2013

# MERCURY IN THE INVERTIVORE FOOD WEB OF ONONDAGA LAKE





BIODIVERSITY RESEARCH INSTITUTE
innovative wildlife science

# MERCURY IN THE INVERTIVORE FOOD WEB OF ONONDAGA LAKE




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***MARCH, 2013***

Biodiversity Research Institute (BRI) is a 501(c)3 nonprofit organization located in Gorham, Maine. Founded in 1998, BRI is dedicated toward supporting global health through collaborative ecological research, assessment of ecosystem health, improving environmental awareness, and informing science based decision making.

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**FRONT PHOTO CAPTION:** *Left: Male red-winged blackbird captured on Onondaga Lake.*
*Right: An array of emergence traps set up in the southwest corner of Onondaga.*

**SUGGESTED CITATION:** *Buck, D.G., K. Regan, T. Divoll, D. Yates, and S. de la Sota. 2013. Mercury in the invertivore food web of Onondaga Lake Report. Submitted to U.S. Fish and Wildlife Service, Cortland, NY. Biodiversity Research Institute, Gorham, Maine.*

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## Species Codes

| 4-letter code | Latin name | Common name |
|---|---|---|
| **Birds** | | |
| SPSA | *Actitis macularia* | Spotted sandpiper |
| TRES | *Tachycineta bicolor* | Tree swallow |
| RWBL | *Agelaius phoeniceus* | Red-winged blackbird |
| **Bats** | | |
| EPFU | *Eptesicus fuscus* | Big-brown bat |
| LABO | *Lasiurus borealis* | Eastern red bat |
| MYLU | *Myotis lucifugus* | Little brown myotis |
| MYSE | *Myotis septentrionalis* | Northern long-eared myotis |
| MYSO | *Myotis sodalis* | Indiana myotis |
| MYSU | *Perimyotis subflavus* | Tri-colored bat* |

*MYSU was initially considered part of the genus *Pipistrellus* (common name Eastern pipistrelle). Recent taxonomic revisions of have placed it in its own genus, *Perimyotis*. We used the traditional abbreviation (MYSU) for this species to avoid confusion with earlier studies.

# 1.0 INTRODUCTION

Research on food web dynamics within contaminated ecosystems suggests that biological transport represents a significant mechanism for the transfer of contaminants from aquatic into adjacent terrestrial ecosystems. One of the primary biological pathways for contaminant exposure in these ecosystems is emergent aquatic insects that 'export' contaminants during emergence (Tremblay et al. 1998; Walters et al. 2008). These emergent aquatic insects are then consumed by terrestrial invertivores such as birds (Maul et al. 2006) and bats (Wada et al. 2010). Recent work has also highlighted the role that spiders can play as a source of Hg to the food web (Cristol et al. 2008; Walters et al. 2010, Northam et al. 2011). Spiders, which also consume aquatic and terrestrial insects, can account for a significant component of the diet in songbirds (20 - 30%, Cristol et al. 2008) and have also been documented in bat diets (Brack and Whitaker 2001).

Biodiversity Research Institute (BRI), under the direction of the Natural Resource Trustees for the Onondaga Lake Natural Resource Damage Assessment, conducted research on mercury (Hg) exposure in invertivores adjacent to Onondaga Lake during 2008 and 2009. Results from these initial screenings of songbirds (Lane et al. 2011) and bats (Divoll et al. 2009) suggest that invertivores adjacent to Onondaga Lake are exposed to Hg. More than 30% of the songbirds sampled during 2008 and 2009 had blood Hg concentrations at or above recently proposed reproductive effect threshold concentrations for the tree swallow : 0.63 µg/g Hg in blood (Lane et al. 2011) and Carolina wren: 0.70 µg/g Hg in blood ( Jackson et al. 2011). Based on Hg egg injection work conducted by Heinz et al. (2009) on 26 bird species, the tree swallow was found to be moderately sensitive to Hg, more sensitive than species such as the mallard and hooded merganser, but less sensitive than species such as the American kestrel and osprey. Heinz et al. (2009) did not evaluate the sensitivity of the Carolina wren or other wren species to injected Hg.

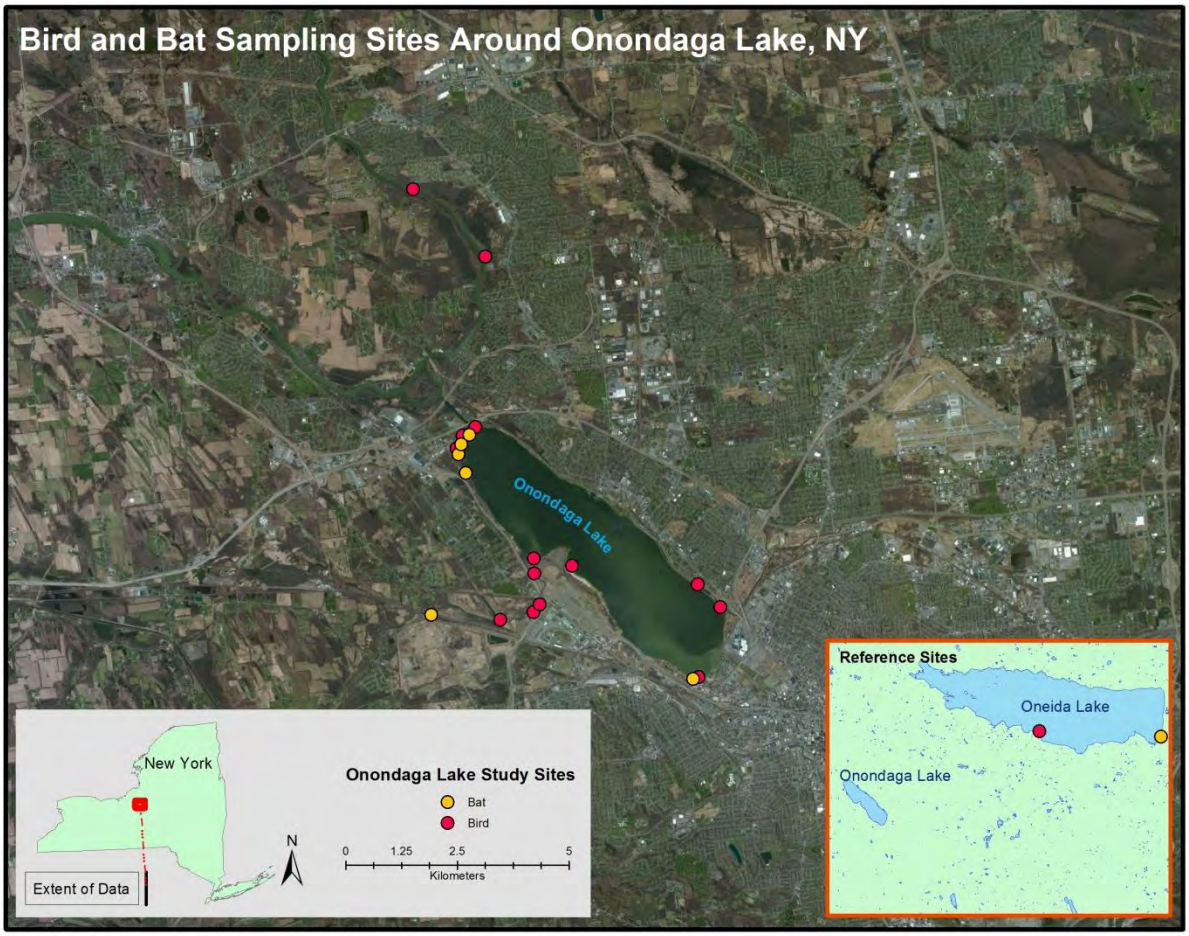
There are no effects thresholds for Hg in bats; however some bats sampled at Onondaga Lake and the Oneida Lake reference area had concentrations of Hg in fur that have

been associated with adverse effects in species such as mink and deer mice. Approximately 53% of the adult bats captured at Onondaga Lake in 2009 had fur Hg concentrations (range = 1.43 - 60.78 µg/g) that exceeded a deer mouse fur lowest observable adverse effects level (LOAEL) of 10.8 µg/g (fw) (Burton et al. 1977). Approximately 28% of adult bats (17 % of juvenile and adult bats) captured at the reference site had fur Hg concentrations in excess of a deer mouse fur LOAEL of 10.8 µg/g. A small number of bats (< 5%) from Onondaga Lake (no bats from reference area) also had fur Hg concentrations that exceeded an adverse effects threshold for mink (40 – 50 µg/g), as described in Basu et al. (2007).

