to test multiple species. However, our review of the data from the 'Indicator Species Study' does not appear to support this approach. The mercury levels for the species sampled does not seem consistent enough to identify a reliable predictor fish species, though this conclusion is somewhat compromised by the small number of lakes sampled. Therefore, we are back to looking at obtaining data at the individual species level.

With regard to the statewide mercury advisory, it remains our goal to be able to characterize the statistical distribution of average lake mercury levels for the various fish species that are commonly consumed. This is necessary in order to reliably estimate an upper percentile lake average (90^{th} or 95^{th} percentile), which currently serves as the basis for the advisory. Such data would also increase our confidence in estimates of the statewide mean. To meet this goal, our objective was to obtain a total of 50 lakes per species to adequately characterize the distribution of lake averages of fish mercury by species. As usual we wanted 5 or more individual fish per lake. Our top priorities for obtaining additional samples were the following species:

1. Brown Trout -BNT– currently have 12 lakes
2. Chain Pickerel-CHP-currently have 13 lakes
3. Splake-SPK– currently have 5 lakes
4. Lake Trout -LKT– currently have 25 lakes
5. Landlocked Salmon-LLS – currently have 25 lakes
6. Brook Trout – BKT-currently have 25 lakes
7 Smallmouth Bass-SMB-

There are two new fish species we wanted data on. Drs. Haines and Evers have provided us some limited data that suggests lake run rainbow smelt have significantly higher mercury concentrations than ocean run Rainbow Smelt. Hence we wanted several lakes sampled for rainbow smelt. It is our understanding that IFW can identify lakes where there is focused activity for catching this species. The second species is rainbow trout. We have also had some questions about Rainbow Trout from Little Androscoggin River. Apparently these are stocked fish (put and take).

In 2002 we asked the Department of Inland Fisheries and Wildlife to collect 5 fish of any of these species they catch in performance of their normal duties. DIFW biologists were able to provide the following samples (see Appendix 2.1 for lengths and weights) :

Brook trout	6 lakes	Brown trout	3 lakes	Chain pickerel	2 lakes
Lake trout	3 lakes	Landlocked salmon	3 lakes		

In addition smallmouth bass from Pocasset Lake in Wayne were sampled by DEP staff. Concentrations ranged from 0.027-0.882 ppm mercury (Table 2.1). Brook trout had lower levels

of mercury than lake trout or landlocked salmon probably due to being younger and smaller. Mercury levels in chain pickerel were lower than previously found in other lakes. From previous studies, it is know that species, size and age, and lake characteristics all affect mercury levels.

Table 2.1.1. MERCURY CONCENTRATIONS IN FISH FROM MAINE LAKES 2002

Summary

DEP Sample ID	Species	Hg conc. (mg/Kg)
Allen P. LK3788	BNT	0.641
Baker P LK0242	BKT	0.326
	LLS	0.618
Carr P LK-1598	LKT	0.537
Daigle P LK-1665	BKT	0.027
Hancock P LK0082	LKT	0.820
Hale Pond LK3652	BKT	0.206
Island P LK-1586	BKT	0.093
Kennebago L LK 2374	BKT	0.322
Kezar L LK0097	CHP	0.197
Kennebunk P. LK3998	BNT	0.090
Mooselookmeguntic L.	LLS	0.406
Maranacook L LK5312	BNT	0.106
Mousam Lk3838	CHP	0.315
Pocasset L.	SMB	0.595
2ND Musquacook L.	LKT	0.882
Spicer P. LK3906	BKT	0.171
Third Sly Brook L LK-1646	LLS	0.446

