High Park Urban Bat Project

Long-Term Monitoring Results

2014 - 2015

Analyses and report by Toby J. Thorne on behalf of High Park Nature Centre

Report Finalised 29 November 2015

Amended 3 December 2015 to add species appendix and clarify the distinction between big brown and silver-haired bats

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Summary:

In summer 2014 long-term monitoring of bats in High Park commenced as part of the Toronto Urban Bat Project. Automatic recorders were used to record bat vocalisations at two sites within the park. Recordings were subsequently analysed and species identifications assigned to bat passes where possible. For species with sufficient activity plots of seasonal activity were created.

A total of five species were confirmed in High Park: big brown, eastern red, hoary, silver-haired and tri-colored bats. All except tri-colored bats were consistently present throughout the season, indicating the park is a useful habitat for them. Patterns of activity by eastern red and silver-haired bats suggested that these species may pass through the park during late season migration. Tri-colored bats were recorded infrequently, indicating that they do not make regular use of the park, but are occasionally present. In addition, a small number of calls from bats in the genus *Myotis* were recorded, although activity was irregular.

Although the *Myotis* bats could not be definitively identified to species level, their presence, along with that of other species, means that almost the entire range of Ontarian bat diversity was represented in High Park during the study period. This indicates that in spite of its urban setting, the park is a useful habitat for bats in the region. The depth of information collected also indicates the value of long-term acoustic monitoring of bats, even at sites that might be expected to support lower bat diversity.

Cover picture: hoary bat (Lasiurus cinereus), © Brock Fenton 2015.

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1. Report Purpose:

In 2015 Toby J. Thorne was contracted to analyse bat recordings made as part of a long-term monitoring project in High Park, Toronto. This report summarises the results of this analysis in terms of species found to be present in the park and their seasonal activity. The report also contains basic interpretation of these data in the light of accepted knowledge about the ecology of the species involved.

This report is not an in-depth or robust scientific analysis. No specific hypotheses are tested, and no attempt is made to draw detailed conclusions.

2. Background:

The Toronto Urban Bat Project[1] (TUBP) commenced in 2014 as collaboration between the High Park Nature Centre and Dr. Brock Fenton of the University of Western Ontario. The project is supported by the Ministry of Natural Resources and Forestry through the Species at Risk Stewardship Fund[2]. The goals of TUBP are to support conservation and stewardship efforts for bats in High Park, and to engage and educate the general public. Alongside community engagement events, two automatic recorders were deployed to monitor bat activity throughout the 2014 and 2015.

Monitoring bat activity by listening to the ultrasonic (> 20 kHz) vocalisations produced by many species for echolocation (orienting using sound in addition to or in place of vision) is an established concept in the study of bats. In recent years, automatic recorders capable of monitoring bat activity over an extended period with minimal human intervention have become available. With regular maintenance, recorders can run indefinitely, allowing continuous recording of bat activity over weeks, months or even years. Long-term monitoring provides a comprehensive species inventory for bats using a site. Further, by allowing comparison of bat activity at different times, long-term monitoring with automatic recorders can provide additional information about bats' use of a site, inferred from patterns of activity. While promising, long-term monitoring of bats in this manner remains a rapidly developing field with multiple issues yet to be addressed.

1: http://www.highparknaturecentre.com/urban-bat-project/
2: http://www.ontario.ca/page/species-risk

3. Data Collection:

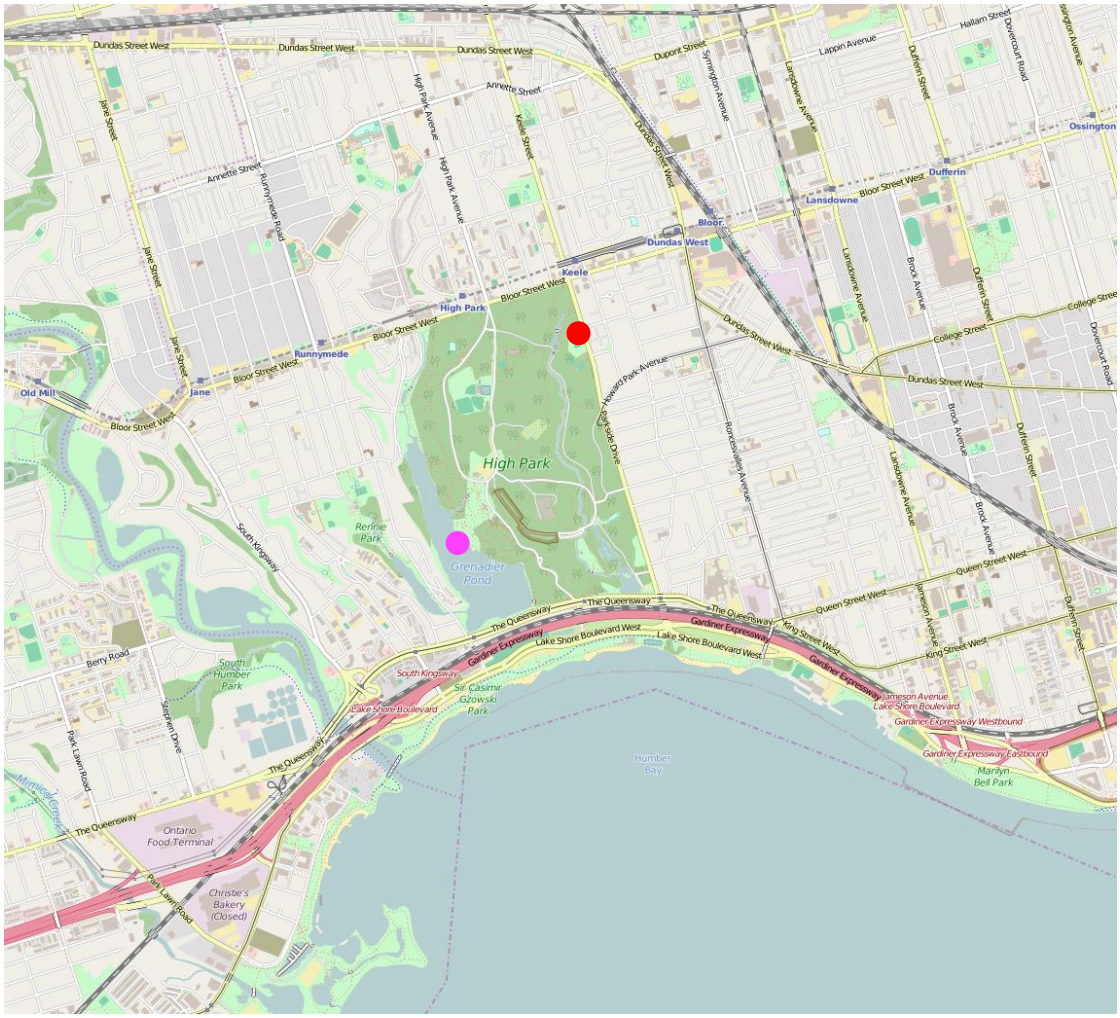
3.1. Recorder Locations:

High Park (Figure 1) is a municipal park in Toronto, located approximately 3 km west of the downtown core. The park has an area of 161 hectares with a variety of land covers, including oak savannah, lawns and gardens, recreational facilities and Grenadier Pond, a large water body (14.2 hectares). The park is surrounded by highly developed urban areas to the east, west and north. The south of the park is bordered by Gardiner expressway, which separates the park from the north shore of Lake Ontario. The Humber River passes approximately 500 m west of the park. Two recorders were deployed to monitor bats in the park for this project.

Recorder 1, referred to hereafter as 'HPNC' is mounted on the Nature Centre building close to the north-east corner of the park (Figure 1, N43.65099° W79.45914°). The microphone for HPNC is mounted on the north side of the Nature Centre building, oriented toward open space with interspersed trees. The microphone is connected via a cable to the body of the recorder, which is located securely inside the building.