In an effort to better understand the mechanisms for the bioaccumulation of Hg in songbirds and bats, we collected potential prey items from multiple sites on Onondaga Lake and the Oneida Lake reference area. In addition, fecal pellets from bats were collected from 129 individuals from Onondaga and Oneida Lakes and analyzed to determine the food habits of bats foraging adjacent to the lake. This report summarizes these results and identifies potential pathways for Hg bioaccumulation on Onondaga Lake.

## 2.0 STUDY AREA

Invertebrate sampling was conducted at sites where bird and bat sampling was also conducted including: the Beach site on Onondaga Lake; 9 Mile Creek; the Southwest Corner of Onondaga Lake, Maple Bay (also referred to as 'Outlet' in Divoll et al. 2009), Wetzel Road along the Oswego River, and a reference site on Oneida Lake. In addition, samples were collected from the shoreline area immediately to the north of the 9 Mile Creek mouth (here referred to as 9 Mile Beach). Detailed descriptions of these sites are provided in Lane et al. 2011.




# 3.0 METHODS

## 3.1 Invertebrate Collection and Taxonomy

Invertebrate collection followed protocols outlined in Buck et al. (2009) and included sweep netting, opportunistic capture with aspirators, emergence traps, and the use of back lights and a white sheet for night-time insect capture. Individual invertebrate samples were stored in snap-cap centrifuge vials (1.5mL), given a unique sample ID, and stored on ice while in the field. Upon returning from the field, sample fresh weights (± 0.0001 g) were determined using an analytical balance and then all samples were stored frozen prior to being transported to BRI's Wildlife Mercury Lab for taxonomic identification. All individuals were identified to Family level. Samples were then freeze-dried and re-weighed to obtain a dry weight. Dry

weight measurements were calculated for each individual. For individuals with a dry weight < 0.02 g, composite samples were made using individuals of the same taxonomic family, collected from the same sample location, and with a similar dry weight. Composited samples were homogenized using acid-rinsed stainless steel spatulas and prepared for analysis.

## 3.2 Collection and Analysis of Bat Feces

A description of the bat capture techniques are provided in Divoll et al. (2009). Bats were held in disposable paper bags for approximately 30 minutes and fecal samples were collected from the bag and stored in snap-cap centrifuge vials. Fecal samples were dried and prey remains were separated for taxonomic identification using methods from Kunz and Whitaker (1983) and Whitaker et al. (2011). Prey remains were identified to lowest taxonomic level possible (order in most cases). A dissecting microscope and comparative reference collections were used. The percent occurrence for each taxon in the feces of individual bats was determined and a visual estimate of the percent volume of each prey taxa was made. Percent occurrence and mean percent volume were then summarized for each bat species at each site. Percent occurrence for a species was calculated as the number of bats of a particular species feeding on a prey taxa divided by the total number of individual bats for a particular species. The mean percent volume was calculated by summing the volume of a prey taxa fed on by a particular bat species divided by the total number of bat species.

## 3.3 Mercury and Methylmercury Analysis of Invertebrate Prey

Invertebrate prey items were analyzed for total mercury (THg) at 2 separate labs. BRI's Wildlife Mercury Research Laboratory analyzed samples following EPA method 7473 by gold-amalgamation atomic absorption spectroscopy following thermal desorption of the sample using a Milestone DMA-80. Additional invertebrate samples were analyzed for both THg and methylmercury (MeHg) at the Wright State University. The concentration of MeHg can vary substantially in invertebrates (Cristol et al. 2008) and knowledge of the percent MeHg in particular prey items can help identify primary pathways for MeHg bioaccumulation within food webs. Dried samples were weighed (+/- 0.00001 g) and placed into 15-mL vessels and then

digested with 1.75 mL of 4.57 M nitric acid for 12 h in a 60° C water bath (Hammerschmidt and Fitzgerald 2006). Digestates were analyzed for monomethylmercury (MMHg=MeHg) by derivatization with sodium tetraethylborate and detection with flow-injection gas chromatographic atomic fluorescence spectrometry. Analyses were calibrated with MeHg standards taken through the acid digestion procedure. All analyses of two standard reference materials from the National Research Council of Canada (TORT-2 and DORM-3) were within the certified range, indicating little or no bias. The method detection limit for MeHg was about 0.3 ng/g for a 10-mg sample. Digestates used for MeHg analysis were oxidized with BrCl and analyzed for total Hg. The method is detailed and validated in Hammerschmidt and Fitzgerald (2006). Total Hg was determined after reduction with stannous chloride by dual-Au amalgamation cold-vapor atomic fluorescence spectrometry (Bloom and Fitzgerald 1988). Analyses were calibrated versus aqueous Hg(II) solutions traceable to the U.S. NIST. Method detection limit for total Hg was about 20 ng/g for a 10-mg sample.

## 3.5 Stable Isotope Analysis of Invertebrate Prey

Stable isotopes measured in producers and consumers can provide an integrated assessment of trophic interactions and help describe food web pathways leading from the base of the food web up to top level consumers (Peterson and Fry 1987). The ratio of stable carbon (e.g., $^{13}C$ and $^{12}C$) and nitrogen (e.g., $^{15}N$ and $^{14}N$) isotopes as measured in tissue samples are reported using the delta notation (δ) and reflect the per mill (‰) difference between the sample and a known reference (Michener and Lajtha 2007). Stable nitrogen isotopic concentrations ($\delta^{15}N$) values help confirm the trophic position of organisms within a food web while stable carbon isotopic concentrations ($\delta^{13}C$) help determine the origin of basal resources within particular food webs (Peterson and Fry 1987; Knoff et al. 2001). When used in conjunction with contaminant analysis, it is possible to examine the bioaccumulation and biomagnification of contaminants within a food web. Contaminants that enter food webs are accumulated by organisms at lower trophic levels and then can be magnified by consumers at higher levels in the food web (Rasmussen and Vander Zanden 2004).

The same subset of samples analyzed for THg and MeHg were split and analyzed for stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopic concentrations at Boston University, Boston Massachusetts, using automated continuous-flow isotope ratio mass spectrometry (Michener and Lajtha 2007). Dried invertebrate samples (approximately 400 micrograms) were transferred to tin capsules and combusted in a EuroVector Euro EA elemental analyzer. The combustion gases ($N_2$ and $CO_2$) were separated on a GC column, passed through a reference gas box and introduced into the GV Instruments IsoPrime isotope ratio mass spectrometer; water was removed using a magnesium perchlorate water trap. Ratios of $^{13}C/^{12}C$ and $^{15}N/^{14}N$ are reported as standard delta (δ) notation and are expressed as the relative permil (‰) difference between the samples and international standards (Vienna Pee Dee Belemnite (V-PDB) carbonate and N2 in air) where:

$$\delta X = (R_{sample} / R_{standard} - 1) \times 1000 \text{ (‰)}$$

Where X = $^{13}C$ or $^{15}N$ and R=$^{13}C/^{12}C$ or $^{15}N/^{14}N$

The sample isotope ratio is compared to a secondary gas standard, the isotope ratio of which was calibrated to international standards. For $^{13}C$-VPDB, the gas was calibrated against NBS 20 (Solenhofen Limestone). The $^{15}N_{air}$ gas was calibrated against atmospheric $N_2$ and International Atomic Energy Agency (IAEA) standards N-1, N-2, and N-3 (all are ammonium sulfate standards).

## 4.0 Results and Discussion

During 2009, BRI collected a total of 776 individual invertebrates. After compositing samples to have adequate mass for analyses, we selected 81 samples as part of this preliminary assessment of Hg within the invertivore food webs of Onondaga. Samples were selected that (1) had sufficient sample mass for both mercury and stable isotope analysis and (2) were captured in the same sampling site as the target invertivores (see section 4.1 and section 4.2). This included 56 samples for THg and an additional 25 samples for THg/MeHg analysis and stable isotope analysis. Samples were distributed across 3 orders and 19 families and were

separated into avian versus bat food webs based on the timing (day vs. night) and location of sampling (Table 1). Small sample sizes prevent any robust statistical tests for differences within the data and the discussion of prey mercury instead focuses on trends within and across sampling sites.