Raw Data

DEP Sample ID	Hg conc. (mg/Kg)
Allen P. LK3788	
LK-3788-BNT-1	0.363
LK-3788-BNT-2	0.271
LK-3788-BNT-3	1.29
Baker P	
BakerP-BKT-1	0.344
BakerP-BKT-2	0.396
BakerP-BKT-3	0.171
BakerP-BKT-4	0.246
BakerP-BKT-5	0.472
BakerP-LLS-1	0.411
BakerP-LLS-2	0.621
BakerP-LLS-3	0.595
BakerP-LLS-4	0.844
BakerP-LLS-5	0.618
Carr P LK-1598	
LK-1598-LKT-1	0.538
LK-1598-LKT-2	0.467
LK-1598-LKT-3	0.648
LK-1598-LKT-4	0.493
LK-1598-LKT-5	0.537
Daigle P LK-1665	
LK-1665-BKT-1	0.017
LK-1665-BKT-2	0.021
LK-1665-BKT-3	0.046
LK-1665-BKT-4	0.026
LK-1665-BKT-5	0.026
Hancock P LK0082	
HancockP-LKT-1	0.759
HancockP-LKT-2	0.722
HancockP-LKT-3	0.634
HancockP-LKT-4	1.23
HancockP-LKT-5	0.754
Hale Pond LK3652	
Hale P.-BKT-1	0.317
Hale P.-BKT-2	0.197
Hale P.-BKT-3	0.186
Hale P.-BKT-4	0.221
Hale P.-BKT-5	0.108

DEP Sample ID	Hg conc. (mg/Kg)
Island P LK-1586	
LK-1586-BKT-1	0.102
LK-1586-BKT-2	0.096
LK-1586-BKT-3	0.078
LK-1586-BKT-4	0.133
LK-1586-BKT-5	0.056
Kennebago L LK 2374	
Kenneb L.-BKT-1	0.256
Kenneb L.-BKT-2	0.425
Kenneb L.-BKT-3	0.225
Kenneb L.-BKT-4	0.177
Kenneb L.-BKT-5	0.527
Kezar LK0097	
LK-0097-PKL-1	0.17
LK-0097-PKL-2	0.222
LK-0097-PKL-3	0.176
LK-0097-PKL-4	0.207
LK-0097-PKL-5	0.212
Kennebunk P. LK3998	
LK-3998-BNT-1	0.087
LK-3998-BNT-2	0.11
LK-3998-BNT-3	0.074
LK-3998-BNT-4	0.099
LK-3998-BNT-5	0.08
Mooselookmeguntic L.	
LK-3302-LLS-1	0.833
LK-3302-LLS-2	0.299
LK-3302-LLS-3	0.325
LK-3302-LLS-4	0.314
LK-3302-LLS-5	0.257
Maranacook L LK5312	
LK-5312-BNT-1	0.064
LK-5312-BNT-2	0.123
LK-5312-BNT-3	0.123
LK-5312-BNT-4	0.123
LK-5312-BNT-5	0.097
Mousam Lk3838	
LK-3838-PKL-1	0.165
LK-3838-PKL-2	0.23
LK-3838-PKL-3	0.187
LK-3838-PKL-4	0.677

DEP Sample ID	Hg conc. (mg/Kg)
Pocasset L	
Pocasset-SMB-1C5	0.595
Second Musquacook L.	
LK-1916-LKT-1	0.64
LK-1916-LKT-2	0.967
LK-1916-LKT-3	1.51
LK-1916-LKT-4	0.725
LK-1916-LKT-5	0.57
Spicer P. LK3906	
LK-3906-BKT-1	0.183
LK-3906-BKT-2	0.097
LK-3906-BKT-3	0.241
LK-3906-BKT-4	0.133
LK-3906-BKT-5	0.2
Third Sly Brook L.M-1646	
LK-1646-LLS-1	0.632
LK-1646-LLS-2	0.546
LK-1646-LLS-3	0.309
LK-1646-LLS-4	0.254
LK-1646-LLS-5	0.491

Androscoggin Lake PCB – DEP

In 2001, a pilot scale study of PCB and other contaminants in fish and shellfish in Androscoggin Lake, on behalf of the Androscoggin Lake Improvement Association, BioDiversity Research Institute (BRI) found levels of PCB in white suckers and white perch much higher than those found by DEP in similar samples of white perch from the same year.

Sampling was repeated by DEP in 2002, using a nationally respected lab, to attempt to determine true concentrations in white perch. A total of 10 white perch were collected and combined into 2 composites of 5 fish each for total PCB analysis. The results were higher than found previously (Table 2.1.2), but still much lower than found by BRI in 2001. Repeat sampling of white suckers in 2002 and 2003 by BRI, however, found much lower levels than in 2001, bringing into question their 2001 data. Concentrations in the DEP white perch exceeded the Maine Bureau of Health's Fish Tissue Action Level (FTAL=11ug/kg) in all samples during 2001 and 2002. A sample of smallmouth bass from Pocasset Lake had lower concentrations than found in bass from Androscoggin Lake in 2001.

