

# **ESTIMATING LITTLE BROWN BAT (*MYOTIS LUCIFUGUS*) COLONY SIZE IN SOUTHERN YUKON: A MARK- RECAPTURE APPROACH**

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## Summary

Bats are a little-known, but important component of Yukon's biodiversity. The little brown bat is currently assessed as *Endangered* by COSEWIC (Committee on the Status of Endangered Wildlife in Canada). The main threat to these bats is the alien and invasive disease white nose syndrome, which is responsible for the collapse of populations in northeastern North America. In addition, bats are considered important indicators of ecosystem health and they may respond markedly to changes to the climate and landscape. As such, monitoring Yukon populations of bats is of management interest. Monitoring bat populations, however, is challenging. In an effort to provide a rigorous approach to estimating bat colony sizes in order to monitor their trends, I explored the use of a mark-recapture approach.

Two colonies were studied: the Squanga/Salmo and Little Atlin Lake colonies. Bats were captured at the colonies on 3-4 occasions, and marked with wing bands. Mark-recapture models were fit to the data using Program Density 4.4.

## Key Findings

- At the Squanga/Salmo colony we captured 517 individual bats 705 times during 4 capture sessions. At Little Atlin Lake colony we captured 518 individual bats 568 times during 3 capture sessions.
- The best supported model produced a population estimate of  $874.4 \pm 44.4$  (95% C.I. = 797.4 – 972.5) adult female bats for the Squanga/Salmo colony and  $2,085.7 \pm 259.2$  (95% C.I. = 1,654.2 – 2,681.1) for the Little Atlin Lake colony.
- Apparently, this study provides the first mark-recapture based population estimates for summer colonies of little brown bats. I demonstrate that mark-recapture methodology can provide a statistically robust framework for enumerating summer maternity colonies of little brown bats, with associated measures of error and confidence intervals.
- This study provides an important baseline for these colonies from which future change can be measured. Application of mark-recapture methodology may aid in monitoring bat populations and track changes that may be associated with climate warming or emerging diseases such as white nose syndrome.

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## Introduction

Bats are a little-known, but important component of Yukon's biodiversity. Two species are confirmed in Yukon: the little brown bat (*Myotis lucifugus*) and the northern long-eared bat (*Myotis septentrionalis*; Jung et al. 2006). The little brown bat is widespread through southern Yukon, north to Dawson City, where it is sporadic (Slough and Jung 2008). The northern long-eared bat was only recently noted in southeastern Yukon, likely being restricted to the Liard drainage (Lausen et al. 2008). Other species most likely occur in Yukon (Slough and Jung 2007), but have yet to be confirmed.

Both the little brown bat and the northern long-eared bat are currently assessed as *endangered* by COSEWIC (Committee on the Status of Endangered Wildlife in Canada). The main threat to these bats is the alien and invasive disease white nose syndrome, which is responsible for the collapse of populations and the loss of an estimated 5.5 to 6.5 million little brown bats in northeastern North America (Frick et al. 2010a, Foley et al. 2011). White nose syndrome is not yet known from western Canada, but it is anticipated to move westward at an alarming rate. In addition, bats are considered important indicators of ecosystem health (Jones et al. 2009) and they may respond markedly to changes to the climate and landscape (Crampton and Barclay 1998, Jung et al. 1999, Humphries et al. 2002, Patriquin and Barclay 2003).

As such, monitoring Yukon populations of bats is of management interest.

Monitoring bat populations is challenging, given that they are small-bodied, nocturnal, and volant (able to fly). They are most easily monitored directly at their winter hibernation (e.g. caves or mines) or summer roost sites (e.g. buildings or dead tree hollows). In Yukon, we are not aware of any winter hibernacula (Slough and Jung 2008), so monitoring must necessarily occur at summer maternity roost sites. Typically, the size of summer maternity colonies are estimated through the use of emergence counts, which may vary in their accuracy and often do not provide the ability to estimate confidence intervals around the estimate. In essence, these are so-called total counts, even though many bats are likely not counted.

In an effort to provide a rigorous approach to estimating bat colony sizes in order to monitor their trends, I explored the use of a mark-recapture approach. Mark-recapture approaches have been used somewhat regularly to monitor survival and longevity of bats (e.g. Ellison 2010, Frick et al. 2010b, Papadatou et al. 2011), but only rarely to estimate population size. For example, Gaisler and Chytil (2002) used this approach to explore trends in cave-dwelling bats in the Czech Republic.

Here, I conducted a pilot study to assess the feasibility of a mark-recapture approach to develop statistical rigorous population estimates and associated confidence intervals for summer maternity colonies of little brown bats in southern Yukon.

## Methods

### *Study Colonies*

Two summer breeding colonies of little brown bats were selected to test mark-recapture methodology as applied to estimating colony size in bats. These colonies were selected based on ease of access and because they were believed to contain a relatively large number of bats (Figure 1).