**Table 1. Invertebrate prey items selected for total-Hg, methyl-Hg, and stable isotope analysis**

| | AVIAN FOOD WEB | | BAT FOOD WEB | |
|---|---|---|---|---|
| **TAXA** | THg | MeHg & isotopes | THg | MeHg & isotopes |
| **Aranaea** | | | | |
| Lycosidae | 7 | 3 | | |
| Tetragnathidae | 4 | 3 | | |
| **Diptera** | | | | |
| Culicidae | | | 1 | |
| Dolichopodidae | | | 6 | 2 |
| Sciomyzidae | | | | 2 |
| Muscidae | | 1 | 4 | 2 |
| Syrphidae | | 1 | | |
| Chironomidae | | | | 1 |
| Sarcophagidae | 1 | | | |
| Scathophagidae | 4 | 1 | 1 | |
| Sepsidae | 4 | | | |
| Sphaeroceridae | 4 | 1 | | |
| Therevidae | | | 1 | 1 |
| Tipulidae | | | 1 | 1 |
| **Coleoptera** | | | | |
| Carabeidae | | | | 1 |
| Chrysomelidae | | | 4 | 1 |
| Curculionidae | | | 7 | 2 |
| Elatridae | | | 2 | |
| Scarabeidae | | | 5 | 2 |
| **subtotal** | 24 | 10 | 32 | 15 |

## 4.1 Avian Food Web

The Spotted Sandpiper (SPSA) was the primary avian invertivore target for the preliminary assessment of Hg bioaccumulation. Spotted Sandpipers sampled during the 2008 and 2009 field seasons had the highest blood Hg concentration of any bird sampled during those years (Lane et al. 2011). On Onondaga Lake, SPSA have been observed in the highest densities along the southwestern shore of the lake, between the Beach and the 9-Mile Creek mouth (Lane et al. 2011). SPSA are primarily ground foraging birds that utilize shorelines and aquatic vegetation washed up on shores to forage for adult and larval invertebrates including flies (Diptera), crickets (Orthoptera), spiders (Aranaea), as well as worms, mollusks, crustaceans and occasional carrion washed up on shore (Rubbelke 1976; Oring et al. 1997).

The invertebrate prey items collected from the Beach and 9-Mile Creek Beach sites included 2 families of spiders (Table 2). Lycosid (wolf) and Tetragnathid (long-jawed) spiders are predatory spiders commonly found within littoral and riparian zone habitats. Both families have been the focus of other contaminant studies linking spiders as a source of Hg to birds and other vertebrates (Cristol et al. 2008; Walters et al. 2010; Northam et al. 2011; Buck et al. 2011). Tetragnathid spiders collected from Lake George, NY, a lake in the Adirondacks region, were previously reported as having a mean THg of 0.31 ppm (dw) (Buck et al. 2011). Lycosid spiders within the riparian zone of the South River (Virginia), a site impacted by a point source of mercuric sulfate, had a mean THg concentration of 1.24 ppm (dw) (Cristol et al. 2008). Mean THg concentrations in Lycosid spiders from the Onondaga Lake beach sites are higher than either of these studies [Table 2; mean THg of 1.34 ppm (dw)]. Both Lycosid and Tetragnathid spiders from Onondaga Lake have relatively high $\delta^{15}N$ isotopic concentrations (mean of 12.3 ± 0.2 ‰ and 11.7 ± 0.2 ‰, respectively). Based on these $\delta^{15}N$ values, spiders at the two beach sites occupy a similar or slightly higher trophic level as SPSA (Table 2).

In addition to spiders, day-time capture of invertebrates at the Beach and 9-Mile Creek Beach sites included several families of sapro- and coprophagous flies (Table 2). Sphaerocerid flies are often referred to as dung flies or corpse flies and play an important role in the

decomposition of organic matter (Roháček 2001). Both Sepsid and Scathophagid flies have similar life histories and feeding strategies as Sphaerocerids, with larval and adult stages consuming decaying plant and animal matter (McAlpine 1987). Sarcophagid flies (commonly referred to as flesh flies) lay eggs within decaying plant and animal matter (McAlpine 1987). At both the 9-Mile Beach and Beach sites, these above-mentioned families of flies were abundant along the littoral zone of the lake, particularly in areas where aquatic vegetation, algal mats and fish carcasses had washed ashore. The other two families of flies analyzed as part of this study include Syrphid and Muscid flies. Syrphid flies are often referred to as flower flies and can have a wide range of feeding habits but are primarily considered nectar feeders (McAlpine 1987). Muscid flies include the common house fly.

The fly samples analyzed here represent adult Dipterans. We note that larval dipterans may accumulate greater or lesser amounts of Hg than adults (Sarica et al. 2009; Wurtsbaugh et al. 2011; Rossaro et al. 1986).

Mitchell et al. (1996) report stable isotopic concentrations for food web components of nearby Oneida Lake. Lower trophic levels within Oneida Lake such as sediments and seston have $\delta^{15}N$ values ranging from 6.0 ‰ to 7.5 ‰ while upper trophic level fish such as yellow perch and walleye have $\delta^{15}N$ values of 12.5 ‰ and 15.7 ‰, respectively (Mitchell et al. 1996). Walleye collected in Onondaga Lake as part of Honeywell's baseline monitoring program had $\delta^{15}N$ values of 18 – 19 ‰ (Parsons et al. 2012), possibly reflecting greater organic inputs to Onondaga Lake than Oneida Lake.

**Table 2. Mercury, methylmercury (MeHg) and stable isotope concentrations (mean ± 1 standard deviation) of different trophic levels within the avian invertivore food web of Onondaga Lake collected during the 2009 field season (sample sizes are shown in parentheses).**

| | THg (ppm, ww) | THg (ppm, dw) | MeHg (ppm, dw) | % MeHg | $\delta^{13}C$ (‰ vs. VPDB) | $\delta^{15}N$ (‰ vs. AIR) |
|---|---|---|---|---|---|---|
| **Invertivores *** | | | | | | |
| **Spotted Sandpiper** | 1.91 +/- 0.47 (9) | 2.54 +/- 0.63 ^ | | > 90‡ | -24.8 +/- 0.2 (9) | 11.4 +/- 0.7 (9) |
| **Tree Swallow** | 0.39 +/- 0.04 (18) | 0.52 +/- .05 ^ | | > 90‡ | -28.1 +/- 0.2 (18) | 10.9 +/- 0.2 (18) |
| **Red-winged Blackbird** | 0.77 +/- 0.21 (28) | 1.03 +/- 0.28 ^ | | > 90‡ | -21.4 +/- 0.5 (28) | 9.1 +/- 0.4 (28) |
| **Aranaea** | | | | | | |
| **Lycosidae** | | 1.34 +/- 0.36 (10) | 0.84 +/- 0.21 (3) | 84.1 | -25.9 +/- 0.2 (3) | 12.3 +/- 0.2 (3) |
| **Tetragnathidae** | | 0.54 +/- 0.16 (7) | 0.40 +/- 0.17 (3) | 78.4 | -27.9 +/- 0.7 (3) | 11.7 +/- 0.2 (3) |
| **Diptera** | | | | | | |
| **Sphaeroceridae** | | 0.37 +/- 0.15 (5) | 0.31 (1) | 93.9 | -25.3 (1) | 14.7 (1) |
| **Sepsidae** | | 0.28 +/- 0.12 (4) | ----- | ----- | ----- | ----- |
| **Scathophagidae** | | 0.18 +/- 0.11 (5) | 0.051 (1) | 87.9 | -26.3 (1) | 12.9 (1) |
| **Sarcophagidae** | | 0.12 (1) | ----- | ----- | ----- | ----- |
| **Muscidae** | | 0.055 (1) | 0.04 (1) | 72.7 | -26.5 (1) | 5.9 (1) |
| **Syrphidae** | | 0.03 (1) | 0.009 (1) | 29 | -28.2 (1) | 6.7 (1) |

* Mercury and stable isotope concentrations in bird blood Lane et al. (2011; Appendix D); data only from Onondaga Lake

^ Wet weight to dry weight conversion done assuming 75% moisture loss (Rimmer et al. 2005).

