REPORT TO THE ST. LAWRENCE RIVER RESEARCH AND EDUCATION FUND
NEW YORK POWER AUTHORITY

Project Title: *Assessment of Mercury Levels in Wetland Wildlife in the St. Lawrence River and the St. Lawrence River Valley*

November 7, 2011

Research Project Proposed/Initiated by Marilyn Mayer, Department of Biology, St. Lawrence University (2010)
Additional Project Work, Data Analysis, and Report Prepared by Dr. Lorraine Olendzenski, Associate Professor of Biology; Dr. Matt Skeels, Assistant Professor of Chemistry; and Carol Cady, GIS Map Specialist (2011)

Report Overview

This report summarizes data collected as part of the SLRREF research grant awarded to Dr. Marilyn Mayer, Department of Biology, in March 2010. Work was conducted during the spring and summer of 2010 by Marilyn Mayer and student research assistants Kylie Rock and Eloise Lachance. During the summer of 2011, project sampling was continued by student assistant Allysa Houle under the guidance of Carol Cady and Matt Skeels. Both Allysa and Kylie participated in this project as research assistants with the support of the institutionally-funded University Summer Fellows Program. Wildlife from fifteen sites was monitored and sampled during the summer of 2010 (See Table 1), with additional sites sampled in 2011. These sites represent both managed and natural wetland areas and some upland areas. Animals sampled include bullfrogs, tree swallows, minnows, and turtles.

The following sections describe the site preparation, site sampling activities, data analysis, preliminary results, and project outcomes, grouped by animal specimen category.

Tree Swallows

In spring of 2010, 51 existing and new tree swallow nest boxes were erected and monitored at 9 sites: Fish Creek Wildlife Management Area (WMA), Kring-created wetland Upper & Lower Lakes WMA, Irish Settlement Rd. near Upper & Lower Lakes, Willson Hill WMA, USFWS St. Lawrence Wetlands & Grasslands Management Area Richville, St. Lawrence River White House Point, Lisbon Bowdish, and Buddleman (Fig. 1). In spring of 2011, the sample sites were expanded to include the St. Lawrence Campus uplands and wetlands, the Beaver Pond at the St. Lawrence University Kip Tract, Fort Drum, and Pierrepont Streit (Fig. 2). Ninety-four tree swallows were banded in 2010 under a permit to Tom Langen of Clarkson University. In 2011, 52 birds were banded under permits to Carol Cady of St. Lawrence University and Tom Langen. Age, sex when applicable, weight, and culmen, wing and tail length were collected for each individual. Banding data can be obtained by contacting Carol Cady at St. Lawrence University. During the summer of 2010, both tail and breast feathers were sampled from chicks and adults. In Kring Wetland birds, flight feathers were sampled. In 2011, tail and breast feathers were sampled predominantly from chicks; only two adults were sampled

(Table 1). Feathers were stored in the freezer until processing, cleaned in acetone and dried before measurement of total mercury. Larger feathers were cut and replicate samples measured. For chick feathers, whole samples were measured at once. For all analyses, two clean samples and a blank were first run through the analyzer, followed by a sample of the certified DORM3 standard (National Research Council of Canada). Measurement of every five animal samples was followed by a clean sample and the DORM3 certified reference standard for trace metals to ensure that the machine was calibrated correctly. Sample weights were obtained in the mercury analyzer.
Mercury Data Results: Mercury concentrations from 2010 samples ranged from 0.0019 to 0.1528 ppm (Fig. 3). In 2011 samples from 5 sites, mercury levels ranged from 0.0006 to 0.0793 ppm (Fig. 4). Average values for breast feathers compared to those for tail feathers were systematically lower (Tables 3 and 4). At all sites tested, average mercury levels were similar, except for the larger range of values found at Kring Wetland in 2010. The measured Kring samples all came from one nest box and were comprised of feathers from a single female and four chicks. All tree swallow values obtained in this study are one to two orders of magnitude lower than the range of mercury values (1.5 – 3.5 ppm) found in tree swallow feathers from across Acadia National Park, Maine (Longcore et. al, 2007)[1].