Table 2.1.2. Total PCB in fish from Androscoggin Lake and Pocasset Lake, ug/kg

Sample ID	1998	2001	2002	2002 Pocasset L
smallmouth bass C1	3.61	11.1		2.67
smallmouth bass C2	2.59	19.8		
white perch C1	5.09	12.9	29.1	
white perch C2	4.10	31.2	52.3	
white sucker C1	5.22			
white sucker C2	4.81			

2.2

WILDLIFE CRITERION VALUE -LOONS

2002 & 2003

Assessing the impacts of methylmercury on piscivorous wildlife using a wildlife criterion value based on the Common Loon, 1998-2002

(Report BRI2003-07)

2002 Report

Submitted to:

Maine Department of Environmental Protection
Surface Water Ambient Toxic Monitoring Program
State House Station 17
Augusta, Maine 04333

Submitted by:

David C. Evers, Oksana P. Lane, and Lucas Savoy
BioDiversity Research Institute[1]

12 June 2003

[1]Send correspondence to: BioDiversity Research Institute, 411 U.S. Route 1, Suite 1, Falmouth, Maine 04105 (207-781-3324) (david.evers@briloon.org)

Please cite this report as: Evers, D. C., O. P. Lane, and L. Savoy. 2003. Assessing the impacts of methylmercury on piscivorous wildlife using a wildlife criterion value based on the Common Loon, 1998-2002. Report BRI 2003–07 submitted to the Maine Department of Environmental Protection. BioDiversity Research Institute, Falmouth. Maine.

Table of Contents

Executive Summary:

Anthropogenic inputs of mercury (Hg) into the environment have significantly increased in the past century. In conjunction, the current availability of methylmercury (MeHg) in aquatic systems has increased to levels posing risks to human and ecological health. Risk levels vary considerably in response to MeHg availability, which is affected by lake hydrology, biogeochemistry, habitat, topography, and proximity to airborne sources. We selected the Common Loon as the most suitable bioindicator of aquatic Hg toxicity, based on ecological, logistical, and other criteria, including public valuations of natural resources. Opportunistic and probability-based sampling efforts from 1994-2002 indicate New England's breeding loon population is at unacceptable levels of risk to Hg contamination, particularly in Maine. Based on risk categories developed from the literature and *in situ* studies by BioDiversity Research Institute and their collaborators, at least 22% of the breeding loon population in Maine is estimated to be at risk.

Because results from national sampling indicated loons were at most risk from Hg in New England, we identified several individual- and population-level parameters to better understand the extent of mercury toxicity across Maine. From 1994-02 we collected 248 abandoned eggs (49 in 2002) as well as blood and feather samples from 370 adult (67 in 2002) and 120 juvenile (17 in 2002) loons in Maine. The Hg concentrations in these samples were used to relate sublethal impacts on behavior, developmental stability, individual survival, egg development, and overall reproductive success. In the Rangeley Lakes Study Area, a total of 176 loon territories were monitored on 44 lakes during 1998-02. Current monitoring efforts and historical data comprise 845 territory-years measured. Behavioral observations were conducted for over 1,500 hours on 16 lakes with 38 loon territories from 1998 to 2000.

Several reproductive measures significantly declined for loon pairs at high risk to prey MeHg availability, thereby corroborating studies in high-risk sites in Nova Scotia and Wisconsin that show Hg impacts reproductive success. Based on 212 loon territories representing 1,153 territory-years surveyed we found that pairs above the lowest observed adverse effect level (LOAEL) (i.e., >3.0 ppm in the blood) fledged 40% fewer young than pairs below our no observed adverse effect level (i.e., <1.0 ppm in the blood). We also found similar significant patterns of lower productivity for other reproductive measures. We view the implication of long-term declines in these reproductive measures as serious and contend they would not be detected by traditional survey techniques.

