Bats: exit counts at roosts—cameras and recorders

Version 1.0

This specification was prepared by Jane Sedgeley in 2012.

Contents

Disclaimer
This document contains supporting material for the Inventory and Monitoring Toolbox, which contains DOC's biodiversity inventory and monitoring standards. It is being made available to external groups and organisations to demonstrate current departmental best practice. DOC has used its best endeavours to ensure the accuracy of the information at the date of publication. As these standards have been prepared for the use of DOC staff, other users may require authorisation or caveats may apply. Any use by members of the public is at their own risk and DOC disclaims any liability that may arise from its use. For further information, please email biodiversitymonitoring@doc.govt.nz

Department of Conservation
Te Papa Atawhai

Synopsis

Infrared cameras and recorders can be used to count bats at their roost sites by filming and recording evening emergence (Figs 1 and 2). The most commonly used set-ups incorporate a small independent camera linked to either a 12 V video cassette recorder (VCR) or a secure digital (SD) memory card recorder. Alternatively, a handheld digital camera and recorder can be used (e.g. Sony Handycam). VCRs with a time-lapse facility and SD card recorders can be used for recording bat activity patterns at roosts throughout the whole night, for predator surveillance, and for investigating aspects of bat behaviour.

Observers usually count bats manually by playing back the video at a later date. The video can be reviewed at slower speeds and tally counters can be used when counting large numbers of bats, rapid bursts of bats, and bats exiting and entering simultaneously. DOC has developed two standardised camera and recorder systems that are now in common use. One incorporates a VCR and the other an SD card recorder. The DOC Electronics Workshop in Wellington can be contacted for further information.

Infrared cameras and infrared light sources are required to cope with the low light levels during bat emergence and are necessary to avoid disturbing the bats. Conventional 'white' lighting shone at a bat roost will usually disturb the bats so much that they will not emerge. Long-tailed bats start to emerge from roosts while it is still light so can be counted directly, without the aid of cameras and video equipment. For more information, see 'Bats: exit counts at roosts—simple visual counts' (docdm-590804).

In contrast, lesser short-tailed bats always emerge after dark. Therefore, infrared cameras and recorders are currently the only method available for obtaining accurate roost exit counts for this species. Other methods used for counting bat emergence, such as 'Bats: roost occupancy and indices of bat activity—infrared beam counters' (docdm-131260), can only provide a coarse index of activity. To achieve accurate counts, roosts must be checked for multiple exit holes, and multiple camera and recorder set-ups used if necessary. Cameras and lighting must be carefully positioned, either on the ground or mounted on the roost tree, so the whole of the exit hole is in view. To achieve accurate counts, recording must begin at least 30 minutes before sunset for long-tailed bats and at sunset for lesser short-tailed bats.

Counts of exiting bats can be used for simple inventories at roost sites, but this method is a relatively expensive way of establishing whether bats are simply present or absent. Exit counts can give an accurate assessment of the total number of bats exiting a particular roost on a particular night. However, exit counts often underestimate roosting group size because some bats may not leave the roost, and those remaining inside can seldom be counted (especially inside tree roosts). The most accurate counts of bats using a roost will generally be achieved by combining counts of bats exiting a roost at dusk with counts of bats remaining inside the roost. Counts inside roosts are only practical for bats roosting inside caves or buildings. See O'Donnell (2002) and 'Bats: counting inside roosts' (docdm-590915) for more details.

Although roost exit counts can provide an estimate of minimum population size in an area, they are generally of limited value for obtaining accurate one-off estimates of population size or for monitoring population trends over time. Members of a colony are frequently spread among several communal roosts and many solitary roosts on any one night. Therefore, unless all roosts are known and are counted simultaneously, roost counts will always underestimate the total population by an indeterminate, and usually considerable, amount. Studies have also shown that roost counts are poor estimators for monitoring purposes because changes in average roost counts do not always reflect changes in population size (Walsh et al. 2001).

Figure 1. Small camera and a strip of infrared lights set up outside a lesser short-tailed bat roost on Codfish Island (photo: J. Sedgeley).

Figure 2. A still photograph of long-tailed bats emerging from a roost, taken from a video recording. Note, the female leaving the roost has a radio tag on her back and she has her baby under her wing (photo: C. O'Donnell).

Assumptions

- Bats will emerge from the roost.
- All bats emerge from the roost.
- All exit holes have been accounted for.
- All individuals are visible on the recordings.
- Trends in roost counts reflect trends across the population.

Advantages

- Some camera and recording systems can be operated remotely and can therefore operate without observers being present.
- Some systems can be timed to record emergence over several nights.
- The method can be used to count both evening emergence and record activity patterns at roosts throughout the night.
- Video can be reviewed at slower speeds to obtain accurate counts.