‡ Bird blood contains greater than 90% MeHg (Rimmer et al. 2005).

## 4.2 Bat Food Web

A total of 151 bats from 5 different species were captured during the 2009 assessment of Hg exposure in bats on Onondaga Lake and nearby Oneida Lake (Yates et al. 2012). Mean bat fur Hg for all species collected from Onondaga Lake was two times higher in adult bats and almost 4 times higher in juvenile bats than the reference site of Oneida Lake. In an effort to understand potential food web pathways for Hg accumulation within bats on Onondaga Lake, BRI collected fecal samples from captured bats and evaluated the prey remains.

Bat fecal analysis provides valuable information on the feeding habits of bats without sacrificing animals. The disadvantages of fecal analysis have been noted in the literature, including a bias towards hard-bodied insects (Rabinowitz and Tuttle 1982) and the challenge of identifying beyond order for certain taxa such as moths without culled insect parts collected from a roosting site (Whitaker et al. 2011). These limitations to bat fecal analysis can be minimized by pooling samples for individual species to obtain a more accurate assessment of preferred prey items of insectivorous bats (Kunz and Whitaker 1983).

Fecal samples were collected from a total of 129 individual bats from 5 different sites, including 3 sites at Onondaga Lake, 1 site along the Oswego River, and 1 site on Oneida Lake (Table 4; see figure 1 in Divoll et al. 2009 for locations). In this section of the report, we discuss the feeding habits and their relation to the observed THg concentrations in the two most commonly captured bats on Onondaga Lake, *Myotis lucifugus* (Little brown myotis) and *Eptesicus fuscus* (Big brown bat). The full data set of prey remains is presented in Appendix 1.

**Table 3. Number of bat fecal samples distributed by site and species.**

| Bat Species | Southwest Corner | 9-Mile Creek | Maple Bay | Oswego River | Oneida (reference) |
|---|---|---|---|---|---|
| MYLU | 13 | 25 | 10 | 6 | 16 |
| EPFU | 13 | -- | -- | 10 | 14 |
| MYSE | -- | -- | 8 | 3 | -- |
| MYSO | -- | -- | 9 | -- | -- |
| MYSU | -- | 1 | -- | -- | -- |
| LABO | 1 | -- | -- | -- | -- |

### 4.2a *Myotis lucifugus* – little brown myotis

The little brown myotis (*Myotis lucifugus*, MYLU) was the most commonly caught bat at Onondaga Lake during the 2009 field season (Yates et al. 2012). Previous studies on the diet of MYLU have suggested that it is an opportunistic feeder foraging on a broad prey base including Coleoptera, Hemiptera, Lepidoptera, Diptera, and Trichoptera (Whitaker and Hamilton 1998). Results from our bat fecal analysis are consistent with these results (Figures 1a and 1b; Appendix 1). MYLU on Onondaga Lake forage on a broad prey base that includes Coleoptera, Lepidoptera, and Diptera and to a lesser degree, Trichoptera and Hymenoptera (Figure 1a). Lepidopterans dominate the diet, with a percent volume consistently near 60% (Figure 1b). The exception to this is MYLU captured adjacent to the Oswego River whose diet had a lower percent volume of Lepidopterans (15.4%) and a higher percent volume of Dipterans relative to the MYLU from the other sites (Figure 1b; Appendix 1).

Mean THg in fur from adult MYLU on Onondaga Lake ranged from 8.88 µg/g (fw) at Maple Bay (near the outlet of the lake), to 15.77 µg/g (fw) at 9-Mile Creek, and up to 22.23 µg/g (fw) in the Southwest corner of the lake. Mean THg in MYLU fur from the Oswego River was 7.18 µg/g (fw) and mean THg in the fur of Oneida Lake bats was 3.83 µg/g (fw) (Yates et al. 2012; table 6). No Diptera were collected from the Maple Bay site but THg concentrations in Diptera were higher in the Southwest corner of Onondaga Lake than at 9-Mile Creek (Table 5).

Although Lepidopterans represented a significant component of the MYLU diet, no Lepidoptera were collected during field sampling. Along the South River, VA, Cristol et al. (2008) reported an average THg in Lepidopterans of 0.38 ± 2.08 $\mu$g/g dw and a percent MeHg of 24 ± 20 %. The large standard deviation in the data from the South River suggests significant variability in Lepidoptera Hg accumulation. While no data exist on Lepidopterans from Onondaga Lake, these above-mentioned South River data suggest that Lepidopterans could potentially represent a significant pathway of THg within the bat food web, particularly given their prominence within the bat diet at Onondaga Lake.

### 4.2b *Eptesicus fuscus* – big brown bat

Big brown bats (EPFU) were caught at three sites during the 2009 field season, including the southwest corner of Onondaga Lake, the Oswego River, and Oneida Lake (Table 4). Big brown bats are considered beetle (Order Coleoptera) specialists (Black 1974; Carter et al. 2003). Beetle remains were recorded in every EPFU fecal sample at consistently high percent volumes (Figure 2a and 2b). On Oneida Lake and along the Oswego River, EPFU consumed a higher volume of Elaterid beetles than EPFU from the southwest corner of Onondaga Lake (52.8% (Oneida) and 39.7% (Oswego) versus 11.7% (SW corner @ Onondaga). EPFU captured in the SW corner consumed a larger volume of Scarabeid beetles relative to the other sites {30.2% (SW corner) versus 14.7% (Oswego) and 11.1% (Oneida)} (Appendix 1). In addition to beetles, Lepidopterans occurred in over 80% of the EPFU fecal remains from the SW corner while occurring in only 20% or less of the EPFU fecal samples from Oneida Lake and the Oswego River (Figure 2a and 2b).

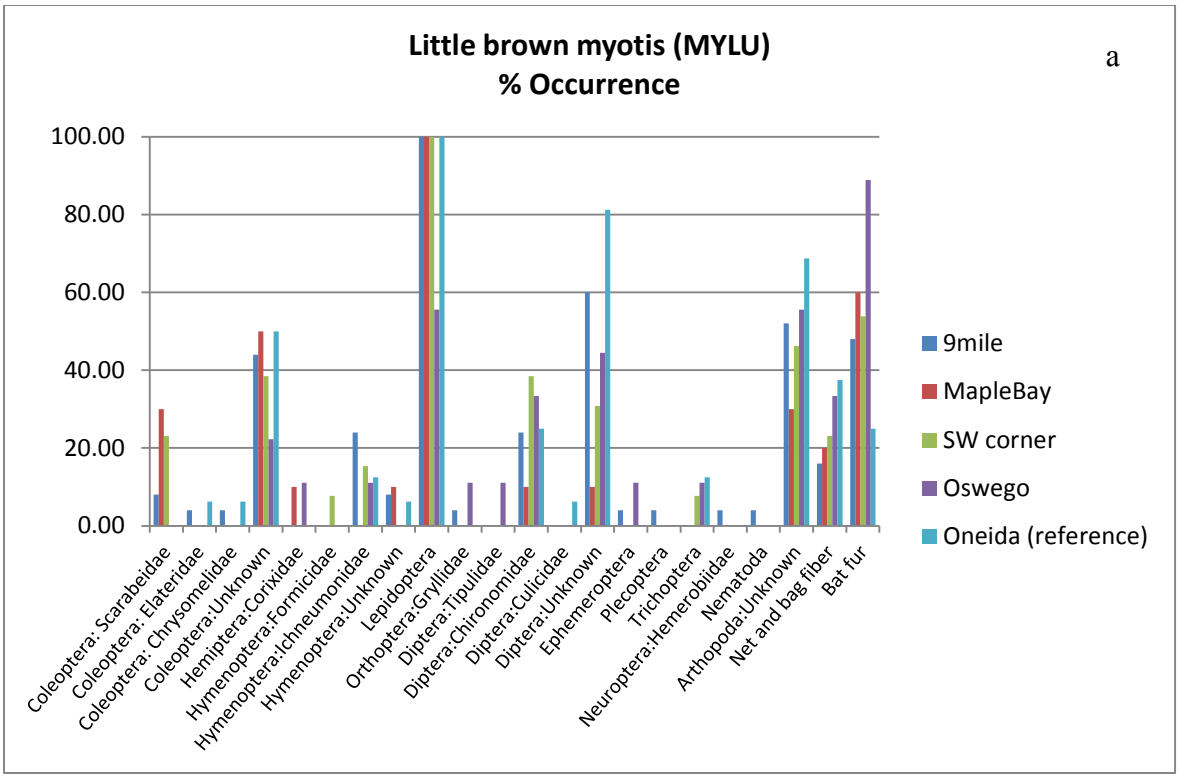
These within species dietary differences in prey selection across sites may explain the differences observed in the THg concentrations of EPFU across these sites as well. EPFU captured along the Oswego River had the highest mean THg of any species at any site (mean THg = 29.08 µg/g, fw) (Yates et al. 2012). These bats consumed more Chrysomelid, Elaterid and Carabid beetles than other EPFU while also consuming less Lepidoptera than EPFU

captured at the SW corner. Carabid beetles are carnivorous and Elaterid beetles feed on carrion as larvae, potentially exposing them to high concentrations of Hg.

