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

Prepared by: Thomas S. Jung

Yukon Environment

August 2013

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

Yukon Department of Environment
Fish and Wildlife Branch
TR-13-13

Acknowledgements

I thank the many people that were willing to stay up very late and capture bats, including Amy Bernier-Desmarais, Karen Clyde, Matthias Clyde, Jane Harms, Michelle Henley, Lars Jessup, Kaz Kuba, Piia Kukka, Tess McLeod, Carrie McLelland, Rachel Shively, and Brian Slough. A special thanks to Piia Kukka for organizing several of the capture sessions and data management.

Copies available from:
Yukon Department of Environment
Fish and Wildlife Branch, V-5A
Box 2703, Whitehorse, Yukon Y1A 2C6
Phone (867) 667-5721, Fax (867) 393-6263
Email: environmentyukon@gov.yk.ca

Also available online at www.env.gov.yk.ca

Suggested citation:

JUNG, T.S. 2013. Estimating little brown bat (*Myotis lucifugus*) colony size in southern Yukon: a mark-recapture approach. Yukon Fish and Wildlife Branch Report TR-13-13. Whitehorse, Yukon, Canada.

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 ± 44.4 (95% C.I. = 797.4 – 972.5) adult female bats for the Squanga/Salmo colony and 2,085.7 ± 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.

Table of Contents

List of Figures

List of Tables

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, were 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. 2010*a*, 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. 2010*b*, 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-sitein 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 (± 0.1 g) using a digital scale and forearm measurements were taken with digital calipers (± 0.1 mm).

Each captured bat was banded was 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 ± 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 ± 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.

Capture Session	Total Number of Bats Captured	Number of Marked Bats Recaptured	Number of Unmarked Bats Captured
	Salmo/Squanga Lake Colony		
Session 1	159	73	86
Session 2	168	111	57
Session 3	177	177	70
Session 4	201	138	63
	Little Atlin Lake Colony		
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 ± SE	95% CI	Capture Probability	Log Likelihood	K	AICc	ΔAICc	Rank
			Salmo/Squanga Lake Colony					
M(0) Null	873.0 ± 44.2	794.2 – 969.1	0.5919	-1164.412	2	2332.9	9.3	4
M(t) Darroch	871.0 ± 44.1	792.6 – 966.7	0.5929	-1160.995	5	2332.1	8.5	3
M(b) Zippin	1339.0 ± 340.5	932.9 – 3171.9	0.4294	-1160.511	3	2327.0	3.4	2
Huggins	874.4 ± 44.4	797.4 – 972.5	0.5913	-1160.817	1	2323.6	--	1
			Little Atlin Lake Colony					
M(0) Null	2080.0 ± 258.7	1654.5 – 2698.7	0.0910	-739.049	2	1482.1	9.8	4
M(t) Darroch	2072.0 ± 257.5	1647.8 – 2686.7	0.0914	-736.247	4	1480.6	8.3	3
M(b) Zippin	1125.0 ± 218.3	844.0 – 2015.6	0.1858	-736.861	3	1479.8	7.5	2
Huggins	2085.7 ± 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.

Literature Cited

BRODERS, H. G., AND G. J. FORBES. 2004. Interspecific and intersexual variation in roost-site selection of northern long-eared and little brown bats in the Greater Fundy National Park ecosystem. Forest Ecology and Management 68:602-610.

CHAO, A., AND R. M. HUGGINS. 2005. Modern closed population capture-recapture models Pages 58-87 *in* S. C. Amstrup, T. L. McDonald, and B. F. J. Manly, editors. Handbook of capture-recapture analysis. Princeton University Press: Princeton, New Jersey.

CRAMPTON, L. H., AND R. M. R. BARClay. 2003. Selection of roosting and foraging habitat by bats in different-aged aspen mixedwood stands. Conservation Biology 12:1347-1358.

EFFORD, M. G., D. K. DAWSON, AND C. S. ROBBINS. 2004. DENSITY: software for analysing capture-recapture data from passive detector arrays. Animal Biodiversity and Conservation 27:217-228.

FENTON, M. B., R. M. R. BARCLAY. 1980. *Myotis lucifugus*. Mammalian Species 142:1-8.