Recorder 2, referred to hereafter as 'PUMP' is mounted on a pump building on the eastern shore of Grenadier Pond (Figure 1, N43.64276° W79.46731°). The microphone for PUMP is mounted on an antenna approximately 6 m above ground level, and 3 m above the building roof, oriented towards the pond. The body of the recorder is located securely inside the building, connected to the microphone via a cable. The recorder is surrounded by the pond to the west, and mowed grass with intermittent tress to the east.

Figure 1. Map showing the layout of High Park, and its immediate surroundings. HPNC recorder indicated by red dot, PUMP recorder indicated by magenta dot. ©OpenStreetMap Contributors.



3.2. Recording:

At each monitoring site, bat echolocation calls were recorded using a Song Meter SM2BAT (Wildlife Acoustics, U.S.A.). The recorders were programmed to be active from dusk until dawn, and to automatically record any potential bat sounds during this time, while attempting to filter out non-target noise. Recordings are saved to a SD memory card. Weekly inspections battery replacement and data downloads were undertaken by Nature Centre Staff.

The periods over which data covered by this report were collected are summarised in Table 1. Monitoring at HPNC began later in 2014 due to delayed installation of the recorder.

Table 1. Data collection periods.

Year	Recorder	Start Date	End Date
2014	HPNC	3 June	30 September
	PUMP	28 August	30 September
2015	HPNC	8 January	30 September
	PUMP	8 January	30 September

Throughout the monitoring periods both detectors functioned intermittently, with multiple gaps in data collection. General difficulties that degraded recorder uptime included premature battery failure, equipment faults and intermittent interference affecting the quality of recordings. Specific issues included a high degree of interference affecting the recorder at PUMP in May – June 2015. The interference created a high-level of false triggers and degraded the quality of recordings make it impossible to identify bats during this period. The cause of this interference is not known, and had resolved itself by the time the occurrence was discovered. In September 2015, the recorder at PUMP failed completely, and there was a gap in monitoring while it was replaced.

4. Data Analyses:

4.1. Species Identification:

Despite live filtering by the recorders, a proportion of non-bat sounds were still recorded, along with low quality calls unsuitable for species identification. Prior to further analysis, files were filtered using the Sonobat Batch Scrubber (version 5.4) set to exclude signals <20 kHz and the highest level of filtering to maximise the quality of calls taken forward for analysis.

Recordings were interpreted in terms of bat ‘passes’. A pass is defined as a continuous sequence of calls produced by an individual bat passing the microphone. Examining bat passes rather than individual calls is beneficial for species identification. A single call can be ambiguous, whereas a sequence of calls with shared characteristics provides a more robust identification. As the recorders were triggered by bat calls each file typically contains a single bat pass and was considered on this basis.

After filtering, the remaining files were reviewed using Sonobat (base, 4.0.5) and a species was assigned for the pass in each file where possible. Species

identifications were based on visual inspection and measurement of multiple parameters, including duration, frequency range, frequency of highest energy, and others. For some passes, it was not possible to assign a specific species and calls were instead assigned to categories containing multiple species:

- Big brown bats and silver-haired bats both produce a wide range of call types, and there is a considerable overlap between the ranges of each species. It is difficult to accurately assign species identifications for calls that fall into this range of overlap. Each species also produces calls outside of the range of overlap which can be confidently identified to species level. Calls for these two species were therefore assigned to one of three exclusive categories: 1) big brown bat, 2) silver-haired bat, 3) big brown or silver-haired bat (for calls in the overlap zone which could not be distinguished.
- Passes by these two species containing calls with parameters outside of the overlap were assigned to the relevant species.
- The maximum recording frequency of the recorders used in the project is 98 kHz. Some species in the genus *Myotis* echolocate at frequencies exceeding this limit. This limits the viability of identifying *Myotis* bats from recordings made from SM2BAT recorders. Therefore, no attempt was made to identify *Myotis* vocalisations beyond genus and all myotis passes were categorised as '*Myotis* Species'.
- If bat signals were present but could not be identified to species or any other category, for example due to overlapping noise, the pass was categorised as 'unidentified bat'.

4.2. Seasonal Activity Plots:

In order to visualise activity of bats in the park, the total number of passes for each species on each night was calculated and seasonal patterns in this activity was plotted. However, this was confounded by the intermittent functioning of the recorders, i.e. it was not always clear whether zero passes indicated no bats, or that the recorder was not functioning.

In order to address this concern, information on recorder activity was extracted from the recorders' sensor logs. While active, the recorder creates a text file to log the reading of its internal temperature sensor. As temperature data is only

recorded when the recorder is active, the sensor logs can be used to indicate when the recorder was active. However, several sensor logs were missing from the final data set. To address this, a conservative approach was taken: on nights when bats were recorded, or when no bats were recorded but sensor logs indicated the recorder was active, the recorder was considered active. When there was no confirmation that the recorder was active, the recorder was presumed to be inactive. When the recorder was active but no bats were recorded, activity was plotted as zero. When the recorder was inactive no activity was plotted.

5. Limitations of Acoustic Surveying:

The primary function of bat echolocation is the detection of objects in the individual's surroundings, in order to avoid or interact with them. Therefore, call parameters are determined by the need to usefully interact with a species' environment and target prey. This contrasts with other biological signals such as many bird or frog calls, where species recognition is a primary function. As a result of the function of echolocation for orientation, different bat species flying in the same environment or hunting similar prey may have very similar echolocation calls. Similarly, an individual of a single species may have considerably different calls when in different environments or undertaking different behaviours (e.g. hunting vs. commuting). There can often be more variation within a species than between multiple species.

All identifications in this report should be considered indications rather than definitive answers. However, for all species described as present in the park, multiple clear, high quality passes were recorded with calls typical of the species, allowing the highest confidence possible with acoustic identification. In all cases, but especially for species with larger overlaps, acoustic identifications are no substitute for physical identification of captured individuals.

6. Results:

6.1. Overview:

A total of 30 096 bat passes were identified throughout the data collection periods (Table 1), summarised in Table 2.

Table 2. Total monthly passes for each species or category at HPNC and PUMP.

Site	Year	Month	Big Brown Bat	Eastern Red Bat	Hoary Bat	*Myotis* Species	Silver-Haired Bat	Tri-Colored Bat	Big Brown or Silver Haired Bat[3]	Unidentified Bat
HPNC	2014	Aug	128	48	42	1	171	1	1718	125
		Sep	105	66	19	1	76	1	2308	137
PUMP		Jun	85	72	454	3	134	0	820	89
		Jul	104	185	363	3	74	0	579	62
		Aug	83	321	496	3	298	3	880	119
		Sep	3	64	54	2	45	0	172	38
HPNC	2015	Jan	2	0	0	0	0	0	6	0
		Feb	0	0	0	0	0	0	0	0
		Mar	1	0	0	0	0	0	16	0
		Apr	8	0	6	4	2	0	35	8
		May	47	11	21	0	55	0	619	64
		Jun	13	9	20	0	13	0	277	80
		Jul	67	44	289	1	277	0	3526	1448
		Aug	7	405	42	0	178	2	2260	1356
		Sep	0	257	20	0	91	1	877	441
PUMP		Jan	1	0	0	0	0	0	1	2
		Feb	0	0	0	0	0	0	0	0
		Mar	16	0	0	0	0	0	80	99
		Arp	1	0	1	0	0	0	28	34
		May	0	0	0	0	0	0	1	1985
		Jun	0	2	8	0	5	0	18	34
		Jul	44	67	169	1	60	1	917	1312
		Aug	63	199	159	7	358	2	1497	2410
		Sep	2	126	101	3	264	2	230	787
Species Total:			**780**	**1876**	**2264**	**29**	**2101**	**13**	**16865**	**10630**

[3] As described in section 4.1, there is a large overlap in the calls produced by big brown and silver-haired bats. Passes containing calls in this zone that could not be confidently identified to species were assigned to this joint category. This category is therefore distinct from the results for 'big brown' and 'silver-haired' bats, which contain passes that could be confidently identified to species level.