Insight into why loons are facing Hg-based population declines can be viewed through our hazard assessment process that is based on a weight-of-evidence approach. Physiological impacts of Hg are measured through two key biomarkers: corticosterone stress hormone levels and flight feather asymmetry. Circulating corticosterone hormone levels are strongly linked with increasing blood Hg levels and are not related to capture and handling stress. Corticosterone hormone levels increase on an average of 14.6% for every one ppm of increase in blood Hg levels (n=239). This indicates that loons with high blood Hg levels have higher rates of chronic stress and may therefore have compromised immune systems. Asymmetry measurements provide insights into developmental stability and potentially reproductive fitness. Three years of flight feather measurements have shown agreement among years that loon breeding populations with greater exposure to Hg have significantly greater asymmetry than populations at low risk (n=227). Greater asymmetry may indicate disruptions from stressors on embryonic development, current physiological status and decline in reproductive fitness.

Many behavioral impacts that appear to be related to the neurotoxic effects of MeHg can rarely be observed in the field. We found adult loons in high risk situations left eggs unattended 14% of the time, compared to 1% in controls. Several cases of direct field observations indicate that adult loons with high MeHg body burdens avoid incubating their eggs and display atypical behaviors such as patrolling in front of, or sitting next to the nest. We documented a significant negative relationship between adult blood Hg and foraging behavior, and a significant positive relationship between adult blood Hg and brooding behavior. Analyzing our data according to energy demands revealed a significant inverse relationship between blood Hg and time spent in high energy behaviors. Our findings are consistent with other studies linking Hg and lethargy, reduced motivation to hunt prey, and compromised foraging abilities.

Current levels of Hg in Maine's lacustrine ecosystems also appear to be impacting individual survival of adult and juvenile loons. Recaptured adult loons exhibit a significant annual increase of Hg (9% in males, 5.6% in females) that we predict will significantly reduce lifetime individual performance. A model of this impact indicates a decline of 13 to 8 young produced over a loon's lifetime. Further, juveniles from high-risk territories have increasing blood Hg levels of 3% per day during the summer, potentially reaching dangerous levels after the final feather molt at 11 weeks of age.

Characterization of the risk imposed by MeHg bioavailability in aquatic systems to high trophic level obligate piscivores such as the Common Loon indicates negative population level impacts in Maine. Although the impacts of Hg on loons are varied, complex, and not yet fully understood, the combination of high exposure to a significant part of the breeding population and the "bottom-line" impact of reducing overall reproductive success to 40%, is is not sustainable for the Common Loon in Maine.

Current models indicate a negative population growth rate. Because of the loon's life history strategy (i.e., long lived, slow maturing, and low fecundity) the annual and continual impacts of this type of stressor causes an erosion of the non-breeding or buffer population that serves as a natural cushion to catastrophic events. Once this buffer population is exhausted, the occupancy of established territories will shrink and it will be more obvious that loon populations are declining. However, the realization of shrinking loon populations at that stage will require drastic and potentially expensive efforts to reverse the decline. Models based on a 25-year, statewide comprehensive monitoring effort in New Hampshire show approximately half of Maine's buffer population has been exhausted. Certain areas in Maine, such as the Allagash area that may be particularly impacted from Hg, may already exhibit exhaustion of the buffer population and a shrinking number of territorial pairs. Continued refinement of model parameters and either a probability-based sampling scheme or new sampling efforts in northern Maine will provide higher confidence in our estimates that will therefore assist in state-based policy efforts as well as national regulations that reflect the ecological injury Hg is currently having on the freshwater landscape.

Our approach to a high resolution risk characterization for the Common Loon provides the necessary information for developing a Maine-based wildlife criterion value (WCV). Recent efforts by the USEPA have established a generic WCV with several major limitations that we are improving with this study. A WCV estimates wildlife population viability through measurement of contaminant stressors such as surface water Hg concentrations.

Two-year measurements of exposure parameters indicate a bioconcentration factor (BCF) of 72,000 for trophic level 3 and 142,000 for trophic level 4 based on the relationship of total Hg in unfiltered water with total Hg in yellow perch (or perch equivalents). Based on the mean Hg

levels of four fish size classes and their relationship with the loon blood Hg levels of known impact (i.e., >3.0 ug/g, ww) we chose a prey effect level of 0.15 ug/g (ww, whole body, total Hg). The threshold or test dose of Hg that causes chronic LOAEL for adult loons is 179ug Hg/kg bw/d for males and 142 ug Hg/kg bw/d for females. Based on the use of the Great Lakes Water Quality Initiative uncertainty factors totaling 6, a reference dose of 30 ug Hg/kg bw/d is determined for adult male loons and 24 ug Hg/kg bw/d for adult females (similar to the USEPA generic avian model of 26ug Hg/kg bw/d). The WCV model currently indicates that an unfiltered total Hg water level less than 1.41 ng Hg/L is protective of loons and wildlife at the population level.