**Table4. Mercury, methylmercury and stable isotope concentrations (mean ± 1 standard deviation) of different trophic levels within the bat food web of Onondaga Lake (sample sizes are shown in parenthesis)**

| | THg (ppm, dw) | MeHg (ppm, dw) | % MeHg | $\delta^{13}C$ [1] (‰ vs. VPDB) | $\delta^{15}N$ [1] (‰ vs. AIR) |
|---|---|---|---|---|---|
| **9 Mile Creek** | | | | | |
| **Coleoptera** | 0.05 +/- 0.05 (2) | -- | -- | -- | -- |
| **Diptera** | 0.13 +/- 0.04 (5) | 0.18 +/- 0.03 (2) | 82 | -24.9 +/- 0.9 (2) | 15.1 +/- 1.7 (2) |
| **Maple Bay** | | | | | |
| **Coleoptera** | 0.09 +/- 0.12 (13) | 0.02 +/- 0.03 (4) | 10.9 | -29.1 +/- 1.8 (4) | 2.5 +/- 1.5 (4) |
| **SW corner** | | | | | |
| **Diptera** | 0.53 +/- 0.18 (5) | 0.40 +/- 0.53 (2) | 51.9 | -26.1 +/- 0.5 (2) | 9.4 +/- 3.5 (2) |
| **Oswego** | | | | | |
| **Coleoptera** | 0.03 +/- 0.04 (3) | 0.053 (1) | 70.6 | -25.5 (1) | 7.9 (1) |
| **Diptera** | 0.23 +/- 0.18 (6) | 0.13 +/- 0.15 (3) | 79.8 | -25.6 +/- 0.8 (3) | 8.9 +/- 2.8 (3) |
| **Oneida (reference)** | | | | | |
| **Coleoptera** | 0.05 +/- 0.03 (6) | 0.01 (1) | 22.9 | -27.3 (1) | 4.5 (1) |
| **Diptera** | 0.08 +/- 0.03 (7) | 0.07 +/- 0.01 (2) | 89.4 | -26.4 +/- 0.3 (2) | 8.3 +/- 0.4 (2) |

1 Samples for stable isotopes in bats were not collected during the 2009 field season. Stable isotope data on invertebrates are reported here for future reference.