6.2. Unidentified Bats:

A total of 10630 (31% of all calls) passes were not identified beyond noting that they were bat vocalisations. The most common reasons that calls could not be identified include the presence of noise in the recording, from insects and unknown sources, or because passes only contained one or two ambiguous calls, from which a confident identification could not be derived.

6.3. Big Brown or Silver-Haired Bats:

As noted in section 4.1, there is a large overlap in the call repertoires of these two species and calls that fall in this overlap are difficult distinguish to a specific species. This category contains calls in the overlap zone, which could not be confidently assigned to a specific species, and is therefore distinct from the specific species categories below. This category accounted for the majority of passes recorder (49% of all calls). However, because it is not possible to know the proportion of each species represented in this category, nor to know whether the proportion is constant throughout the season, little can be learned from examining this category and no annual plot was created.

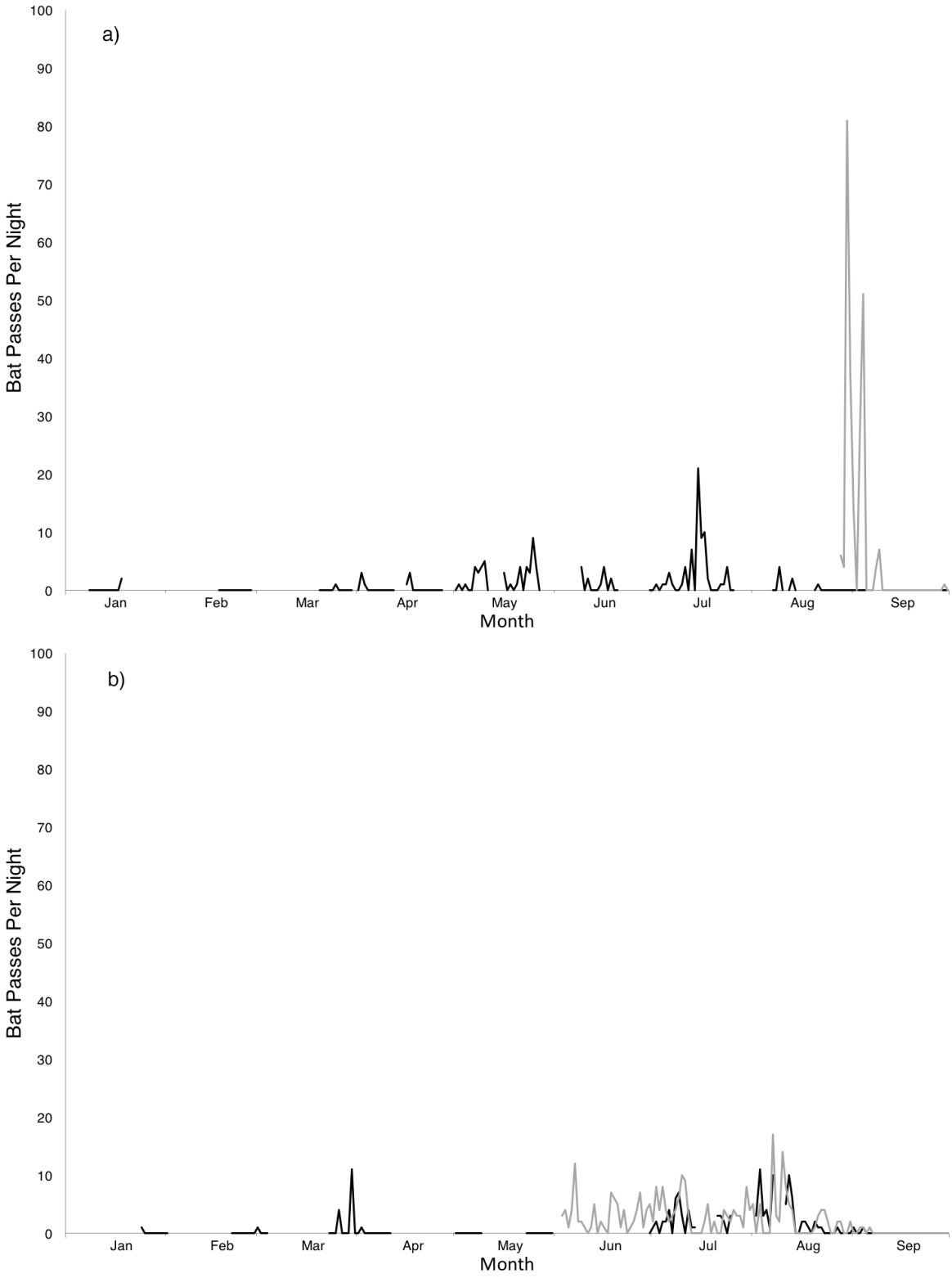
6.4. Big Brown Bat (*Eptesicus fuscus*):

Big brown bats are the second largest bat species in Ontario, and considered one of the most common. They are widely distributed across the province and are present in a wide range of habitats, including both rural and urban sites. Big brown bats typically forage in more open spaces and along edge habitat. This species roosts in tree cavities, as well as readily occupying human-made structures.

Big brown bats were present at both monitoring sites consistently throughout the monitoring periods, (Figure 2). Activity of big brown bats at both sites began around the beginning of April, and the bats were active until the end of September in both years, although activity at PUMP appeared to reduce in September relative to the summer. The presence of big brown bats throughout the summer suggests that High Park is useful habitat for this species, although without further information it is not possible to assess the importance of the park relative to the surrounding area. Frequent feeding buzzes by big brown bats were recorded, indicating that they were foraging in the park.

Notably, several big brown bat passes were recorded at both sites in late January, during the middle of winter. The timing of the passes, in mid-winter, suggests the bats were overwintering nearby. They may have left their winter roosts to drink and / or urinate and defecate, or due to disturbance. Big brown bats are thought to overwinter close to their summer foraging sites, and activity during January suggests that some individuals overwinter near to, or within, the park.

Figure 2. Seasonal activity patterns of big brown bats at: a) HPNC and b) PUMP during 2014, grey, and 2015, black. No line is plotted where the recorder was not active.