Bullfrogs

Bullfrog tadpoles were captured using minnow traps and D-nets. Fourteen different wetlands in the area were sampled, but 3 yr old bullfrog tadpoles were captured from only three locations. Tadpoles were euthanized in the field and brought back to the lab for size measurements and processing. Their digestive tracts were removed from the body so tissue analysis would not be biased by food material. Tadpole biomass (wet weight) was measured after the removal of the digestive tract. Tadpoles were freeze-dried and then homogenized using a ball mill. Samples (3 replicate subsamples per individual tadpoles) were analyzed on the Leco AMA254 mercury analyzer. A one-way ANOVA to test for the effect of location (Kring: created = 14yrs; Richville: created = 11yrs; and Irish Settlement: natural) on the total mercury concentration was conducted using Minitab.
Mercury Data Results: Total mercury concentration (ppm) in bullfrog tadpoles collected from Kring, Richville and Irish Settlement were not significantly different. (ANOVA, $p = 0.331$) (Fig. 5). Tadpole mercury concentration was not significantly related to tadpole size (biomass wet weight) (Fig. 6). Mercury levels for tadpoles at Irish Settlement, Richville, and Kring wetlands are comparable to levels in Ferris Lake, N.Y. (BioDiversity Research Institute N.Y. Hg Herpetofauna Dataset), a lake on the eastern border of the Adirondacks, and are somewhat higher than those found in Acadia National Park, Maine (Fig. 6). Kylie Rock presented these data as a poster at the annual St. Lawrence University Festival of Science and Parent's Weekend events (Fig.6).

[1] Longcore, J., Haines, T. and W. Halteman (2007) Mercury in Tree Swallow Food, Eggs, Bodies, and Feathers at Acadia National Park, Maine, and an EPA Superfund Site, Ayer, Environmental Monitoring & Assessment, Vol. 126 Issue 1-3, p129-143.

Other Samples

Seven painted turtles, 1 Blanding's Turtle and 8 Snapping Turtles were caught across 6 of the wetlands in 2010 using minnow traps. Toenails were clipped, cleaned, and stored frozen. These samples await powdering in a bead mill and measurement for total mercury. Fish were also monitored and sampled across the wetlands in 2010 using minnow traps and nets. Forty-eight mud minnows are frozen and waiting to be processed for mercury measurements.

Project Outcomes

Currently, St. Lawrence senior Kylie Rock is using this research experience as a foundation for continued work on the effects of mercury on amphibian development. Because tadpole metamorphosis may be highly sensitive to tadpole mercury levels and these levels probably increase during metamorphosis with the re-absorption of the tail, she is examining mercury concentration and distribution in the bodies of tadpoles of the model frog species *Xenopus laevis* before and after metamorphosis. Kylie and her faculty mentor, Assistant Professor of Biology Alexander Schreiber, have developed a frog model for mercury uptake and analysis. Kylie and Dr. Schreiber are moving their project to the next level, where they will study the development and behavioral effects of mercury in the frog model and translate those results back to the environment. During the 2011-2012 academic year, Kylie will be presenting her work at the Annual Society of Integrative and Comparative Biology meeting in Charleston, SC in January 2012; this presentation will be supported with funding from the St. Lawrence Academic Dean's Office. She will also present at the annual campus "Festival of Science" in April. Kylie's research on this project will be incorporated into her Honor Thesis, and Dr. Schreiber expects her work to result in a publication; he also believes that this work will be of interest to faculty at the University of Ottawa.

Conclusion

The samples measured in this project have generated much needed baseline data for mercury levels in wildlife in St. Lawrence County. We are grateful to New York Power Authority's SLRREF for supporting this work, which has not only provided research opportunities for at least three St. Lawrence University biology students, but has also yielded useful baseline data that can be used for future study.

Financial Summary

Budget Component	**Expenses**
Faculty Salary/Benefits	$ 7,751
Student Researcher Wages/Benefits	$ 3,763
Project Supplies	$ 1,006
Travel to Field Sites	$ 2,730
Student Campus Summer Housing	$ 1,080
Total	**$ 16,330**

REPORT ATTACHMENTS

Tables

Figures

Table 1. Field sites and samples collected, January 2011

Proposed research sites sampled	Tree Swallows					Turtles				Bullfrogs		Fish
	Nest Boxes	Nests	Birds Banded	Chicks	Adults	Trapping Effort	Snapping	Blanding	Painted	Tadpoles	Adults	Mud Minnow s
French Creek WMA	-	-	-	-	-	-	-	-	-	-	-	-
French Creek Carpenter's Branch WMA	-	-	-	-	-	-	-	-	-	2	0	0
Grindstone Island Delaney Bay Marsh (M+N)	-	-	-	-	-	-	0	0	6	0	0	0
Butterfield Marsh on Crooked Creek - M	-	-	-	-	-	-	-	-	-	NTr	0	0
Butterfield Marsh on Crooked Creek - N	-	-	-	-	-	-	-	-	-	NTr	0	0
Ettingers Wetland (b/w French Creek & Delaney Bay)	-	-	-	-	-	-	-	-	-	0	0	0
Fish Creek Wildlife Management Area	3	2	0	0	0	-	-	-	-	0	0	40
Kring-created w etland (adjacent to Fish Creek) U + W	5	3	5/12*	4/11	1/1	-	0	1	0	5	0	1
Upper & Low er Lakes WMA	3	3	11	9	2	-	2	0	0	0	0	3
Irish Settlement Rd. nr. Upper & Low er Lakes	3	3	12	10	2	16	1	0	0	5	2	2
Wilson Hill Wildlife Management Area	6	2	6	4	2	-	4	0	0	1	0	0
Additional sites sampled												
Richville: USFWS St. L. Wetlands & Grasslands MA	11	4	18	13	5	-	1	0	1	5	2	1
St. Law rence River White House Point	20	18	34	32	2	-	-	-	-	-	-	-
Lisbon Bow dish	3	1	5	5	0	-	-	-	-	0	3	1
Buddleman	1	1	6	4	2	-	-	-	-	-	-	-
Fort Drum, NY (2011) U	-		5	5	0	-	-	-	-	-	-	-
St. Law rence University Campus (2011) U	6		22	22	0	-	-	-	-	-	-	-
Kip Tract Beaver Pond (2011) (U + W)	1		4	4	0	-	-	-	-	-	-	-
Piercefield - Streits (2011) U	2		9	8	1	-	-	-	-	-	-	-
Total	64		149	118	18		8	1	7	18	7	48