The full report is available as a separate file with the SWAT report at http://www.maine.gov/dep/blwq/docmonitoring/swat/index.htm

Development of a Maine-based wildlife criterion value with special emphasis on the Common Loon, 1998-2003

(Report BRI2004-05)

2003 Report

Submitted to:

Maine Department of Environmental Protection
Surface Water Ambient Toxic Monitoring Program
State House Station 17
Augusta, Maine 04333

Submitted by:

David C. Evers, Oksana P. Lane, Lucas Savoy and Wing Goodale
BioDiversity Research Institute[1]

15 June 2004

[1]Send correspondence to: BioDiversity Research Institute, 19 Flaggy Meadow Road, Gorham, Maine 04038) (david.evers@briloon.org)

Please cite this report as: Evers, D. C., O. P. Lane, L. Savoy and W. Goodale. 2004. Assessing the impacts of methylmercury on piscivorous wildlife using a wildlife criterion value based on the Common Loon, 1998-2003. Report BRI 2004–05 submitted to the Maine Department of Environmental Protection. BioDiversity Research Institute, Gorham, Maine.

Table of Contents

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Because results from national sampling indicated loons were at most risk from Hg in New England, we identified several individual- and population-level parameters to better understand the extent of mercury toxicity across Maine. From 1994-03 we collected 324 abandoned eggs (769 in 2003) as well as blood and feather samples from 408 adult (38 in 2002) and 142 juvenile (22 in 2003) loons in Maine. The Hg concentrations in these samples were used to relate sublethal impacts on behavior, developmental stability, individual survival, egg development, and overall reproductive success. In the Rangeley Lakes Study Area, a total of 176 loon territories were monitored on 44 lakes during 1998-2003. Current monitoring efforts and historical data comprise 845 territory-years measured. Behavioral observations were conducted for over 1,500 hours on 16 lakes with 38 loon territories from 1998 to 2000.

Several reproductive measures significantly declined for loon pairs at high risk to prey MeHg availability, thereby corroborating studies in high-risk sites in Nova Scotia and Wisconsin that show Hg impacts reproductive success. Based on 212 loon territories representing 1,153 territory-years surveyed we found that pairs above the lowest observed adverse effect level (LOAEL) (i.e., >3.0 ppm in the blood) fledged 40% fewer young than pairs below our no observed adverse effect level (i.e., <1.0 ppm in the blood). We also found similar significant

patterns of lower productivity for other reproductive measures. We view the implication of long-term declines in these reproductive measures as serious and contend they would not be detected by traditional survey techniques.

Insight into why loons are facing Hg-based population declines can be viewed through our hazard assessment process that is based on a weight-of-evidence approach. Physiological impacts of Hg are measured through two key biomarkers: corticosterone stress hormone levels and flight feather asymmetry. Circulating corticosterone hormone levels are strongly linked with increasing blood Hg levels and are not related to capture and handling stress. Corticosterone hormone levels increase on an average of 14.6% for every one ppm of increase in blood Hg levels (n=239). This indicates that loons with high blood Hg levels have higher rates of chronic stress and may therefore have compromised immune systems. Asymmetry measurements provide insights into developmental stability and potentially reproductive fitness. Three years of flight feather measurements have shown agreement among years that loon breeding populations with greater exposure to Hg have significantly greater asymmetry than populations at low risk (n=227). Greater asymmetry may indicate disruptions from stressors on embryonic development, current physiological status and decline in reproductive fitness.