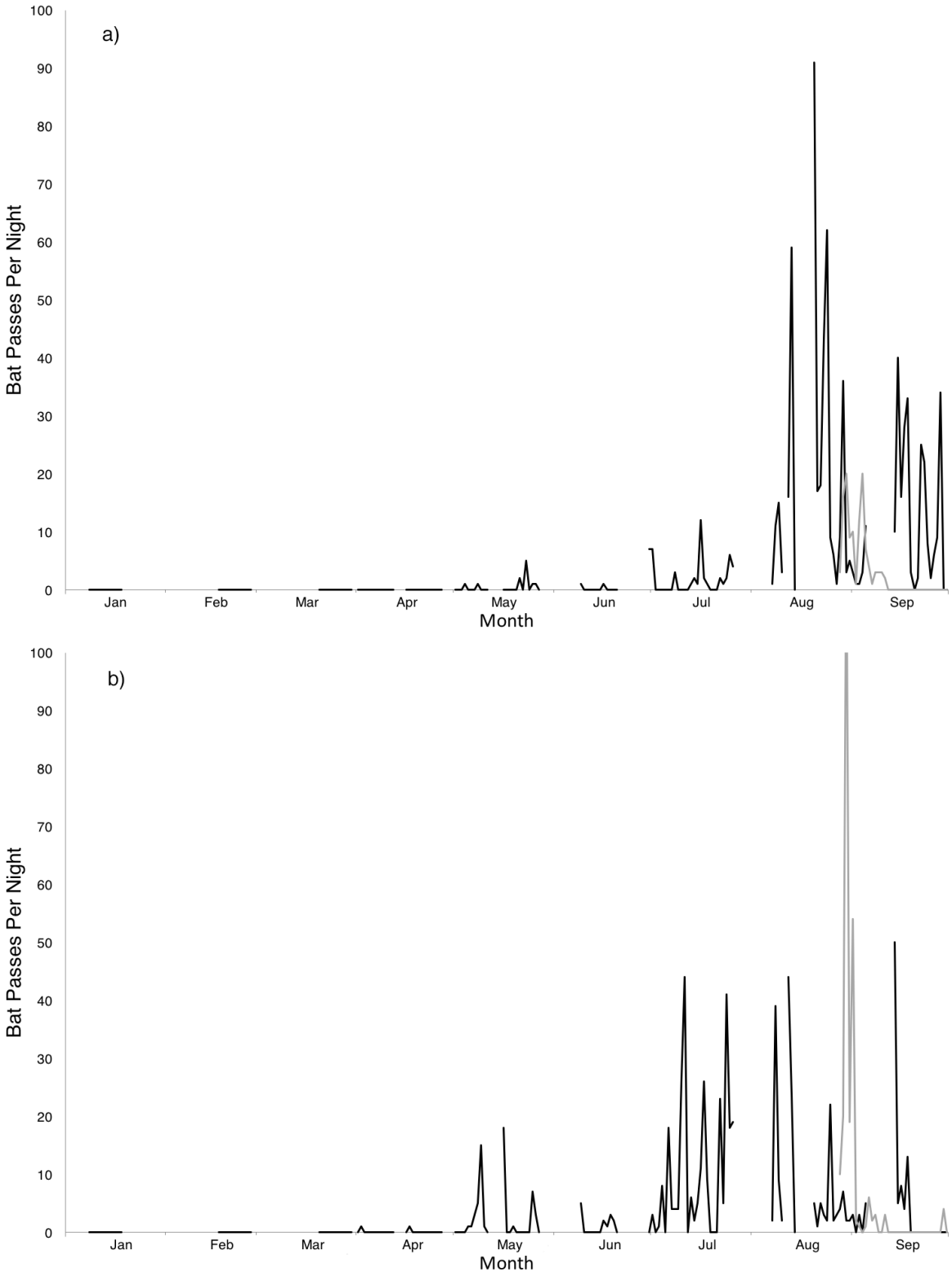
6.5. Eastern Red Bat (*Lasiurus borealis*):

Eastern red bats are a widespread species in Ontario. They are a largely solitary bat, roosting almost exclusively in trees where they hang freely among the foliage. Eastern red bats are considered a migratory species, and populations in Ontario are thought to travel south for the winter, although many details of this behaviour remain unknown.

Regular activity throughout May – July indicates some summer use of High Park by eastern red bats (Figure 3). This is of interest as eastern red bats are frequently described as ‘rural’ bats, less commonly encountered in urban settings. Although it is not possible to quantify the activity of this species in the park relative to rural sites, the level of activity observed does indicate that this species can make use of urban habitats.

Of further interest, the available data for both sites appears to indicate an increase in activity of this species during August and September, relative to earlier months. Although the cause of this increase in activity cannot be definitively determined, the timing is consistent with migratory behaviour. This could suggest that eastern red bats pass through High Park while travelling south prior to winter. Notably, no activity of this species was recorded in the spring, when individuals would be travelling north. Such activity may have been missed through intermittent recorder activity, or if bats followed a different route while travelling north. An alternative explanation for the increase in activity in the later part of the season is increased numbers as young of the year take flight, or as resident bats increase foraging to build energy reserves prior to migration.

Figure 3. Seasonal activity patterns of eastern red bats at: a) HPNC and b) PUMP during 2014, grey, and 2015, black. No line is plotted where the recorder was not active.

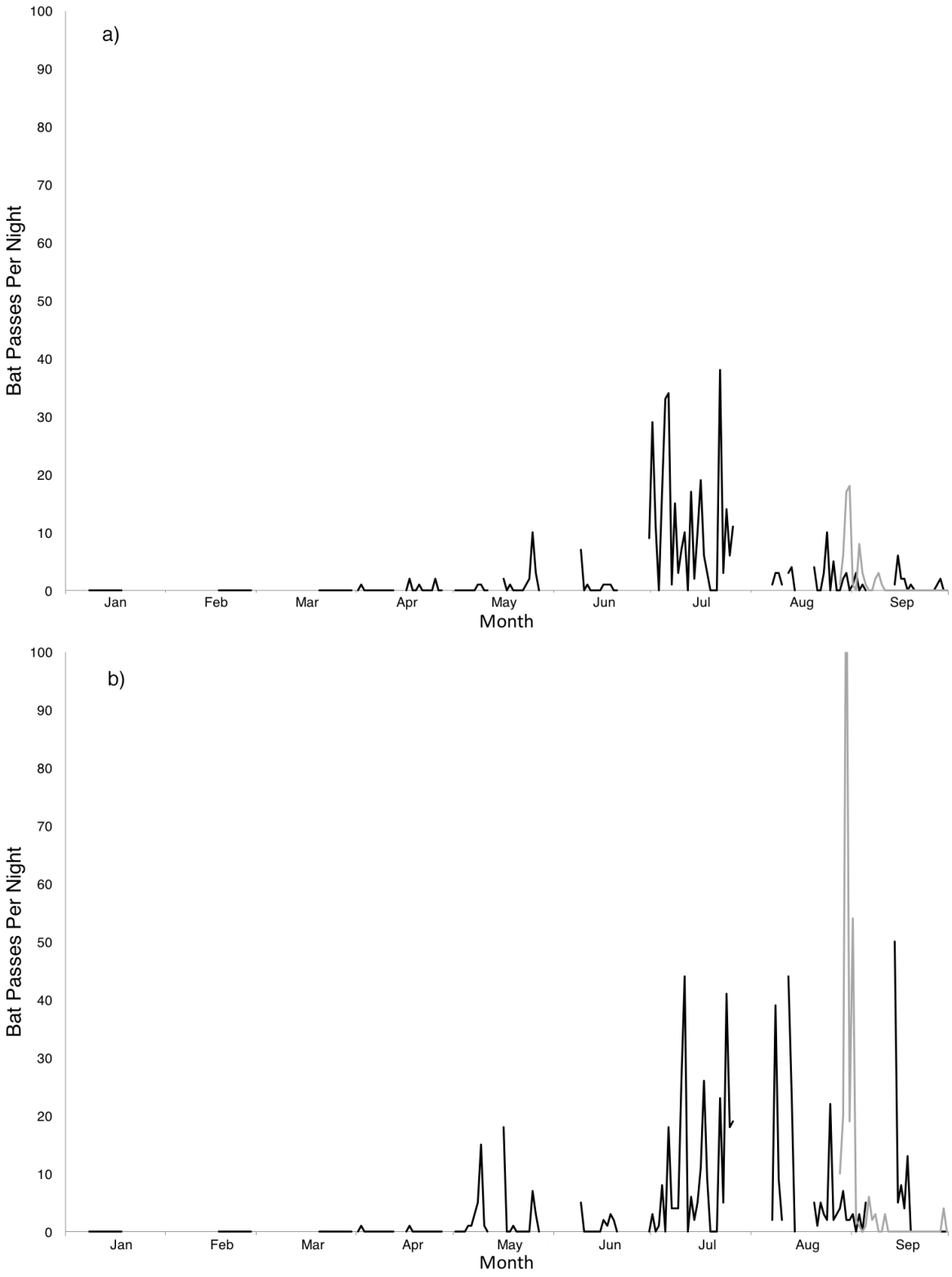


6.6. Hoary Bat (Lasiurus cinereus):

The hoary bat is the largest bat species in Ontario. It is a fast flier and forages in open spaces. Hoary bats roost almost exclusively in trees, resting on the bark and among the foliage, and are largely solitary. Hoary bats are widespread across North America, and are noted for their southward winter migrations, covering perhaps hundreds or thousands of kilometres, although the difficulty of studying this behaviour means many details are unknown.