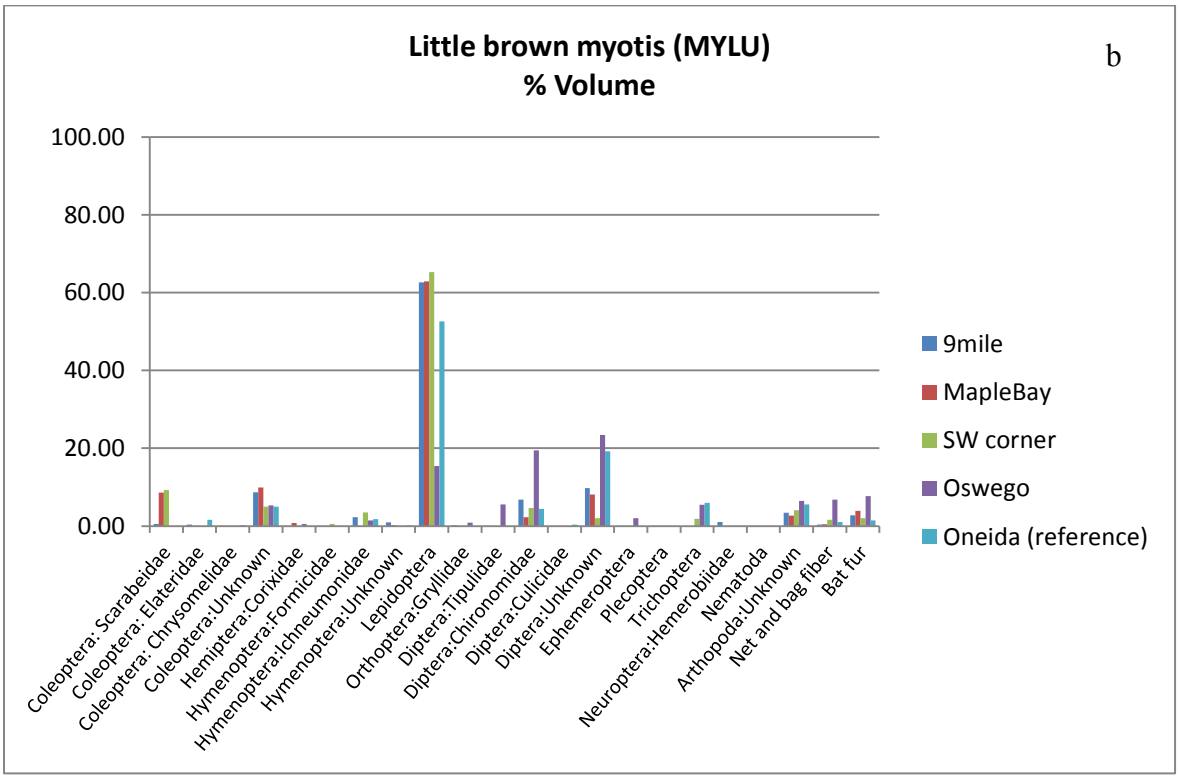




**Figure 1. Percent occurrence and percent volume of invertebrate prey in fecal pellets of MYLU.**

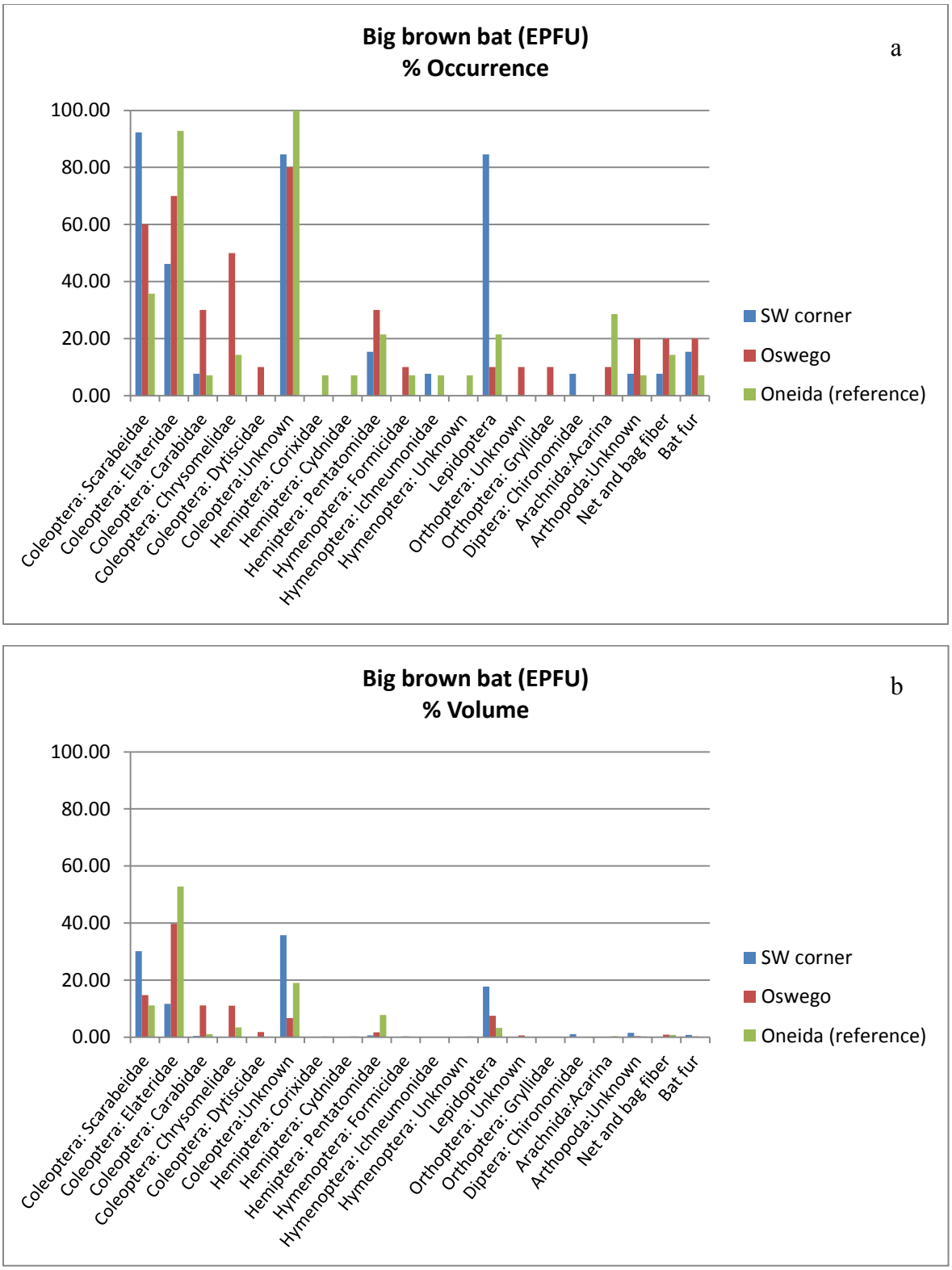



**Figure 2. Percent occurrence and percent volume of invertebrate prey in fecal pellets of EPFU.**

### 4.2c Other Species of Interest

Other bat species captured on Onondaga Lake for fecal analysis included MYSE, LABO, MYSO, and MYSU (Table 4). Sample sizes were low for these species (Table 4) but Lepidopteran prey represented large components of the diet for all of these bat species captured on Onondaga Lake. The percent volume of Lepidopteran remains in fecal pellets ranged from 38.7% of the volume in fecal remains of the Northern long-eared myotis (*Myotis septentrionalis*, MYSE) to 97% in the feces of the single juvenile *Lausurus borealis* (Eastern red bat, LABO) captured in the Southwest corner (Appendix 1). Lepidopterans occurred in 100% of the fecal remains of the Indiana bat (*Myotis sodalis*, MYSO) with an estimated volume of 56.8% (Appendix 1). MYSO also consumed a high concentration of beetles (Appendix 1).

## 4.3 Comparison of Invertebrate Hg Concentrations Between Sites

Invertebrates collected for Hg analysis at the Onondaga Lake sites (Beach, 9-Mile Creek Beach, SW Corner, Maple Bay) included individuals of the orders Aranaea (spiders), Diptera (flies), and Coleoptera (butterflies and moths). At the Oneida Lake reference site, only limited numbers of Dipterans and Coleopterans were collected. Dipterans from Oneida Lake were dominated by individuals from the family Muscidae (only 1 non-Muscidae sample), whereas Onondaga Lake samples included samples from eleven Dipteran families, with only one Muscidae sample. The only Coleopterans in common between the Onondaga and Oneida Sites were samples from the families Chrysomelidae and Curculionidae. Sample sizes are considered too limited for comparative purposes.

### 4.4 Comparison of Spider Hg concentrations at Onondaga Lake with other studies

Both Lycosid and Tetragnathid spiders have been the focus of recent contaminant studies linking spiders as a source of Hg to birds and other vertebrates (Cristol et al. 2008; Walters et al. 2010; Northam et al. 2011; Buck et al). Tetragnathid spiders collected from Lake George, NY, a lake in the Adirondacks region, were previously reported as having mean THg of 0.31 ppm (dw) (Buck et al. 2011). Tetragnathid spiders from Onondaga Lake have a mean THg concentration of 0.54 ± 0.16 ppm (dw). Sample size differences and non-normal distributions between the two sites prohibit the use of parametric statistics to compare the two sites. However, when compared using the non-parametric Mann-Whitney U-statistic, mean THg in Tetragnathids is higher at Onondaga Lake than at Lake George ($U = 22$; $p = 0.002$). Lycosid spiders from the previously mentioned study at Lake George have a mean THg concentration of 0.462 ppm (dw) (Buck et al. 2011). Total Hg concentrations in Lycosids from Onondaga Lake (mean THg = 1.34 ± 0.36 ppm (dw)) are significantly higher than at Lake George ($U = 7$; $p=0.015$). The THg concentrations in Lycosid spiders at Onondaga Lake are more comparable to those measured on Lycosids within the riparian zone of the South River (Virginia), a site impacted by a point source of mercuric sulfate. Lycosids at the South River had a mean THg concentration of 1.24 ppm (dw) (Cristol et al. 2008).

## 5.0 Summary

Spotted sandpipers on Onondaga Lake have high THg body burdens. Results from this food web study suggest that some invertebrates, including spiders, also contain high THg and MeHg concentrations and may represent a pathway for the bioaccumulation of Hg within the

sandpiper food web. The $\delta^{15}N$ values for spiders from this study are similar to or greater than the $\delta^{15}N$ values for SPSA, suggesting that spiders may not constitute a significant portion of the SPSA diet. A more intensive dietary study would be needed to clarify the relationship between SPSA blood Hg and Hg concentrations in their diet.

The diet of bats on Onondaga Lake is dominated by beetles (Coleoptera), moths (Lepidoptera), and flies (Diptera). During 2009, the little brown bat (*Myotis lucifugus*) was the most commonly caught bat on Onondaga Lake and its diet was dominated by moths, and to a lesser degree flies. Big brown bats (*Eptesicus fuscus*) on Onondaga Lake primarily consumed beetles. Of the invertebrate prey items sampled during this study, Dipterans were consistently higher in THg and MeHg than other insect orders. Although Lepidopterans were consistently present in the diet of bats on Onondaga, no site-specific data are currently available on mercury concentrations in these prey items.

Data were insufficient to compare Hg concentrations in invertebrates from Onondaga Lake and Oneida Lake. However, a comparison of Hg concentrations in spiders from Onondaga Lake with other studies indicates that Hg concentrations in these spiders are elevated above Hg concentrations in spiders from Lake George, New York and the South River, VA.

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**Appendix 1.** Percent occurrence and percent volume of prey items for each bat species from each site captured during the 2009 field season.

| | 9 Mile Creek | | | | Maple Bay | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MYLU | | MYSU | | MYLU | | MYSE | | MYSO | |
| | %Occ | %Vol | %Occ | %Vol | %Occ | %Vol | %Occ | %Vol | %Occ | %Vol |
| *Arthropoda* | | | | | | | | | | |
| *Arachnida: Acarina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Insecta* | | | | | | | | | | |
| *Coleoptera* | | | | | | | | | | |
| *Adenophaga: Carabidae* | 0 | 0 | 100 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Polyphaga* | | | | | | | | | | |
| *Chrysomelidae* | 4 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Curculionidae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Elateridae* | 4 | 0.36 | 0 | 0 | 0 | 0 | 62.5 | 16.1 | 11.1 | 1.1 |
| *Scarabeidae* | 8 | 0.56 | 0 | 0 | 30 | 8.6 | 25 | 5.1 | 22.2 | 9.2 |
| Unknown | 44 | 8.68 | 0 | 0 | 50 | 9.9 | 75 | 12.1 | 66.7 | 24.2 |
| *Diptera* | | | | | | | | | | |
| *Chironomidae* | 24 | 6.8 | 0 | 0 | 10 | 2.3 | 0 | 0 | 0 | 0 |
| *Unknown* | 60 | 9.76 | 0 | 0 | 10 | 8.1 | 12.5 | 0.5 | 0 | 0 |
| *Hemiptera: Heteroptera: Pentatomidae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Hymenoptera: Ichneumonidae* | 24 | 2.28 | 100 | 8 | 0 | 0 | 12.5 | 2.5 | 0 | 0 |
| *Lepidoptera: Unknown* | 100 | 62.6 | 100 | 72 | 100 | 62.9 | 100 | 55.9 | 100 | 56.8 |
| Unknown | 52 | 3.4 | 100 | 12 | 30 | 2.7 | 37.5 | 3.1 | 22.2 | 6 |
| Bat Fur | 48 | 2.76 | 100 | 1 | 60 | 3.9 | 25 | 3.3 | 11.1 | 0.1 |
| Net and Bag Fiber | 16 | 0.4 | 100 | 4 | 20 | 0.5 | 0 | 0 | 11.1 | 0.3 |
| Other | 1.8 | 0.1 | 0 | 0 | 1.3 | 0.1 | 0.8 | 0 | 0.7 | 0 |