Proposed research sites not used
Kring-natural w etland (adjacent to Fish Creek)
Little Cranberry Creek - natural
Cranberry Extension-natural
Cranberry Marsh - managed
Chippew a Tributary w etland-riparian natural
Coles Creek Wetland *
Richard's Landing *
St. Regis Mohaw k- Raquette River mouth
St. Regis Mohaw k-Ducks Unlimited
St. Regis Mohaw k-Snye Marsh

M = Managed Site; N = Natural Site U = upland; all others are w etland sites

* = 2010 samples/2011 samples

Table 2. Average total mercury concentrations (ppm) for Tree Swallow feathers sampled in 2010

Site	All samples Average (±S.D.)	Breast Feathers Average (±S.D.)	Tail Feathers Average (±S.D.)
Wilson Hill	0.044 (±0.025)	NA	NA
Lisbon	0.041 (±0.016)	0.026 (±0.002)	0.051 (±0.006)
Fish Creek	0.045 (±0.001)	NA	NA
Irish Settlement	0.030 (±0.020)	NA	NA
Buddleman	0.034 (±0.008)	NA	NA
Upper and Lower	0.033 (±0.016)	NA	NA
Kring	0.101 (±0.039)	NA	NA
Richville	0.032 (±0.016)	NA	NA
StLR Wetlands and Grassland	0.027 (±0.012)	NA	NA

Table 3. Average total mercury concentrations (ppm) for Tree Swallow feathers sampled in 2011

Site	All samples Average (±S.D.)	Breast Feathers Average (±S.D.)	Tail Feathers Average (±S.D.)
Fort Drum (U)	0.022 (±0.019)	0.006 (±0.003)	0.036 (±0.022)
Piercefield - Streits (U)	0.031 (±0.022)	0.009 (±0.009)	0.040 (±0.020)
St. Lawrence U. Campus (U+W)	0.027 (±0.019)	0.011 (±0.008)	0.038 (±0.017)
Beaver Pond (U+W)	0.013 (±0.014)	0.015 (±0.001)	0.025 (±0.008)
Kring - (W)	0.026 (±0.020)	0.006 (±0.008)	0.040 (±0.013)