The available data (Figure 4) indicates that hoary bats are present in High Park from mid-April onwards, with peak activity in July and August. Hoary bats were regularly observed at the PUMP recorder, with many feeding buzzes, which might reflect the more open environment. While hoary bats in Ontario are assumed to participate in winter migration, there was no pattern of activity in the park that correlates to this movement. There are multiple reasons why hoary bat migration might not have been recorded, such as them taking different routes or not flying within range of the detectors in the park, and it is not possible to accurately determine the reasons without greater understanding of this species in Ontario.

Figure 4. Seasonal activity patterns of hoary bats at: a) HPNC and b) PUMP during 2014, grey, and 2015, black. No line is plotted where the recorder was not active.



6.7. *Myotis* Species:

Myotis species were encountered at both sites at extremely low frequencies, and hence no activity plot was created. Activity through the monitoring periods was slightly higher at PUMP (22 passes) compared to HPNC (7 passes).

All three *Myotis* species in Ontario have recently been listed as Species at Risk by the provincial government. This is due to the decline in their populations caused by White Nose Syndrome (WNS). WNS is caused by a fungus that grows in the caves these bats overwinter in and infects bats during hibernation, causing typical mortality rates >95% per winter.

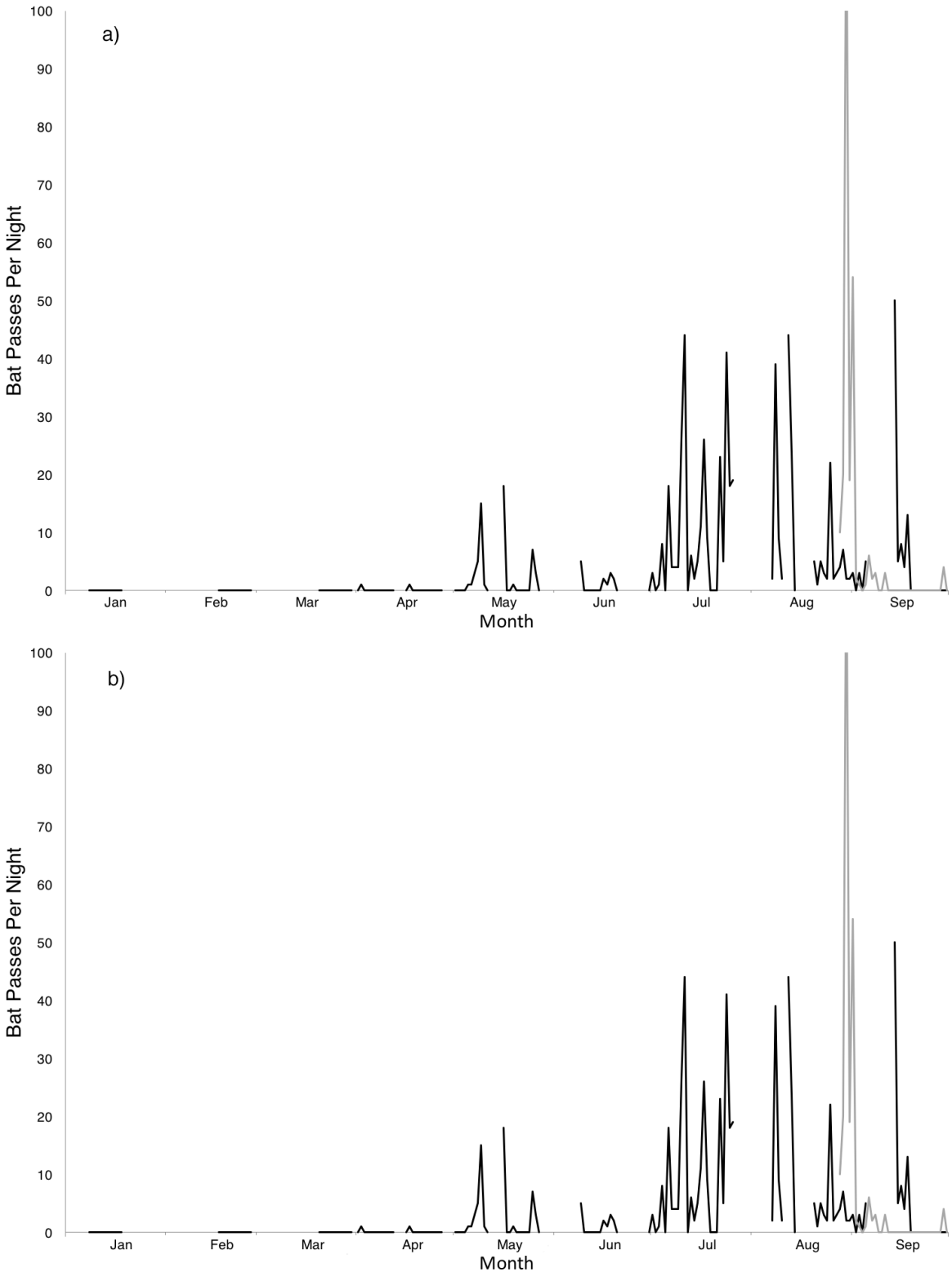
The low activity of *Myotis* species recorded may reflect population declines attributed to WNS. However, as there is no data on *Myotis* activity in High Park prior to the arrival of WNS in Ontario a trend cannot be established.

6.8. Silver-Haired Bat (Lasionycteris noctivagans):

Silver-haired bats are a solitary species, widespread across Ontario. They roost in tree cavities. This species is migratory, and individuals are believed to travel south for the winter. Silver-haired bats are thought to forage typically in sheltered areas and around water.

As illustrated in Figure 5, activity of silver-haired bats at PUMP was low in the early part of the year. Activity appeared regular but low through June and July, followed by an increase in August and September. Activity at HPNC occurred from May through September, but without an obvious seasonal change. The late season increase at PUMP could result from migratory activity by silver-haired bats. There were frequent feeding buzzes, continuing through August and September, suggesting that the bats were feeding in the park during this time. However, further investigation is required to establish whether the late-season acoustic activity reflects migration by this species.

Figure 5. Seasonal activity patterns of silver-haired bats at: a) HPNC and b) PUMP during 2014, grey, and 2015, black. No line is plotted where the recorder was not active.



6.9. Tri-Coloured Bat (*Perimyotis subflavus*):

Tri-colored bats are present across Ontario, but are less frequently encountered than many other species. As with many bat species in Ontario, many aspects of their ecology are poorly understood. A small number of distinct calls were recorded during the monitoring periods, however numbers were very low (HPNC: 5, PUMP: 8) and no activity plot was created. This suggests that tri-colored bats do pass High Park on an infrequent basis, but are likely not resident in the area.

7. General Conclusions:

7.1. Bats in High Park:

The presence of activity and feeding buzzes throughout the season suggests that big brown, eastern red, hoary and silver-haired bats are all resident in High Park. With the inclusion of infrequent calls by tri-colored bats and *Myotis* species, although the latter could not be identified beyond genus, the data collected indicate that almost all species of bats present in Ontario are present in the park. This is impressive considering the location of the park is close to a dense urban centre, and is illustrative of the high level of bat diversity that can be found even in urban areas.

7.2. Monitoring

Extended monitoring of bats across two seasons, using automated recorders, provided considerable insight into bat activity in the park. However, attempting to survey on such a scale also raised multiple issues, indicative of the difficulties with this emerging method of data collection. In particular, the intermittent functioning of the recorders, due to a variety of factors, created difficulties for the interpretation of seasonal patterns. Ideally this would be addressed by increased reliability and logging of activity. Although the recorders produce a file that can be used to interpret their activity (e.g. on vs. off) this is not the primary purpose of the file, and the data is difficult to interpret.