- Cameras and recorders also have other applications, e.g. predator surveillance, investigating aspects of bat behaviour.

Disadvantages

- Cameras, lighting and recorder set-ups are frequently technologically complex. Initial outlay costs are high and equipment requires ongoing maintenance.
- Reviewing videotapes or SD cards to count bats can sometimes be difficult and it usually takes a long time.
- Depending on the type of set-up, the equipment may be cumbersome and difficult to carry into remote locations.
- It can be difficult to charge enough batteries to service video recorders when working in remote locations.
- With just a basic single camera and recorder set-up it may not be possible to adequately observe all entrances to a roost that has multiple exit holes.
- The insides of tree roosts are not usually accessible, making it hard to count any bats that remain inside. Technology may improve and camera sizes may become small enough to allow recording inside roosts. However, it may still be difficult to interpret and count clusters of bats inside roost cavities and crevices.

Suitability for inventory

- Counts of emerging bats are suitable for an inventory of the number of bats using roost sites. With an unobscured view of roost entrances, this technique can provide an accurate count of bats exiting a particular roost on a particular night. However, exit counts at communal roosts will usually be poor estimators of total population size because (a) exit counts will always underestimate the total number of bats using a roost unless bats remaining inside the roost can also be counted, and (b) members of a colony or population are always spread among several communal roosts and a large number of solitary roosts on any one night.
- Counts of bats inside roosts are only practical for bats roosting inside caves or buildings. See O'Donnell (2002) and 'Bats: counting inside roosts' (docdm-590915) for more details.
- Using infrared cameras to record bats exiting roosts can be used for simple inventories at roost sites, but this method is a relatively expensive way of simply establishing presence of bats in an area.
- Coarse, one-off population estimates for lesser short-tailed bats can be calculated (e.g. by using the Lincoln-Peterson Estimator) if exit counts are used in conjunction with automatic PIT-tag readers and data loggers at roost entrances. See 'Bats: trapping at roosts—estimating survival and productivity' (docdm-590867) for more details.
- Lesser short-tailed bats emerge after dark, so using infrared cameras and recorders is one of the only ways to count bats exiting roosts, and is currently the most accurate (e.g. when compared with infrared beam counters).

- Long-tailed bats start to emerge from roosts while it is still light and can be counted directly (see 'Bats: counting away from roosts—visual counts'—docdm-590754). However, at times, long-tailed bat emergence may carry on after dark so it can be useful to use infrared cameras and recorders.

Suitability for monitoring

- Studies have shown that roost counts are poor tools for monitoring population changes of bats over time because changes in average roost counts do not always reflect changes in population size (Walsh et al. 2001; Pryde et al. 2005).
- Roost exit counts can give a reasonably accurate assessment of the total number of bats leaving a particular roost on a particular night, and as such can be used to monitor trends in roost use of a particular roost over time (i.e. how many years the roost is occupied and by how many bats).
- Long-tailed bats seldom occupy a roost for more than one day; a colony is usually spread among several roosts on any one night and numbers of bats using a roost are highly variable. This variability means using cameras and recorders to monitor long-tailed bats is impractical and expensive in terms of time and resources.
- Roost exit counts are generally highly variable, often fluctuating from night to night, seasonally, and from year to year, thus making statistical interpretation of raw count data problematic (Walsh et al. 2001). Numbers of roosting bats are influenced by a range of factors such as temperature and other environmental conditions, and stage of the breeding season. Therefore, roost counts are of limited use for monitoring trends, unless factors influencing this variability are recorded.
- Colonies or populations of New Zealand bats are spread over several roosts on any given day. Therefore, minimum population estimates derived from roost counts will always be directly correlated to sampling effort and the number of roosts found during the sampling period. For this reason, trying to interpret data when sampling effort varies from year to year is also problematic. Attempts have been made to improve population estimates by standardising effort, counting at all known occupied roosts simultaneously and then summing the roost counts. However, such counts will always underestimate total population size because it is impossible to know if all roosts have been located, and it is usually impossible to count at all known sites.
- If an exit count is used in conjunction with automatic recording of PIT-tagged lesser short-tailed bats at the roost, then a coarse, one-off population estimate can be calculated. This method has potential for monitoring trends in bat populations, but it has not yet been adequately tested in New Zealand. Researchers are currently examining whether there is a relationship between roost counts and estimated trends in actual populations of long-tailed bats using mark-recapture methods (e.g. Pryde et al. 2005). At the time of writing this analysis had yet to be completed.

Skills

Unless inventory and monitoring is to be undertaken at known roosts, workers will need skills to locate new roosts in addition to the skills necessary for maintaining camera and recording equipment, setting it up at roost trees, counting bats on the recordings and interpreting the counts.