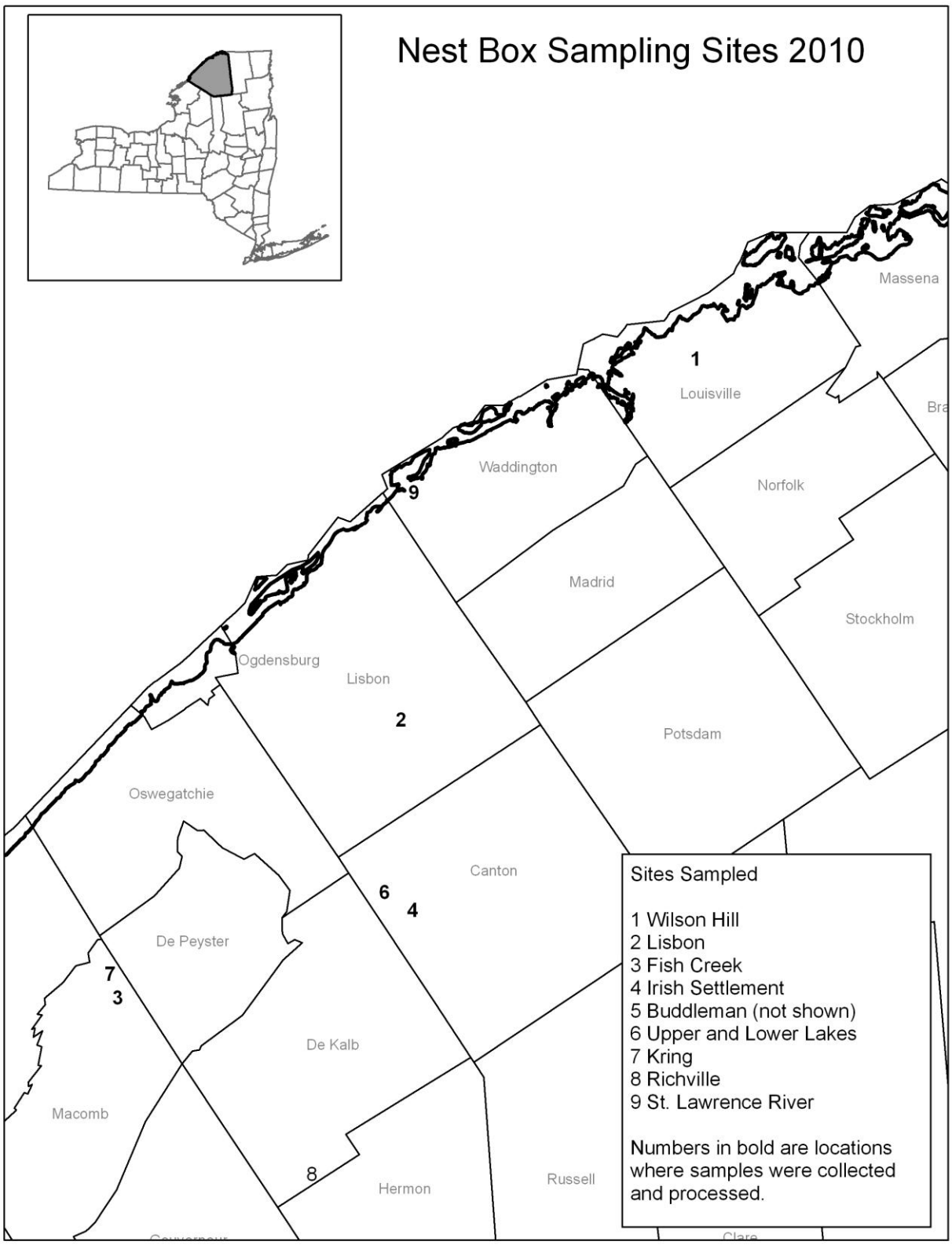

Figure 1. Map showing sites within St. Lawrence County sampled during 2010. Wilson Hill