8. Appendix – Example Spectrograms for Species Encountered:

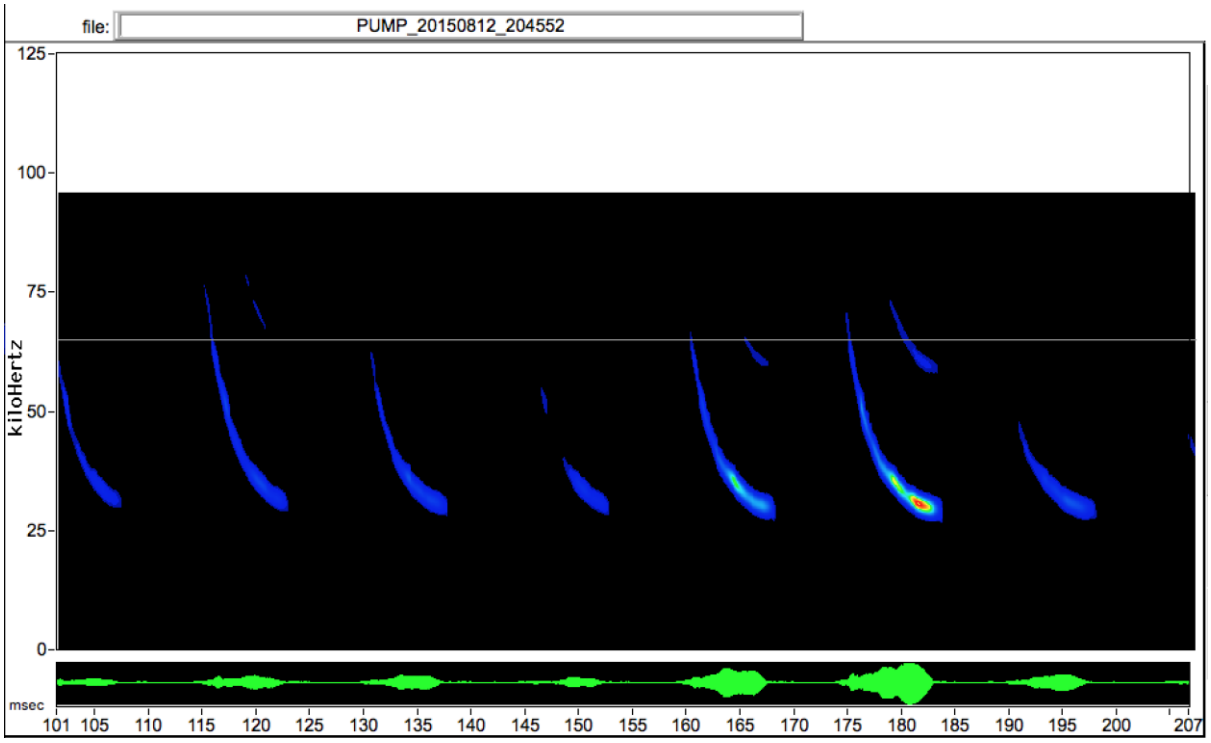
8.1. Notes on Species Identification:

Species identifications were based on high quality search phase echolocation calls, low quality calls were rejected and categorised as ‘unidentified bat’.

Identifications were based on measurements from the document ‘Echolocation Call Characteristics of Eastern US Bats’, compiled by J.M. Szewczak of Humboldt State University Bat Lab, March 2011, measurements of call characteristics of the bats of Ontario provided by Amanda Adams and on the reviewer’s own experience.

Please note that in the following spectrograms the interval between calls has been compressed to make calls easier to view.

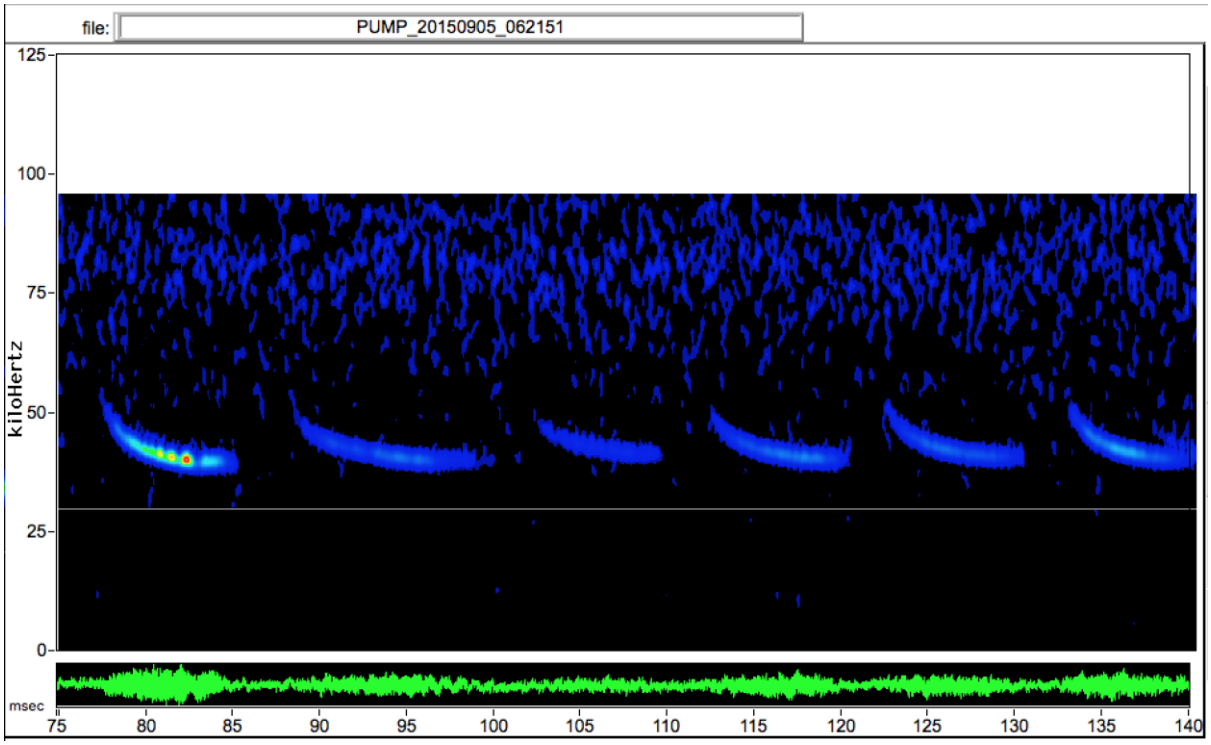
8.2. Big Brown Bat (*Eptesicus fuscus*):



Spectrogram of representative big brown bat search phase echolocation call. A smooth frequency sweep beginning > 65 kHz (indicated by horizontal line) ending at ~ 30 kHz.