One colony was located near Squanga Lake and had been annually monitored by Environment Yukon since 2004. This colony used 2 bat houses established adjacent to Salmo Lake, as well as a bat house and picnic shelter at the Yukon government campground at Squanga Lake. At this time, it is unclear if these 2 colonies are functionally separate colonies or a single colony that uses the various available roost-sites. For the purpose of this pilot study I treated them as a single, closed population, given that our banding records indicate substantial movement between the roost-sites within and between years (Slough and Jung, unpublished data). Subsequent analyses may do differently.

It is likely that other roost-sites were used in the area as well, but these have yet to be identified.

The second colony was located at Little Atlin Lake, and lived in a shed on private property. This colony likely also used another roost-site in the area, but none were identified. The Little Atlin Lake colony had been previously monitored by Environment Yukon in 2007 and 2010.

### *Mark-Recapture Sessions*

Multiple mark-recapture sessions were conducted at each colony during summer 2012. Capture sessions were timed so as to minimize the chance of capturing transient bats that were simply migrating through in late spring or before pups were born. I attempted to sample the colonies at a time when they best approximated a closed population to avoid violating assumptions of closure in our population modeling. Because adult males spatially segregate to roost (Fenton and Barclay 1980, Broders and Forbes 2004), and sampling occurred before pups were born, population estimates are solely for the adult female segment.

Bats were captured in harp traps (Tuttle 1974, Figure 2) shortly before and after sunset during their nightly emergence from their diurnal roost. A sheet of thick plastic was used to block the escape route of bats on the opposite side of the harp trap.

Captured bats were weighed ( $\pm 0.1$  g) using a digital scale and forearm measurements were taken with digital calipers ( $\pm 0.1$  mm).

Each captured bat was banded with a lipped alloy band (Porzana Ltd., Icklesham, East Sussex, UK) that was individually numbered (e.g. YT 1356) for later identification (Figure 3).



**Figure 1.** A near-full bat house at Squanga Lake, Yukon.



**Figure 2.** A harp trap set to a bat house at Squanga Lake, Yukon.



**Figure 3.** A wildlife technician applying a band to a bat at Little Atlin Lake, Yukon.

### ***Population Modeling***

I selected 4 different population models and fit these to the encounter history data. The first 3 models were from Otis et al. (1978), and included a null model,  $M(o)$ , a model that incorporated time,  $M(t)$ , and another that took into account individual behaviour,  $M(b)$ . In addition, I also fitted the Huggins model (Huggins 1989, 1991) for closed populations to the data, however I did not model any covariates. For this report, I chose to use only models that were based on maximum likelihood estimation (MLE) so that  $AIC_c$  values could be calculated. I used  $AIC$  model selection to rank the resulting models. All models were fit using Program DENSITY 4.4 (Efford et al. 2004).

### **Results**

#### ***Squanga/Salmo Colony***

At Squanga Lake, we captured 517 individual bats 705 times during the 4 capture sessions (Table 1). Most of the models (3 of 4) provided very similar results (Table 2).  $AIC$  model selection suggested that the Huggins model provided the most supported population estimate, which was  $874.4 \pm 44.4$  (95% C.I. = 797.4 – 972.5) adult female bats. The Zippin model provided substantially higher population estimate than the others (Table 2), and was the second best ranked model. Capture probability was moderate, and estimated at about 59% for most of the models (Table 2).

### **Little Atlin Lake Colony**

For Little Atlin Lake, 518 individuals were captured 568 times during 3 capture sessions (Table 1). Again, 3 of the 4 models provided very similar results and the Huggins model had the most support (Table 2). The Huggins model estimated the adult female population size at

$2085.7 \pm 259.2$  (95% C.I. = 1654.2 – 2681.1). Contrary to the results for the Squanga/Salmo colony, the Zippin model produced a population estimate that was substantially lower than the others. Capture probability was about 10%, substantially lower than at the Squanga/Salmo colony (Table 2).

**Table 1.** Summary of captures of little brown bats from 2 maternity colonies in southern Yukon, 2012.

<b>Capture Session</b>	<b>Total Number of Bats Captured</b>	<b>Number of Marked Bats Recaptured</b>	<b>Number of Unmarked Bats Captured</b>
<i>Salmo/Squanga Lake Colony</i>			
Session 1	159	73	86
Session 2	168	111	57
Session 3	177	177	70
Session 4	201	138	63
<i>Little Atlin Lake Colony</i>			
Session 1	196	15	181
Session 2	207	28	179
Session 3	169	51	118

**Table 2.** 2012 Population estimation models for adult female little brown bats at the Squanga/Salmo Lake and Little Atlin lake colonies, south-central Yukon. All candidate models are for closed populations. Rank indicates the population estimate model with the most support.