FOLEY, J., D. CLIFFORD, K. CASTLE, P. CRYAN, AND R. S. OSTFELD. 2011. Investigating and managing the rapid emergence of white-nose syndrome, a novel, fatal, infectious disease of hibernating bats. Conservation Biology 25:223-231.

FRICK, W. F., J. F. POLLOCK, A. C. HICKS, K. E. LANGWIG, D. S. REYNOLDS, G. G. TURNER, C. M. BUTCHKOSKI, AND T. H. KUNZ. 2010*a*. An emerging disease causes regional population collapse of a common North American bat species. Science 329:679-682.

FRICK, W. F., D .S. REYNOLDS, AND T. H. KUNZ. 2010*b*. Influence of climate and reproductive timing on the demography of little brown myotis, *Myotis lucifugus*. Journal of Animal Ecology 79:128-136.

GAISLER, J., AND J. CHYTIL. 2002. Mark-recapture results and changes in bat abundance at the cave of Na Turoldu, Czech Republic. Folia Zoologica 51:1-10.

HUGGINS, R. M. 1991. Some practical aspects of a conditional likelihood approach to capture experiments. Biometrics 47:725-732.

HUGGINS, R. M. 1989. On the statistical analysis of capture-recapture experiments. Biometrika 76:133-140.

HUMPHRIES, M. M., D. W. THOMAS, AND J. R. SPEAKMAN. 2002. Climate-mediated energetic constraints on the distribution of hibernating mammals. Nature 418:313-316.

HUMPHREY, S. R., AND J. B. COPE. 1976. Population ecology of the little brown bat, *Myotis lucifugus*, in Indiana and north-central Kentucky. The American Society of Mammalogists Special Publication 4:1-81.

JONES, G., D. S. JACOBS, T. H. KUNZ, M. R. WILLIG, AND P. A. RACEY. 2009. Carpe noctem: the importance of bats as bioindicators. Endangered Species Research 8:93-115.

JUNG, T. S., B. G. SLOUGH, D. W. NAGORSEN, T. A. DEWEY, AND T. POWELL. 2006. First record of the Northern Long-eared Bat, *Myotis septentrionalis*, in the Yukon Territory. Canadian Field-Naturalist 120:39-42.

JUNG, T. S., AND B. G. SLOUGH. 2005. Mortality of Little Brown Bats, *Myotis lucifugus*, in a rodent trap in the boreal forest. Canadian Field-Naturalist 119:589-590.

JUNG, T. S., I. D. THOMPSON, R. D. TITMAN, AND A. P. APPLEJOHN. 1999. Habitat selection by forest bats in relation to mixedwood stand types and structures in central Ontario. Journal of Wildlife Management 63:1306-1319.

KUNZ, T. H., AND E. L. P. ANTHONY. 1977. On the efficiency of the Tuttle bat trap. Journal of Mammalogy 58:309-315.

LAUSEN, C. L., T. S. JUNG, AND J. M. TALERICO. 2008. Range extension of the northern long-eared bat (*Myotis septentrionalis*) in the Yukon. Northwestern Naturalist 89:115-117.

LEWIS, S. E. 1995. Roost fidelity of bats: a review. Journal of Mammalogy 76:481-496.

OTIS, D. L., K. P. BURNHAM, G. C. WHITE, AND D. R. ANDERSON. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monograph 62:1-135.

PAPADATOU, E., C. IBANEZ, R. PRADEL, J. JUSTE, AND O. GIMENEZ. 2011. Assessing survival in a multi-population system: a case study on bat populations. Oecologia 165:925-933.

PATRIQUIN, K. J., AND R. M. R. BARCLAY. 2003. Foraging by bats in cleared, thinned and unharvested boreal forest. Journal of Applied Ecology 40:646-657.

PUECHMAILLE, S. J., AND E. J. PETIT. 2007. Empirical evaluation of non-invasive capture-mark-recapture estimation of population size based on a single sampling session. Journal of Applied Ecology 44:843-852.

SLOUGH, B. G., AND T. S. JUNG. 2007. Diversity and distribution of the terrestrial mammals of the Yukon Territory: a review. Canadian Field-Naturalist 121:119-127.

SLOUGH, B. G., AND T. S. JUNG. 2008. Observations on the natural history of bats in the Yukon. Northern Review 29:127-150.

TUTTLE, M. D. 1974. An improved trap for bats. Journal of Mammalogy 55:475-47