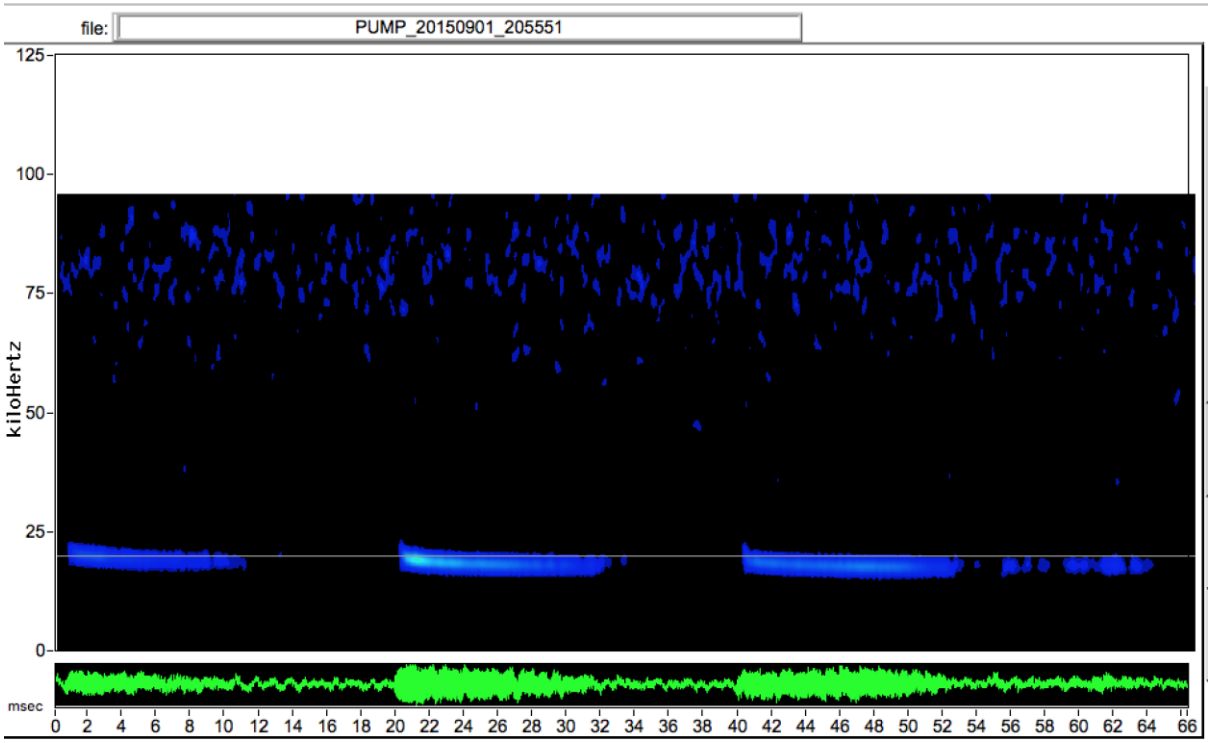
Note that silver-haired bats can produce similar calls, in addition to their narrowband calls described below. However, the frequency sweeps of silver-haired bats do not typically begin above 65 kHz, allowing some distinction.

8.3. Eastern Red Bat (*Lasiurus borealis*):



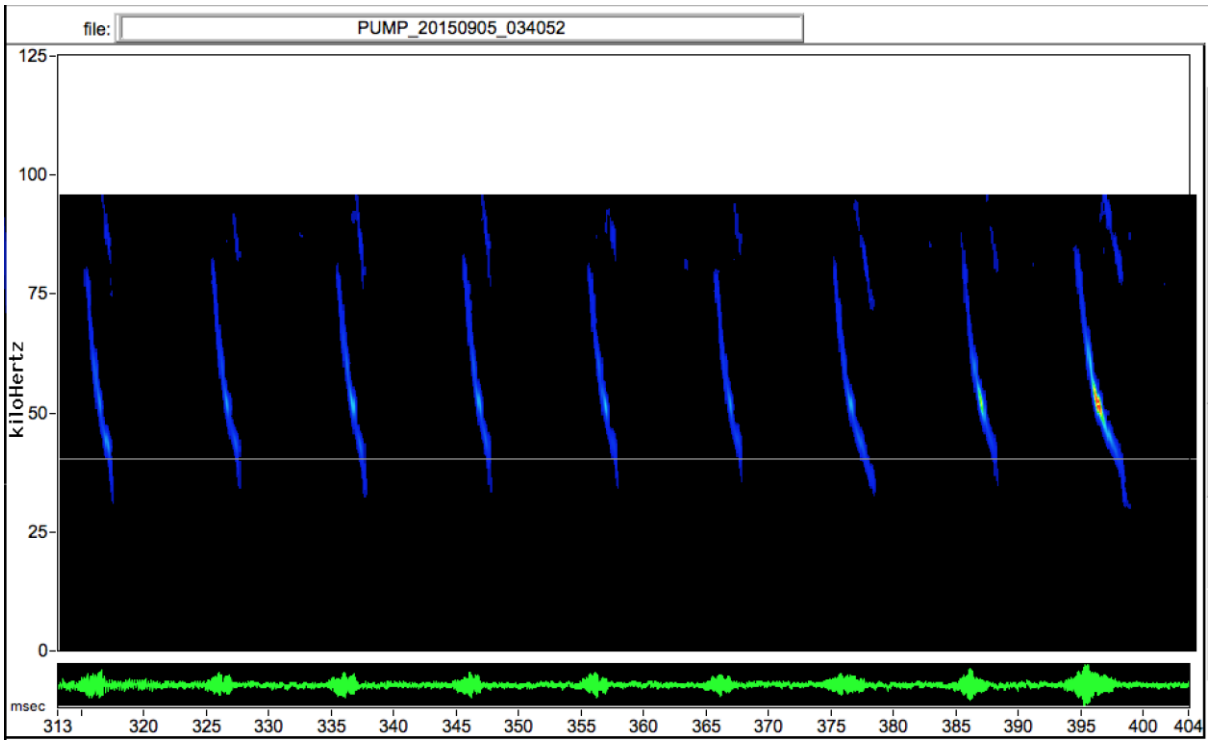
Spectrogram of representative eastern red bat search phase echolocation call. A short, smoothly curved (even U shaped) frequency sweep between ~ 60 kHz and ~ 35 kHz.

8.4. Hoary Bat (Lasiurus cinereus):



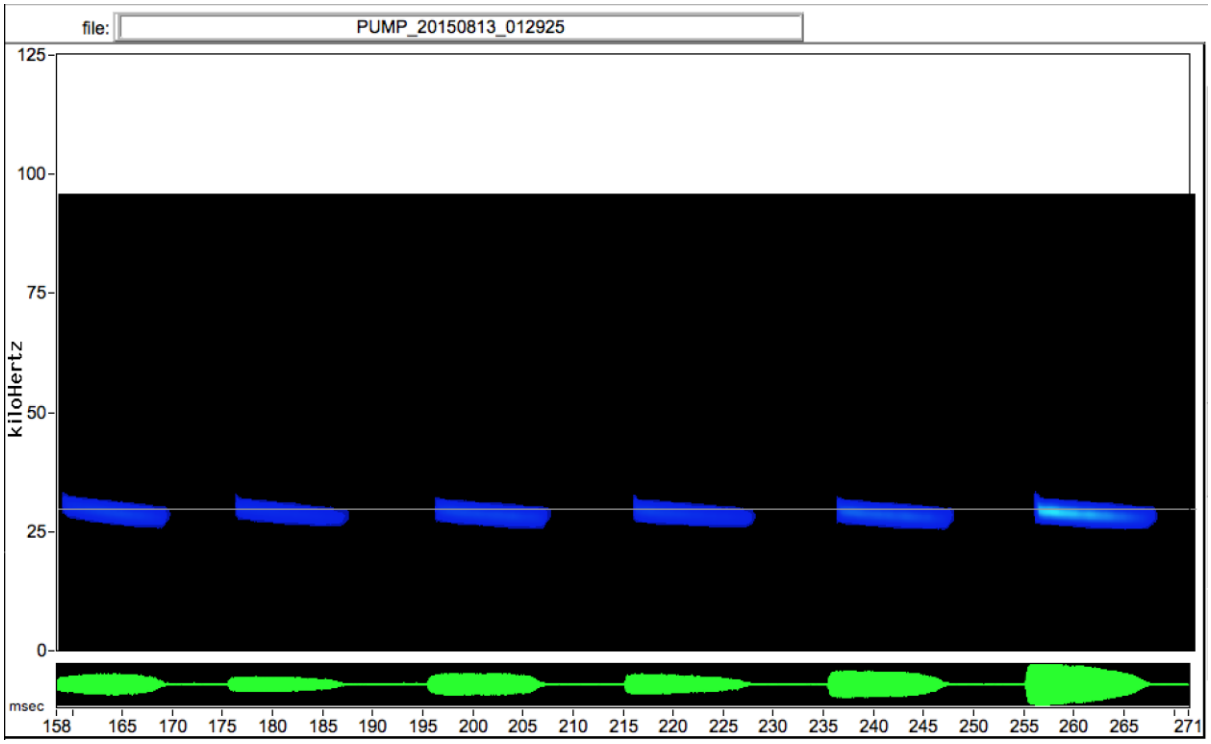
Spectrogram of representative hoary bat search phase echolocation call. A long (> 10 ms) narrowband call at ~ 20 kHz.