Appendix 1, cont.

| | SouthWest Corner | | | | | | Oswego River | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MYLU | | EPFU | | LABO | | MYLU | | MYSE | | EPFU | |
| | %Occ | %Vol | %Occ | %Vol | %Occ | %Vol | %Occ | %Vol | %Occ | %Vol | %Occ | %Vol |
| *Arthropoda* | | | | | | | | | | | | |
| *Arachnida: Acarina* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33.3 | 0.3 | 10 | 0.1 |
| *Insecta* | | | | | | | | | | | | |
| *Coleoptera* | | | | | | | | | | | | |
| *Adenophaga: Carabidae* | 0 | 0 | 7.7 | 0.4 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 11.1 |
| *Polyphaga* | | | | | | | | | | | | |
| *Chrysomelidae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 11 |
| *Curculionidae* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33.3 | 26.7 | 0 | 0 |
| *Elateridae* | 0 | 0 | 46.2 | 11.7 | 0 | 0 | 0 | 0 | 0 | 0 | 70 | 39.7 |
| *Scarabeidae* | 23.1 | 9.2 | 92.3 | 30.2 | 100 | 1 | 0 | 0 | 33.3 | 15.3 | 60 | 14.7 |
| Unknown | 38.5 | 5 | 84.6 | 35.8 | 0 | 0 | 22.2 | 5.3 | 100 | 8.7 | 80 | 6.7 |
| *Diptera* | | | | | | | | | | | | |
| *Chironomidae* | 38.5 | 4.7 | 7.7 | 1.1 | 0 | 0 | 33.3 | 19.4 | 0 | 0 | 0 | 0 |
| *Unknown* | 30.8 | 2 | 0 | 0 | 0 | 0 | 44.4 | 23.4 | 0 | 0 | 0 | 0 |
| *Hemiptera: Heteroptera: Pentatomidae* | 0 | 0 | 15 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 1.7 |
| *Hymenoptera: Ichneumonidae* | 15.4 | 3.5 | 8 | 0 | 0 | 0 | 11.1 | 1.4 | 0 | 0 | 0 | 0 |
| *Lepidoptera: Unknown* | 100 | 65.2 | 85 | 18 | 100 | 97 | 55.6 | 15.4 | 66.7 | 38.7 | 10 | 7.5 |
| Unknown | 46.2 | 4.1 | 7.7 | 1.5 | 0 | 0 | 55.6 | 6.4 | 66.7 | 5.3 | 20 | 0.3 |
| Bat Fur | 53.8 | 2 | 15.4 | 0.8 | 100 | 2 | 88.9 | 7.7 | 33.3 | 0.7 | 20 | 0.2 |
| Net and Bag Fiber | 23.1 | 1.6 | 7.7 | 0.2 | 0 | 0 | 33.3 | 6.8 | 66.7 | 4.3 | 20 | 0.9 |
| Other | 1 | 0.1 | 0 | 0 | 0 | 0 | 3.5 | 0.9 | 0 | 0 | 2.5 | 0.2 |

Appendix 1, cont.

| | **Oneida Lake – Reference Site** | | | |
|---|---|---|---|---|
| | MYLU | | EPFU | |
| | %Occ | %Vol | %Occ | %Vol |
| *Arthropoda* | | | | |
| *Arachnida: Acarina* | 0 | 0 | 28.6 | 0.4 |
| *Insecta* | | | | |
| *Coleoptera* | | | | |
| *Adenophaga: Carabidae* | 0 | 0 | 7.1 | 1.1 |
| *Polyphaga* | | | | |
| *Chrysomelidae* | 6.3 | 0.2 | 14.3 | 3.4 |
| *Curculionidae* | 0 | 0 | 0 | 0 |
| *Elateridae* | 6.3 | 1.6 | 92.9 | 52.8 |
| *Scarabeidae* | 0 | 0 | 35.7 | 11.1 |
| Unknown | 50 | 5 | 100 | 19 |
| *Diptera* | | | | |
| *Chironomidae* | 25 | 4.4 | 0 | 0 |
| *Unknown* | 81.3 | 19.3 | 0 | 0 |
| *Hemiptera: Heteroptera: Pentatomidae* | 0 | 0 | 21.4 | 7.8 |
| *Hymenoptera: Ichneumonidae* | 12.5 | 1.8 | 7.1 | 0.1 |
| *Lepidoptera: Unknown* | 100 | 52.6 | 21.4 | 3.2 |
| Unknown | 68.8 | 5.6 | 7.1 | 0.2 |
| Bat Fur | 25.0 | 1.4 | 7.1 | 0.1 |
| Net and Bag Fiber | 37.5 | 1.1 | 14.3 | 0.8 |
| Other | 1.6 | 0.4 | 1.8 | 0.1 |

**APPENDIX 2:** Total Hg, MeHg, and stable isotope concentrations for invertebrate prey items sampled from Onondaga Lake.