Many behavioral impacts that appear to be related to the neurotoxic effects of MeHg can rarely be observed in the field. We found adult loons in high-risk situations left eggs unattended 14% of the time, compared to 1% in controls. Several cases of direct field observations indicate that adult loons with high MeHg body burdens avoid incubating their eggs and display atypical behaviors such as patrolling in front of, or sitting next to the nest. We documented a significant negative relationship between adult blood Hg and foraging behavior, and a significant positive relationship between adult blood Hg and brooding behavior. Analyzing our data according to energy demands revealed a significant inverse relationship between blood Hg and time spent in high-energy behaviors. Our findings are consistent with other studies linking Hg and lethargy, reduced motivation to hunt prey, and compromised foraging abilities.

Current levels of Hg in Maine's lacustrine ecosystems also appear to be impacting individual survival of adult and juvenile loons. Recaptured adult loons exhibit a significant annual increase of Hg (9% in males, 5.6% in females) that we predict will significantly reduce lifetime individual performance. A model of this impact indicates a decline of 13 to 8 young produced over a loon's lifetime. Further, juveniles from high-risk territories have increasing blood Hg levels of 3% per day during the summer, potentially reaching dangerous levels after the final feather molt at 11 weeks of age.

Characterization of the risk imposed by MeHg bioavailability in aquatic systems to high trophic level obligate piscivores such as the Common Loon indicates negative population level impacts in Maine. Although the impacts of Hg on loons are varied, complex, and not yet fully understood, the combination of high exposure to a significant part of the breeding population and the "bottom-line" impact of reducing overall reproductive success to 40%, is not sustainable for the Common Loon in Maine.

Current models indicate a negative population growth rate. Because of the loon's life history strategy (i.e., long lived, slow maturing, and low fecundity) the annual and continual impacts of this type of stressor causes an erosion of the non-breeding or buffer population that serves as a natural cushion to catastrophic events. Once this buffer population is exhausted, the occupancy of established territories will shrink and it will be more obvious that loon populations are declining. However, the realization of shrinking loon populations at that stage will require drastic and potentially expensive efforts to reverse the decline. Models based on a 25-year,

statewide comprehensive monitoring effort in New Hampshire show approximately half of Maine's buffer population has been exhausted. Certain areas at high risk to Hg in Maine, such as the upper Androscoggin, Kennebec and western Penobscot River Watersheds may have particularly high impacts on high risk species such as the Common Loon, Bald Eagle, mink and river otter.

Our approach to a high resolution risk characterization for the Common Loon provides the necessary information for developing a Maine-based wildlife criterion value (WCV). Efforts for the past four years have emphasized both birds (i.e., Common Loon) and mammals (i.e., mink and river otter). Recent efforts by the USEPA have established generic WCVs for birds and mammals with several major limitations that we are improving with this study. A WCV estimates wildlife population viability through measurement of contaminant stressors such as surface water Hg concentrations.

Two-year measurements of exposure parameters indicate a bioconcentration factor (BCF) of 72,000 for trophic level 3 and 142,000 for trophic level 4 based on the relationship of total Hg in unfiltered water with total Hg in yellow perch (or perch equivalents). Based on the mean Hg levels of four fish size classes and their relationship with the loon blood Hg levels of known impact (i.e., >3.0 ug/g, ww) we chose a prey effect level of 0.15 ug/g (ww, whole body, total Hg). The threshold or test dose of Hg that causes chronic LOAEL for adult loons is 17.9ug Hg/kg bw/d for males and 14.2 ug Hg/kg bw/d for females. Based on the use of the Great Lakes Water Quality Initiative uncertainty factors totaling 6, a reference dose of 30 ug Hg/kg bw/d is determined for adult male loons and 24 ug Hg/kg bw/d for adult females (similar to the USEPA generic avian model of 26ug Hg/kg bw/d). The WCV model currently indicates that an unfiltered total Hg water level less than 1.41 ng Hg/L is protective of loons at the population level and for mammals it is 1.14ng Hg/L in mink and 1.29 ng Hg/L in the river otter.