Model	Population Estimate $\pm$ SE	95% CI	Capture Probability	Log Likelihood	K	AICc	$\Delta$ AICc	Rank
<i>Salmo/Squanga Lake Colony</i>								
M(0) Null	873.0 $\pm$ 44.2	794.2 – 969.1	0.5919	-1164.412	2	2332.9	9.3	4
M(t) Darroch	871.0 $\pm$ 44.1	792.6 – 966.7	0.5929	-1160.995	5	2332.1	8.5	3
M(b) Zippin	1339.0 $\pm$ 340.5	932.9 – 3171.9	0.4294	-1160.511	3	2327.0	3.4	2
Huggins	874.4 $\pm$ 44.4	797.4 – 972.5	0.5913	-1160.817	1	2323.6	--	1
<i>Little Atlin Lake Colony</i>								
M(0) Null	2080.0 $\pm$ 258.7	1654.5 – 2698.7	0.0910	-739.049	2	1482.1	9.8	4
M(t) Darroch	2072.0 $\pm$ 257.5	1647.8 – 2686.7	0.0914	-736.247	4	1480.6	8.3	3
M(b) Zippin	1125.0 $\pm$ 218.3	844.0 – 2015.6	0.1858	-736.861	3	1479.8	7.5	2
Huggins	2085.7 $\pm$ 259.2	1654.2 – 2681.1	0.0908	-735.148	1	1472.3	--	1

## Discussion

To the best of my knowledge, this study provides the first mark-recapture based population estimates for summer colonies of little brown bats. Although this work is of a pilot study nature, I demonstrate that mark-recapture methodology can provide a statistically robust framework for enumerating summer maternity colonies of little brown bats, with associated measures of error and confidence intervals. Similar results were reported from a study in France, where researchers used DNA from fecal pellets, rather than banded bats, to mark and recapture a segment of the population (Puechmaille and Petit 2007).

These data provide an important baseline for these colonies from which future change can be measured. Application of mark-recapture methodology in the periodic inventory of bat populations will aid in monitoring populations and track changes that may be associated with climate warming or emerging diseases such as white nose syndrome.

It is important to note that the population models developed for this report are of a preliminary nature. There remain several other important models that may provide more suitable estimates (e.g. Chao and Huggins 2005) and they should be explored using more comprehensive software such as Program MARK.

My choice of using closed population models rested on the assumption that the population was indeed closed. This is premised on the basis that bats are long-lived with high annual survival rates (Frick et al. 2010*b*), high annual fidelity to foraging areas (Humphrey and Cope 1976; Slough and Jung, unpublished data), and that we sampled prior to births occurring. The population unit was the colony, which I defined as bats that shared a common foraging area, not the roost-site. Because within-year roost-switching is common in many bat species (e.g., Lewis 1995, Broders and Forbes 2004), using an individual roost-site as the population unit would not constitute a closed population and open population models would be more appropriate.

The capture probabilities were about 6 times greater at the Squanga/Salmo colony than at the Little Atlin Lake colony. This is likely attributable to 2 factors. First, the Little Atlin Lake colony was largely located in a shed and many bats were able to escape from the roof without being captured. In the case of the Squanga/Salmo colony we were able to capture many of the bats because we could effectively block much of their escape route. Second, I knew of only 1 roost-site at Little Atlin Lake and it is likely that the colony there has a second roost-site nearby that some individuals occasionally use.

It may have simply been that some of the marked bats were at other roost-site(s) on the nights of our captures and because we had a small number of capture sessions we did not encounter them again.

The difference in the capture probabilities between the 2 colonies studied suggest that the Zippin model may be an appropriate model for the Little Atlin Lake colony because it takes into account individual behaviour. Kunz and Anthony (1977) showed that some bats learn to avoid recapture in harp traps. It may be that at the Little Atlin Lake colony, banded individuals recognized the harp trap and were able to avoid it; thus, substantially decreasing captures probabilities for that colony. The population estimate provided by the Zippin model for the Little Atlin Lake colony are significantly lower than for the models that do not account for trappability (individual behaviour), but they appear biologically plausible. Again, further exploration of the various models and their assumptions is warranted, and the estimates provided in this report should be considered preliminary.

Despite further work being needed to choose the most appropriate model for these data, it is clear that the mark-recapture approach provides a robust means to inventory and monitor little brown bat populations in Yukon. I recommend that this approach be continued at these 2 colonies and, there may be an interest extending the approach to another 3 colonies in southern Yukon (e.g. Haines Junction, Whitehorse, and Watson Lake). Where feasible by extending the inventory and monitoring to include up to 5 colonies we can ensure that our monitoring is robust to local circumstances at any 1 individual colony and that we can make larger inferences for the population at the regional scale. In addition, the analyses may benefit from having at least 5 capture sessions at each colony (Otis et al. 1978). For this pilot study, we only conducted 3 and 4 capture sessions at the Little Atlin Lake and Squanga/Salmo colonies, respectively. We suspect that more robust population estimates with smaller confidence intervals can be achieved with more capture sessions.

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