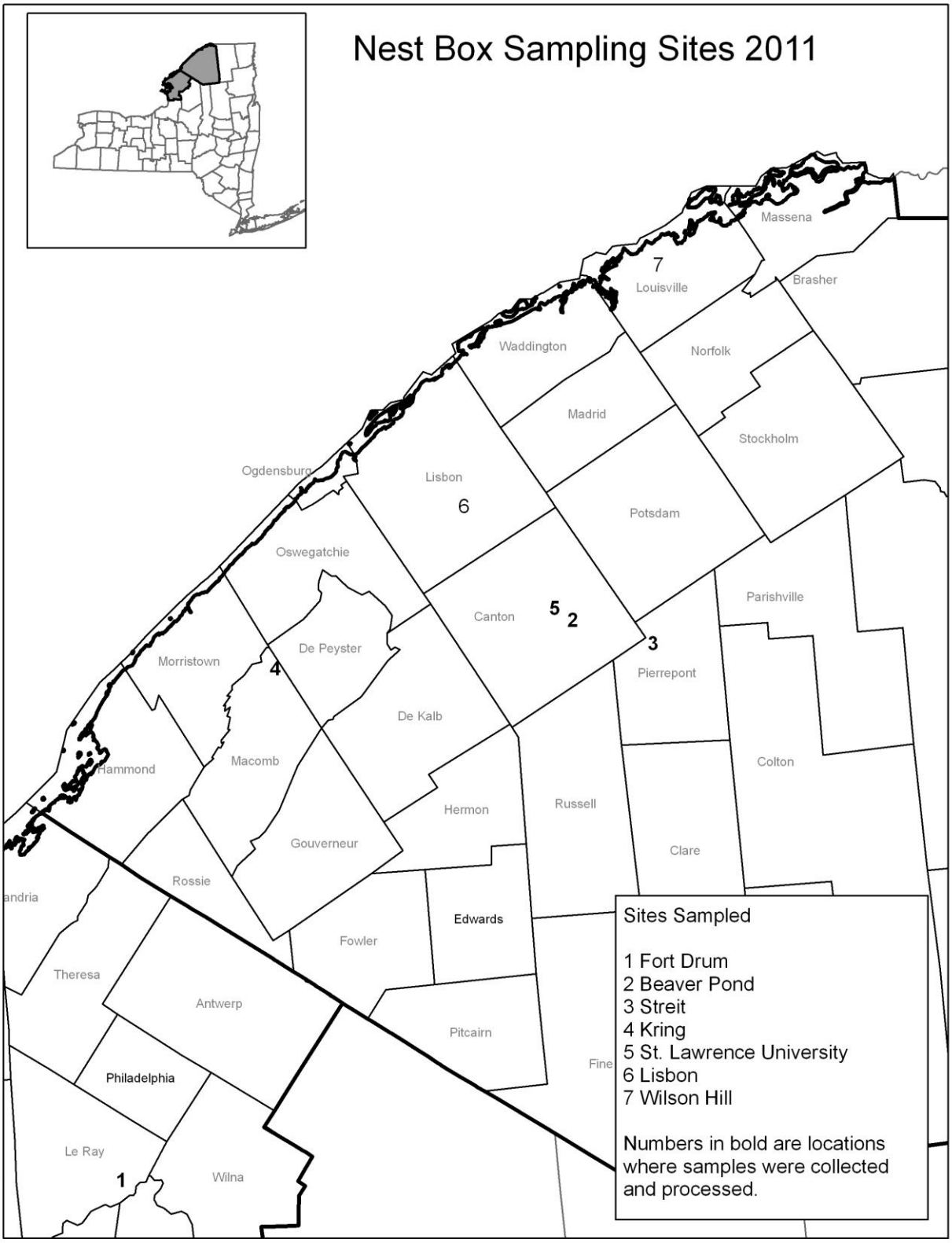

Figure 2. Map showing sites in St. Lawrence and Jefferson Counties sampled during 2011.

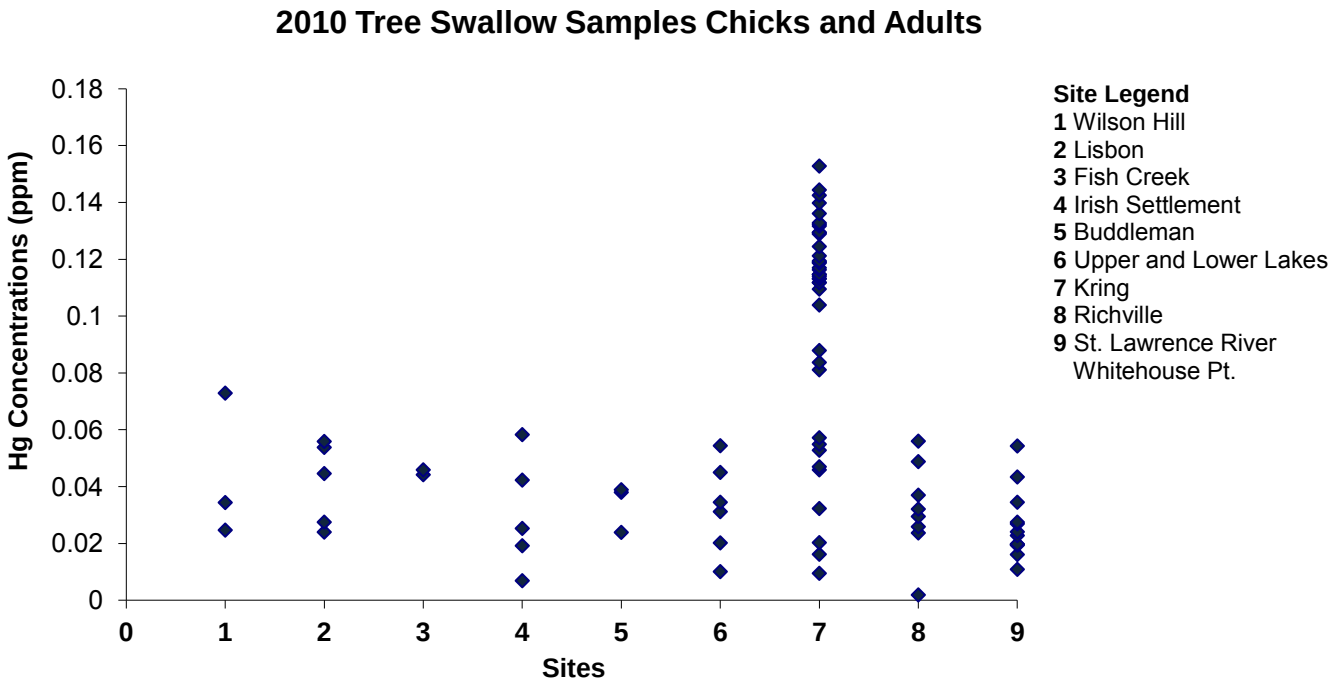

Figure 3. Total mercury concentrations (ppm) in Tree Swallow feathers from chicks and adults from 9 wetland sites.