| Lab ID | Territory | Order | Family | Notes | THg (mg/kg, dw) | MeHg (mg/kg, dw) | %MeHg | d13C, permil | d15N, permil | composited samples |
|---|---|---|---|---|---|---|---|---|---|---|
| **BIRD PREY ITEMS** | | | | | | | | | | |
| ONON-SP1 | beach | Aranaea | Lycosidae | | 1.709 | | | | | # 343, 351, 349, 341, 346 |
| ONON-SP2 | beach | Aranaea | Lycosidae | | 1.403 | | | | | # 347, 352, 350, 348, 342 |
| ONON-SP3 | beach | Aranaea | Lycosidae | | 1.735 | | | | | # 338, 335, 336 |
| ONON-SP4 | beach | Aranaea | Lycosidae | | 1.1 | 1.08 | 98.2 | -26.07 | 12.33 | # 333, 334, 339 |
| ONON-SP5 | beach | Aranaea | Lycosidae | | 1.385 | | | | | # 327, 332 |
| ONON-SP6 | beach | Aranaea | Lycosidae | | 0.756 | 0.674 | 89.2 | -25.67 | 12.18 | # 330, 344 |
| ONON-SP7 | beach | Aranaea | Lycosidae | | 1.901 | | | | | # 337, 340 |
| ONON-SP8 | beach | Aranaea | Lycosidae | | 1.233 | | | | | # 331 |
| ONON-SP9 | beach | Aranaea | Lycosidae | | 1.004 | | | | | # 328 |
| ONON-SP10 | beach | Aranaea | Lycosidae | | 1.18 | 0.766 | 64.9 | -25.85 | 12.54 | # 329 |
| ONON-SP11 | beach | Aranaea | Tetragnathidae | | 0.385 | 0.281 | 73.0 | -27.53 | 11.80 | # 95, 93, 82, 94, 67, 100 |
| ONON-SP12 | beach | Aranaea | Tetragnathidae | | 0.402 | | | | | # 96, 63, 77 |
| ONON-SP13 | beach | Aranaea | Tetragnathidae | | 0.519 | | | | | # 65, 92 |
| ONON-SP14 | beach | Aranaea | Tetragnathidae | Male | 0.436 | 0.322 | 73.9 | -27.51 | 11.49 | # 91, 64 |
| ONON-SP15 | beach | Aranaea | Tetragnathidae | Male | 0.679 | 0.6 | 88.4 | -28.78 | 11.80 | # 61 |
| ONON-SP16 | beach | Aranaea | Tetragnathidae | Male | 0.840 | | | | | # 66 |
| ONON-SP17 | beach | Aranaea | Tetragnathidae | Male | 0.546 | | | | | # 76 |
| ONON-IN1 | 9 mile beach | Diptera | Sepsidae | | 0.345 | | | | | # 274A, 275A, 278A |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ONON-IN2 | 9 mile beach | Diptera | Sepsidae | | 0.169 | | | | | # 279A, 280A |
| ONON-IN3 | 9 mile beach | Diptera | Sepsidae | | 0.190 | | | | | # 281A, 282A |
| ONON-IN4 | 9 mile beach | Diptera | Sphaeroceridae | 30 ind | 0.262 | | | | | # 274, 275, 276 |
| ONON-IN5 | 9 mile beach | Diptera | Sphaeroceridae | 30ind | 0.332 | 0.312 | 94.0 | -25.32 | 14.66 | #277, 278, 279 |
| ONON-IN6 | 9 mile beach | Diptera | Sphaeroceridae | 30ind | 0.284 | | | | | # 280, 281, 282 |
| ONON-IN7 | beach | Diptera | Muscidae | | 0.055 | 0.04 | 72.7 | -26.56 | 5.89 | # 68, 101 |
| ONON-IN8 | beach | Diptera | Sarcophagidae | | 0.117 | | | | | # 84 |
| ONON-IN9 | beach | Diptera | Scathophagidae | | 0.265 | | | | | # 83 |
| ONON-IN10 | beach | Diptera | Scathophagidae | | 0.153 | | | | | # 289, 291 |
| ONON-IN11 | beach | Diptera | Scathophagidae | | 0.098 | | | | | # 309 |
| ONON-IN12 | beach | Diptera | Scathophagidae | | 0.058 | 0.051 | 87.9 | -26.27 | 12.93 | # 307, 308, 304 |
| ONON-IN13 | beach | Diptera | Scathophagidae | | 0.308 | | | | | # 305, 306, 310, 311 |
| ONON-IN14 | beach | Diptera | Sepsidae | | 0.410 | | | | | # 439A, 440A |
| ONON-IN15 | beach | Diptera | Sphaeroceridae | 15 ind | 0.633 | | | | | # 439, 468 |
| ONON-IN16 | beach | Diptera | Sphaeroceridae | 40 ind | 0.317 | | | | | # 440, 469, 470, 471 |
| ONON-IN17 | beach | Diptera | Syrphidae | | 0.031 | 0.009 | 29.0 | -28.16 | 6.74 | # 85, 88 |
| **BAT PREY ITEMS** | | | | | | | | | | |
| ONON-IN18 | 9 mile creek | Diptera | Dolichopodidae | | 0.079 | | | | | # 219 |
| ONON-IN19 | 9 mile creek | Diptera | Dolichopodidae | | 0.183 | | | | | # 220, 221 |
| ONON-IN20 | 9 mile creek | Diptera | Dolichopodidae | | 0.143 | 0.16 | 89.4 | -24.33 | 13.89 | # 225, 228 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ONON-IN21 | 9 mile creek | Diptera | Sciomyzidae | 0.153 | 0.205 | 74.6 | -25.62 | 16.22 | # 218 |
| ONON-IN22 | 9 mile creek | Diptera | Tipulidae | 0.104 | | | | | # 223 |
| ONON-IN23 | oneida | Diptera | Dolichopodidae | 0.092 | | | | | # 408 |
| ONON-IN24 | oneida | Diptera | Muscidae | 0.063 | 0.068 | 92.6 | -26.62 | 8.61 | # 401 |
| ONON-IN25 | oneida | Diptera | Muscidae | 0.068 | | | | | #402 |
| ONON-IN26 | oneida | Diptera | Muscidae | 0.093 | | | | | #403, 404 |
| ONON-IN27 | oneida | Diptera | Muscidae | 0.094 | 0.081 | 86.2 | -26.22 | 8.02 | #405 |
| ONON-IN28 | oneida | Diptera | Muscidae | 0.126 | | | | | #407 |
| ONON-IN29 | oneida | Diptera | Muscidae | 0.033 | | | | | #406, 409 |
| ONON-IN30 | sw corner | Diptera | Chironomidae | 0.783 | 0.78 | 99.6 | -26.41 | 11.91 | #461, 467 |
| ONON-IN31 | sw corner | Diptera | Culicidae | 0.331 | | | | | # 127, 128, 130, 131, 133 |
| ONON-IN32 | sw corner | Diptera | Dolichopodidae | 0.500 | | | | | # 125, 126 |
| ONON-IN33 | sw corner | Diptera | Scathophagidae | 0.437 | | | | | #465, 466 |
| ONON-IN34 | sw corner | Diptera | Tipulidae | 0.611 | 0.026 | 4.3 | -25.73 | 6.93 | #129 |
| ONON-IN35 | wetzel road | Diptera | Dolichopodidae | 0.295 | | | | | #166 |
| ONON-IN36 | wetzel road | Diptera | Dolichopodidae | 0.407 | 0.31 | 76.2 | -24.73 | 11.04 | # 169, 175 |
| ONON-IN37 | wetzel road | Diptera | Dolichopodidae | 0.453 | | | | | #177, 179 |
| ONON-IN38 | wetzel road | Diptera | Sciomyzidae | 0.06 | 0.056 | 93.3 | -26.28 | 5.88 | # 168, 178 |
| ONON-IN39 | wetzel road | Diptera | Therevidae | 0.05 | 0.035 | 70.0 | -25.72 | 10.02 | #170 |
| ONON-IN40 | wetzel road | Diptera | Therevidae | 0.105 | | | | | # 176 |
| ONON-IN41 | maple bay | Coleoptera | Curculionidae | 0.003 | | | | | # 18 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ONON-IN42 | maple bay | Coleoptera | Curculionidae | 0.0048 | 0.0002 | 4.2 | -30.65 | 1.27 | #19 |
| ONON-IN43 | maple bay | Coleoptera | Curculionidae | 0.014 | | | | | #20 |
| ONON-IN44 | maple bay | Coleoptera | Curculionidae | 0.005 | | | | | #21 |
| ONON-IN45 | maple bay | Coleoptera | Curculionidae | 0.006 | | | | | #22 |
| ONON-IN46 | maple bay | Coleoptera | Curculionidae | 0.0043 | 0.0003 | 7.0 | -30.51 | 2.68 | #23 |
| ONON-IN47 | maple bay | Coleoptera | Elatridae | 0.014 | | | | | # 27 |
| ONON-IN48 | maple bay | Coleoptera | Scarabeidae | 0.060 | | | | | #58 |
| ONON-IN49 | maple bay | Coleoptera | Scaraberidae | 0.288 | 0.062 | 21.5 | -27.10 | 4.53 | #59 |
| ONON-IN50 | wetzel road | Coleoptera | Curculionidae | 0.007 | | | | | #199 |
| ONON-IN51 | wetzel road | Coleoptera | Carabidae | 0.075 | 0.053 | 70.7 | -25.51 | 7.86 | #201 |
| ONON-IN52 | wetzel road | Coleoptera | Curculionidae | 0.016 | | | | | #205 |
| ONON-IN53 | 9 mile creek | Coleoptera | Chrysomelidae | 0.050 | | | | | # 253 |
| ONON-IN54 | 9 mile creek | Coleoptera | Scarabeidae | 0.046 | | | | | #254 |
| ONON-IN55 | maple bay | Coleoptera | Scarabeidae | 0.346 | | | | | #256 |
| ONON-IN56 | maple bay | Coleoptera | Scarabeidae | 0.144 | | | | | #257 |
| ONON-IN57 | maple bay | Coleoptera | Scarabeidae | 0.025 | 0.0027 | 10.8 | -27.96 | 1.58 | #258 |
| ONON-IN58 | maple bay | Coleoptera | Scarabeidae | 0.220 | | | | | #259 |
| ONON-IN59 | oneida | coleoptera | Elatridae | 0.071 | | | | | #420 |
| ONON-IN60 | oneida | coleoptera | Curculionidae | 0.005 | | | | | #421 |
| ONON-IN61 | oneida | coleoptera | Chrysomelidae | 0.042 | | | | | #422 |
| ONON-IN62 | oneida | coleoptera | Chrysomelidae | 0.033 | | | | | #424 |
| ONON-IN63 | oneida | coleoptera | Chrysomelidae | 0.077 | | | | | #425 |
| ONON-IN64 | oneida | coleoptera | Chrysomelidae | 0.048 | 0.0111 | 22.9 | -27.27 | 4.47 | #428 |