The full report is available as a separate file with the SWAT report at http://www.maine.gov/dep/blwq/docmonitoring/swat/index.htm

2.2

WILDLIFE CRITERION VALUE -MAMMALS

2002 & 2003

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

2002

Submitted to:

Barry Mower, Maine Department of Environmental Protection
&
Wally Jakubas, Maine Inland Fisheries and Wildlife

Submitted by:

David C. Evers, Dave Yates, and Lucas Savoy

BioDiversity Research Institute
411 North U.S. Rt. 1, Suite 1
Falmouth, Maine 04105

10 December, 2003

Table of Contents

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 36 otter and 73 mink carcasses have been collected. Mercury levels tend to be greater in mink vs. otter, interior vs. coastal populations, and females vs. males. Respectively mean mercury levels in otter and mink fur, were 20.08 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 29% for mink and 61% for otter. Mink and otter fur Hg levels ranged up to 68.5 ppm and 234 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. Ageing based on teeth indicate a significant positive relationship between otter brain Hg levels and age (n=26; mean age = 1.8 years) and no correlation among the three matrices and mink age (n=48; mean age = 0.6 years). A significant negative correlation between otter brain Hg levels and corpus luteum counts was found (n=11; mean age = 1.7 years). No relationship was found with mink and is likely explained by the majority of mink (94%) under breeding age. This investigation will soon provide (1) a geographically-relevant mercury exposure profile, (2) data that can be linked to potential mercury impacts, and (3) contributions toward a wildlife criterion value model that is protective of Maine's mink and river otter population.

The full report is available as a separate file with the SWAT report at
http://www.maine.gov/dep/blwq/docmonitoring/swat/index.htm

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

(BRI 2003-05)

Submitted to:

Barry Mower, Maine Department of Environmental Protection
&
Wally Jakubas, Maine Inland Fisheries and Wildlife

Submitted by:

Dave Yates, David C. Evers, and Lucas Savoy

BioDiversity Research Institute
19 Flaggy Meadow Rd.
Gorham, Maine 04038

June 15, 2004

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Table of Contents

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 are 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.

The full report is available as a separate file with the SWAT report at http://www.maine.gov/dep/blwq/docmonitoring/swat/index.htm

2.3

ANDROSCOGGIN LAKE SEDIMENTS

2.3 ANDROSCOGGIN LAKE SEDIMENTS - DEP

Monitoring of fish from Androscoggin Lake for dioxin as part of Maine's Dioxin Monitoring Program in 1996 documented concentrations of dioxins similar to those found in fish from the Androscoggin River nearby and higher than found in any other lake monitored in Maine (9 lakes). Since the Androscoggin River floods the lake one or more times each year, the river is the suspected source of dioxins to the fish in the lake. Additional fish samples collected SINCE 1998 have documented a continuing decline in dioxin concentrations to levels near background (Dioxin Monitoring Program Report, 2000 at http://www.state.me.us/dep/blwq/monitoring.htm).

In order to document the pathway, in 1999, surficial sediment samples were collected from 4 areas in the lake and analyzed for dioxins. Results were all below the detection limit. To further explore the potential pathway, in 2000 sediment samples were collected at the lake outlet, as in 1999, at a station just upstream of the Dead River Dam and a station approximately half way between. Both surficial and subsurface samples were collected in order to determine historical and recent contamination. Results show that the lake outlet sample had significantly more dioxin than measured in 1999 and that both river stations also had measurable amounts. The difference between the 1999 and 2000 lake outlet concentrations may be due to the patchniness of sediments. It is interesting that in 1999 the fish had more but the sediments had less than in 2000. The 2000 study was repeated in 2002 to provide more documentation of sediment concentrations in the lake and river.

Similar to those of 1999, the results showed very little dioxin in sediments,. One exception was the deep hole that had significantly more than the other stations but which seems questionable given the results at all the other stations. There was no more dioxin in subsurface samples than in surface samples at the only site where multiple samples were analyzed, R1 in the Dead River. These results are curious given the significant amounts found in fish.