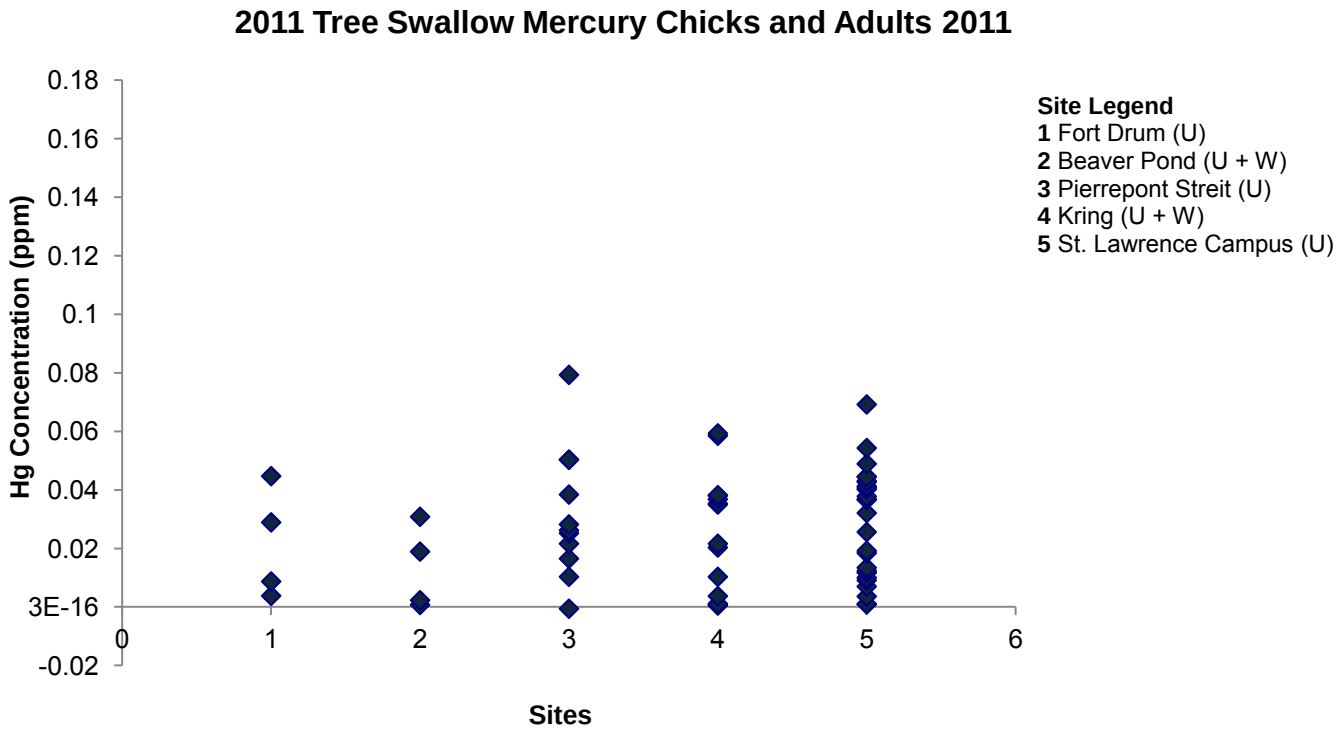

Figure 4. Total mercury concentrations (ppm) in Tree Swallow feathers from chicks and adults from 5 sites. U = upland; W = wetland.

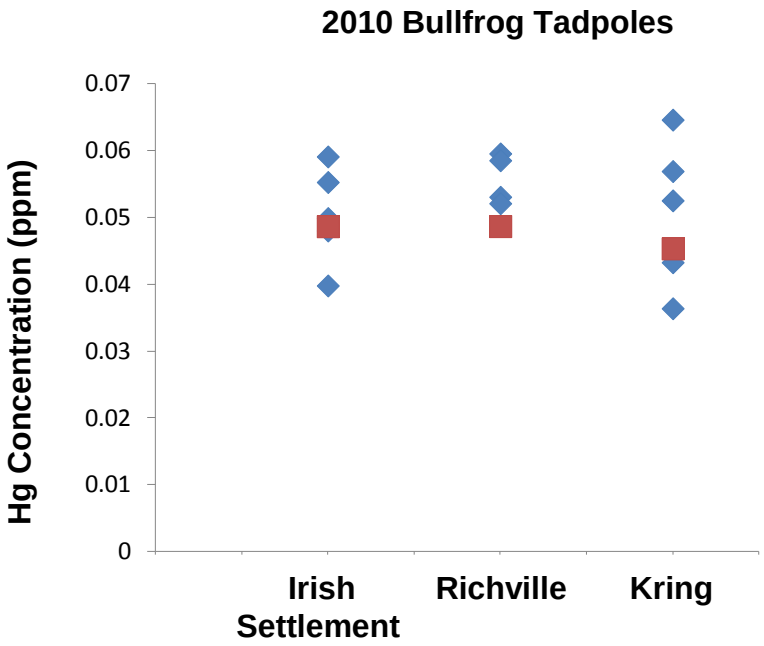

Figure 5. Total mercury concentrations (ppm) in bullfrog tadpoles sampled from three sites.