Skills required for finding roosts

Workers must be able to:

- Demonstrate a basic level of bushcraft.
- Identify areas of bat activity by using bat detectors to survey for bat calls. See ‘Bats: counting away from roosts—bat detectors on line transects’ (docdm-590701) and ‘Bats: counting away from roosts—automatic bat detectors’ (docdm-590733) for more information.
- Set up harp traps or construct mist net rigs in areas of bat activity. Training may be needed to learn how and where to place traps to optimise capture rates.
- Handle bats competently and humanely; identify, age, sex and measure them; and apply transmitters.
- Meet minimum standards—anyone wishing to catch and handle bats must receive appropriate training and must meet the minimum requirements for catching, handling, examining, measuring, and releasing bats described in the ‘DOC best practice manual of conservation techniques for bats’ (docdm-131465).
- Use radio-tracking to follow tagged bats and locate their communal roosts (see ‘Bats: trapping at roosts—estimating survival and productivity’—docdm-590867).

Skills required for using cameras and recorders

- Infrared cameras and recorders can be technologically complex and are often difficult to set up in the field. Training is required to ensure units are functioning correctly, calibrated regularly and maintained.
- In some circumstances, workers may need tree-climbing experience to set up cameras.

Resources

This technique is very expensive in terms of equipment and time. Intensive effort is required to locate the roosts and set up the equipment, particularly if multiple roosts are filmed simultaneously. It is also important to allocate adequate time for viewing recordings and counting bats. This part of the process can be very time consuming.

DOC has developed several automatic systems for recording bats remotely. These units may be purchased or borrowed from the DOC Electronics Workshop in Wellington. The cost of equipment will vary enormously depending on type of camera, recorder and lighting system. The DOC Electronics Workshop should be contacted to discuss options. There are also commercial systems available, e.g.

from Faunatech[1] in Australia, but commercially produced systems are likely to be far more expensive than any developed by the DOC Electronics Workshop.

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on your objective. For more information refer to 'Full details of technique and best practice'.

DOC staff must complete a 'Standard inventory and monitoring project plan' (see docdm-146272).

Minimum attributes to record:

- Observer's name, and contact details
- Date
- Location (place name, GPS coordinates)
- Roost type (tree cavity, under bark, cave, woolshed, etc.) and any roost identification (roost number, cave name, etc.)
- Start time, finish time
- Dusk temperature and weather conditions (cloud cover, wind, rain)

Depending on aims of study, record:

- Total numbers of bats exiting and total number entering
- Time each bat exited or entered the roost
- Total number of bats exiting and entering the roost for defined intervals (e.g. a tally for each 5 or 10 minute period)
- Net number of bats emerging from roost (number exiting minus number entering)

Minimum attributes can be recorded in the field on a standardised recording sheet—see 'Blank field sheet: roost counts' (docdm-131425).

Data storage

Forward copies of completed survey sheets to the survey administrator, or enter data into an appropriate spreadsheet as soon as possible. Collate, consolidate and store survey information securely—also as soon as possible, and preferably immediately on return from the field. The key steps here are data entry, storage and maintenance for later analysis, followed by copying and data backup for security.

Roost exit count results are best summarised in a spreadsheet (e.g. Microsoft Excel). Columns in the spreadsheet should include all data recorded on the original field sheet because the influences of

[1] http://www.faunatech.com.au/

factors such as location, observer, weather, etc. need to be accounted for in any analysis. At present, there are no standardised spreadsheets or databases maintained by DOC to store bat roost count data.

However, exit counts could be recorded in the DOC bat database. Each DOC conservancy should have a separate Excel spreadsheet for this purpose, with access rights held by the conservancy bat contact (see 'Bat Recovery Group contacts'—docdm-132033). If a conservancy has not set up its own spreadsheet, one can be created using the 'National bat database template' (docdm-213136). See the 'Canterbury Conservancy bat database' (docdm-213179) for an example of a spreadsheet containing data. Many of the data entry fields will not be relevant, but there are fields for location, GPS coordinates and for comments that could be used to describe count results (Fig. 3).