8.5. *Myotis* Species:



Spectrogram of representative Myotis species search phase echolocation call. A short (in this case 2-3 ms, can be above 7 ms) frequency sweep from 80-100 kHz to ~ 40 kHz depending on species. Often a relatively straight sweep, often with strong inflection (a distinct change in slope angle). Most notable feature is the downwards sloping tail at the end of the call.

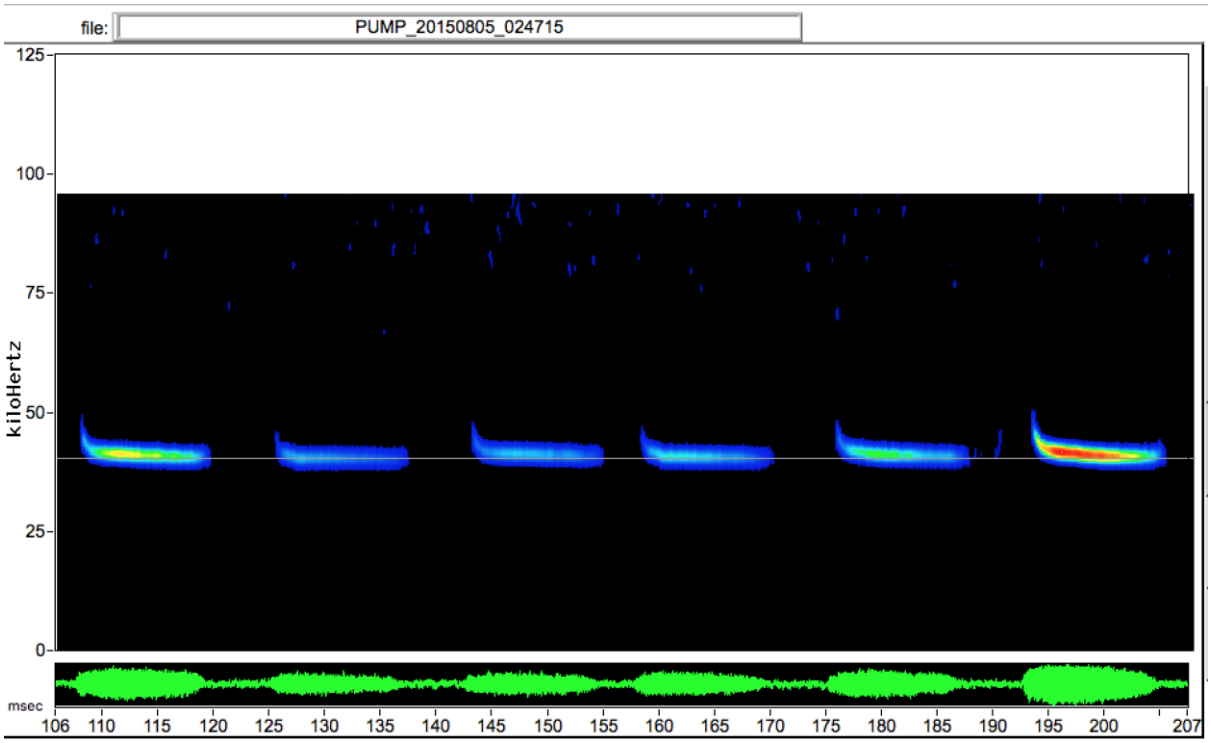
8.6. Silver-Haired Bat (Lasionycteris noctivagans):



Spectrogram of representative silver-haired bat search phase echolocation call. A narrowband call around 30 kHz with no inflection (distinct change in angle partway through the call).

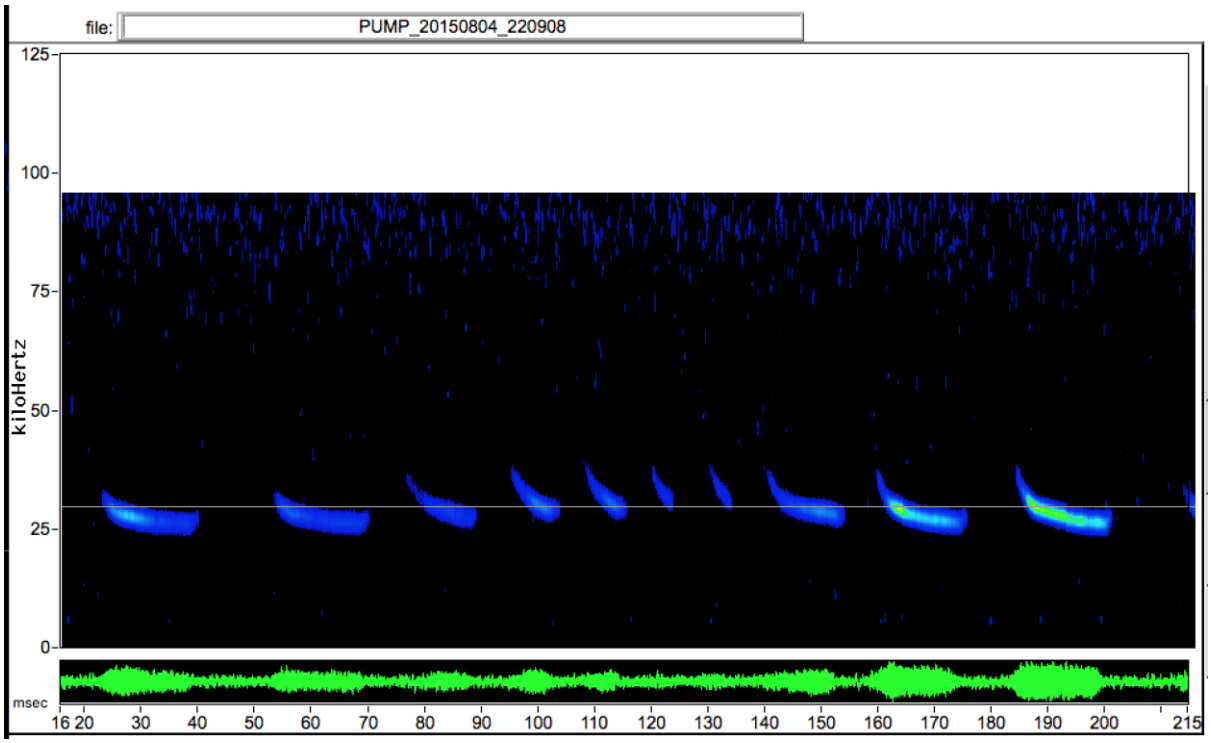
Note that silver-haired bats also produce calls with a larger frequency sweep. These calls overlap with some calls by big brown bats, confounding the identification of these two species. Narrowband calls with no inflection, such as this example, provide a more reliable distinction from big brown bats.

8.7. Tri-Colored Bat (Perimyotis subflavus):



Spectrogram of representative tri-colored bat search phase echolocation call. A very short frequency sweep leading into a large narrowband component > 40 kHz.

8.8. Feeding Buzz:



Search phase echolocation calls and a feeding buzz by a big brown or silver-haired bat (this call falls into the overlap zone of calls by these two species). The feeding buzz is characterised by a sequence of calls with decreasing length and call intervals, and a slight increase in frequency.