Mercury Levels in Bullfrog Tadpoles (*Rana catesbeiana*) in 3 wetlands in St. Lawrence County

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Abstract

Mercury (Hg) is a neurotoxin that bioaccumulates up the food chain. Hg can contaminate aquatic environments and adversely affect wildlife in those environments. Wetlands are hotspots for Hg and created wetlands can have especially high levels of Hg in wildlife. The St. Lawrence River Valley wetlands are important stopover sites for migrating birds and are home to valued wildlife. For that reason, there are several created wetlands, wetland wildlife management areas, and protected wetlands in our area that may be negatively impacted by Hg. This research consisted of the collection of bullfrog tadpoles from wetlands in the St. Lawrence River Valley and the analysis of Hg concentrations in tadpoles. There was no significant difference in total Hg concentrations (ppm, wet weight) in bullfrog tadpoles from the 3 wetland sites studied: Kring, Richville, and Irish Settlement.

Figure 1. Three year old Bullfrog tadpole approximately two to three years of age.

Introduction

Mercury (Hg) is a harmful neurotoxin that can contaminate aquatic ecosystems. The impacts of MeHg range from impairing reproduction to adverse affects on development, growth and mortality.

Wetlands are collection sites for water and so cause them to collect and concentrate dissolved pollutants (Yu et al. 2008) like Hg. Biogeochemical processes in wetlands favor bacterial conversion of harmless, inorganic Hg to toxic methyl mercury (MeHg) which accumulates in organisms and is transferred up the food chain (Lacerda and Fitzgerald 2001).

Atmospheric transport of Hg from distant sources have negatively impacted otherwise pristine areas like the Adirondacks. Spatial heterogeneity in wildlife mercury levels has been demonstrated across northeastern North America and found the Adirondacks to contain especially damaging Hg levels (Evers et al. 2005). Wetlands in the St. Lawrence River valley may also suffer from the elevated Hg supply reaching the Adirondacks. Human activities such as wetland creation and the manipulation of water levels can elevate the conversion of Hg to MeHg and mercury concentrations in wildlife, making it crucial to evaluate both natural and created wetlands (Driscoll et al. 2007).

Bullfrog tadpoles are a great subject for studying Hg levels in natural and created wetlands: they have wide spread distribution among wetlands, they are consumed by other wetland wildlife, their 2-3 yr. duration as tadpoles permit them a lengthy time to accumulate Hg, and metamorphosis is likely to be sensitive to mercury concentrations (Bank et al. 2007). Therefore it is important to evaluate geographic variation in Hg levels in bullfrog tadpoles in created and natural wetlands in St. Lawrence County, N.Y.

Methods

Bullfrog tadpoles were captured using minnow traps and D-nets. We sampled 14 different wetlands in the area, but captured 3 yr old bullfrog tadpoles from only 3 locations. Tadpoles were euthanized in the field and brought back to the lab for size measurements and processing. Their digestive tracts were removed from the body so tissue analysis would not be biased by food material in their large digestive tracts. Tadpole biomass (wet weight) was measured after the removal of the digestive tract. Tadpoles were freeze dried and then homogenized using a ball mill. Samples (3 replicate subsamples per individual tadpoles) were analyzes on a Leco AMA254 total mercury analyzer. For statistical analysis, we conducted a one-way ANOVA to test for the effect of location (Kring: created = 14yrs, Richville; created = 11yrs, and Irish Settlement: natural) on the total mercury concentration using Minitab. We then compared our Hg levels in bullfrog tadpoles to the few measurements found in the literature.

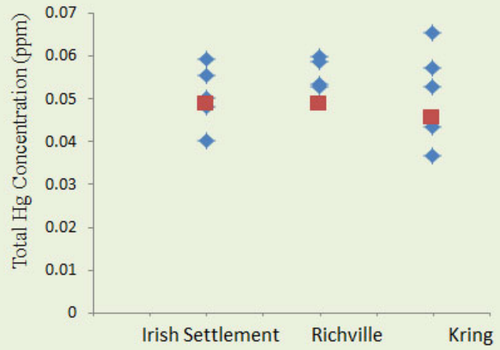

Figure 2. Total mercury (THg) concentrations (ppm, wet weight) for tadpoles from 3 wetland sites in St. Lawrence County, N.Y.: ♦ values for individual tadpoles, ■ site average .