Table 2.3. Dioxin Toxic Equivalents (DTE*) in Androscoggin & Pocasset lakes' sediment samples (ppt)

station	depth	1999 DTE*	2000 DTE*	2002 DTE*	location
L1	0-1"	0.1-0.7	7.6-8.1		lake outlet mouth 10'
	3-4"		8.0-8.2		
L2	0-1"	0.03-0.7		0.6-1.0	lake outlet lake 4'
L3	0-1"	0.01-0.7		6.4-9.6	lake deep hole 38'
	4-5"			na	
L4	0-1"	0.06-0.7		0.4-0.6	lake SW cove behind Lothrop Is
R1	0-1"		13.1-13.2	0.9-1.6	river at Riverbend campground
	2-3"		14.2-14.3	0.6-0.9	
R2	0-1"		7.9-8.3	0.3-0.8	river at Rt 219 Bridge 15'
	1.5-2.5"		11.5-12.0		
PLW	0-1			1.6-5.5	Pocasset L 20'
	3-4"			na	

* = range with non-detects at 0 and the detection limit

Table 2.3. Dioxin levels in Androscoggin Lake and Dead River Sediments

DEP Sample Site	Deep Hole	Lothrop Is	Outlet	Dead R mid	Dead R mid
	L3	L4	L2	DR1 (0-1")	DR1 (2-3")
% Solids	10.54	37.07	52.38	24.47	31.69
Analyte (ng/kg) dry weight					
2378 TCDF	**2.6**	**0.1**	**0.32**	**0.31**	**0.14**
12378 PeCDF	2.2	0.26 E	0.26	0.57 E	0.43
23478 PeCDF	2.0	0.15	0.20	0.5	0.46
123478 HxCDF	3.1	0.23	0.13	0.36	0.12
123678 HxCDF	2.7	0.22	0.12	0.41	0.16
234678 HxCDF	3.2	0.21	0.12 J	0.24	0.17
123789 HxCDF	2.2	0.25	0.15	0.38	0.14
1234678 HpCDF	1.2	0.28	0.18	0.47	0.12
1234789 HpCDF	1.7	0.21	0.21 J	0.67 J	0.17
OCDF	3.9	0.33	0.26	0.74	0.13
2378 TCDD	**3.6**	**0.14**	**0.37**	**0.39**	**0.25**
12378 PeCDD	2.8 J	0.19 J	0.34 I	0.61 I	0.25 J
123478 HxCDD	2.2 J	0.28 J	0.26 J	0.27 I	0.20 J
123678 HxCDD	2.2	0.35	0.29	0.41	0.21
123789 HxCDD	1.7 J	0.29 J	0.22 J	0.29 J	0.17
1234678 HpCDD	4.0	0.13	0.43	0.64	0.22
OCDD	4.6	0.25	0.59	0.72	0.23
DTEo	**6.4**	**0.4**	**0.6**	**0.9**	**0.6**
DTEd	**9.6**	**0.6**	**1.0**	**1.6**	**0.9**

J= Concentration detected is below the calibration range
I = Interference
B = Less than 10 times higher than method blank level
E = PCDE Interference

Table 2.3. Dioxin levels in Androscoggin Lake and Dead River Sediments

DEP Sample Site	Dead R Bridge DR2 0-1"	Pocasset L PLW 0-1"	Blank	LCS Blank Spike
% Solids	**53.05**	**12.91**		**% Recovery**
Analyte (ng/kg) dry weight				
2378 TCDF	**0.10**	**0.73**	**0.14 I**	**98**
12378 PeCDF	0.22E	1.40 E	0.17 J	97
23478 PeCDF	0.42	1.50 J	0.21	100
123478 HxCDF	0.17	1.30 J	0.13 J	96
123678 HxCDF	0.16	1.10 J	0.13 I	97
234678 HxCDF	0.10 J	0.88 J	0.14	103
123789 HxCDF	0.13 J	1.20 J	0.19	95
1234678 HpCDF	0.22	1.20	0.12 J	101
1234789 HpCDF	0.24 J	1.30 I	0.20	92
OCDF	0.14 B	1.70	0.25 J	92
2378 TCDD	**0.24 J**	**1.50**	**0.29**	**102**
12378 PeCDD	0.21 I	2.00 J	0.31	101
123478 HxCDD	0.17 J	1.90 I	0.20	102
123678 HxCDD	0.33 J	2.10 J	0.19	103
123789 HxCDD	0.23 J	1.80 J	0.25	99
1234678 HpCDD	0.41	2.90	0.16 J	94
OCDD	0.31	2.30	0.30J	99
DTEo	**0.3**	**1.6**	**0.8**	
DTEd	**0.8**	**5.5**	**0.9**	

J= Concentration detected is below the calibration range
I = Interference
B = Less than 10 times higher than method blank level
E = PCDE Interference