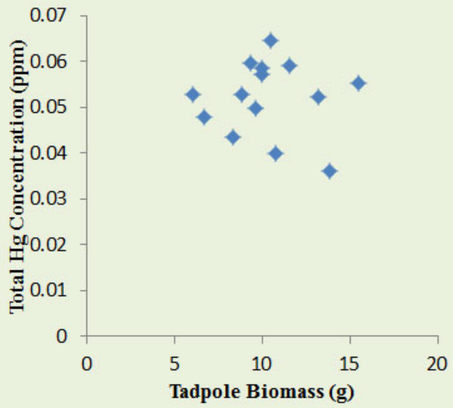

Figure 3. Tadpole Hg concentration (ppm, wet weight) versus tadpole biomass (g, wet weight).

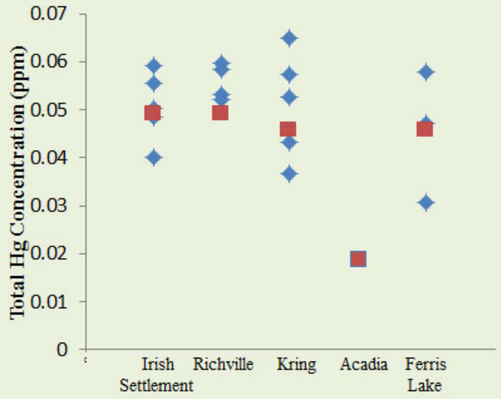

Figure 4. Comparison of total mercury concentrations (ppm, wet weight) for tadpoles from St. Lawrence County wetlands in N.Y. to literature values for tadpoles in Acadia Me. (Bank et al. 2006), and Ferris Lake, N.Y. (BioDiversity Research Institute N.Y. Hg Herpetofauna Dataset): ♦ values for individual tadpoles, ■ site average .

Results

- Total Hg(THg) concentration(ppm) in bullfrog tadpoles collected from Kring, Richville and Irish Settlement were not significantly different. (ANOVA, $p = 0.331$) (Figure 2).
- Tadpole mercury concentration was not significantly related to tadpole size (biomass wet weight) (Figure 3).
- Mercury levels for tadpoles at Irish Settlement, Richville, and Kring wetlands are comparable to levels in Ferris Lake, N.Y. (BioDiversity Research Institute N.Y. Hg Herpetofauna Dataset) a lake on the eastern border of the Adirondacks and are somewhat higher than those found in Acadia (Bank et al. 2006) a national park in Maine (Figure 4).

Discussion

- Deviation from our expected results of mercury concentrations in tadpoles from created wetlands (Richville and Kring) levels exceeding those for tadpoles from a natural wetland (Irish Settlement) may be due to the older age of the created wetlands (Richville ≈ 11 years old, Kring ≈ 14 years old). The elevation of Hg levels in created wetlands and reservoirs decreases over time. These created wetlands may therefore be old enough that the mercury levels are no longer elevated. In addition, differences in other environmental factors among the wetlands such as water temperature, size of wetland drainage basin, concentration of dissolved organic carbon and food availability can also influence mercury levels in tadpoles.
- Our data for Hg concentrations in bullfrog tadpoles at 3 wetland sites in N.Y. substantially increases the pre-existing information on Hg levels in bullfrog tadpoles in N.Y. (1 lake site in the Adirondacks) and the Northeastern U.S. (1 site in N.Y. and a collection of sites in Acadia National Park in Me.

Future Research

- We still hope to collect bullfrog tadpoles from some of the other local wetlands targeted by our study. We were able to collect adult bullfrogs from more sites and those data will be presented later this year.
- Because tadpole metamorphosis may be highly sensitive to tadpole Hg levels and the Hg levels probably increase during metamorphosis with the re-absorption of the tail, this summer project has lead to a related research project examining Hg concentration and distribution in the bodies of tadpoles (a different species *Xenopus laevis*) before and after metamorphosis.

Acknowledgements

We would like to thank the Chemistry Department for use of the Leco AMA254 Hg analyzer, and a special thanks to Matt Skeels for his assistance with Hg analysis and to Eloise LaChance for help in the field. This project also allowed me to assist Eloise LaChance with her study on Tree Swallows and to observe Bullfrog breeding behavior

Literature Cited

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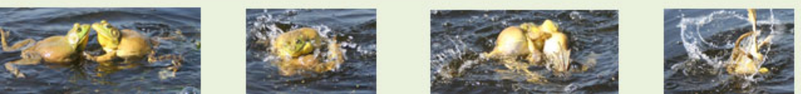

FIG. 6