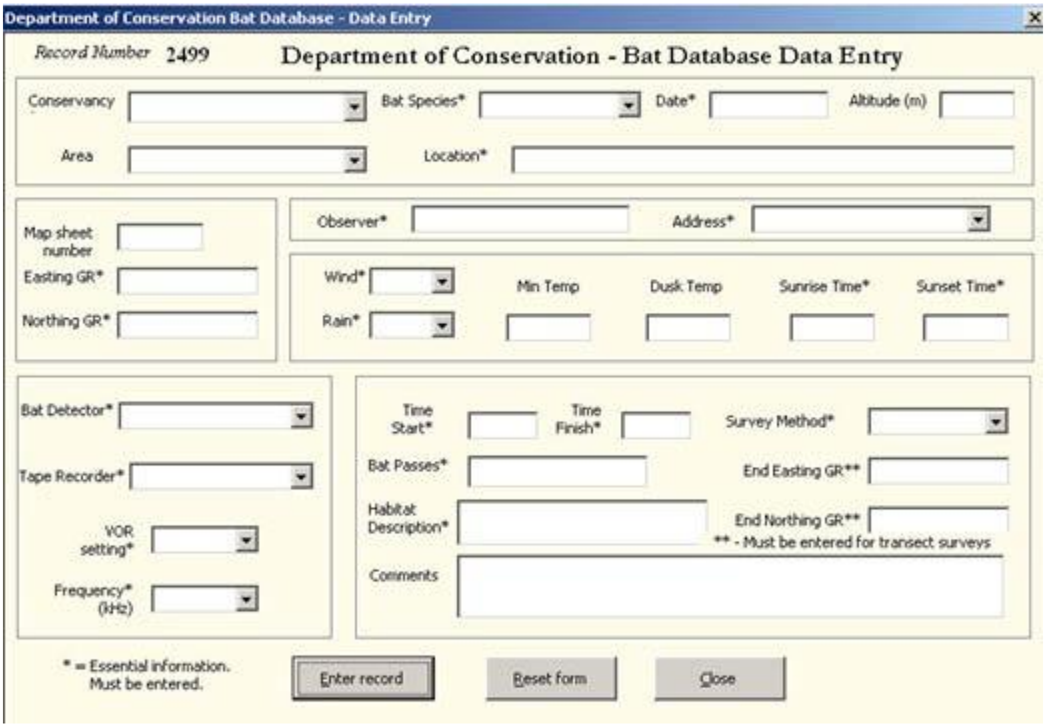
Department of Conservation Bat Database - Data Entry
Record Number 2499
Department of Conservation - Bat Database Data Entry
Conservancy
Bat Species*
Date*
Altitude (m)
Area
Location*
Map sheet number
Easting GR*
Northing GR*
Observer*
Address*
Wind*
Rain*
Min Temp
Dusk Temp
Sunrise Time*
Sunset Time*
Bat Detector*
Tape Recorder*
VOR setting*
Frequency* (kHz)
Time Start*
Time Finish*
Survey Method*
Bat Passes*
End Easting GR**
Habitat Description*
End Northing GR**
** - Must be entered for transect surveys
Comments
* = Essential information. Must be entered.
Enter record
Reset form
Close

Figure 3. Data entry page from the DOC bat database.

Analysis, interpretation and reporting

Seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis. Data will:

- Calculate total number of bats exiting a particular roost on a particular night
- Investigate aspects of bat activity and behaviour at roost sites
- Undertake surveillance monitoring for predators

This method has potential to provide population indices if used in conjunction with a mark-recapture method.

Simple statistics for comparison can be calculated in different ways. If counts are undertaken at single roosts, then maximum counts can be calculated as the largest number of bats exiting any roost during the sampling period. If counts are undertaken at several simultaneously occupied roosts then the total number of bats exiting roosts can be summed per night and again the maximum count is the largest number of bats recorded on any one night over the sampling period (e.g. Fig. 4). Alternatively, average counts per night can be calculated. Raw data can be graphed and used to show daily patterns at single roosts, or averaged to show season patterns at several roosts (as in Fig. 5).

Simple interpretations include statements like: 'Two hundred and ninety-seven lesser short-tailed bats exited roost number 25 in the Eglinton Valley on 10/10/03', or 'An average of 284 ± 67 SE lesser short-tailed bats emerged from roosts on Codfish Island in winter 1998' (Sedgeley 2001). In most circumstances statistical comparisons should only be made after several years of data are collected. However, even if such comparisons can be made, it would be imprudent to assume that the counts reflected actual trends in the whole population.

Data like these can be put into a management context by comparing average counts before and after some management activity. For example, there was concern that lesser short-tailed bats on Codfish Island were at risk from secondary poisoning during a poisoning operation to eradicate introduced rats (kiore) from the island. Sedgeley & Anderson (2000) showed that maximum counts of lesser short-tailed bats emerging from the roosts they sampled were similar before, during and after the poisoning operation. The poison operation did not appear to kill many bats. However, it was recognised that only part of the larger population was sampled and it was unlikely that the method would detect whether individual bats had been killed by poisoning. This example demonstrates that only general inference can be drawn using these data (i.e. there were still plenty of bats present after the poisoning, so it was unlikely that a significant number had been affected by secondary poisoning). If exit counts are being used to assess population trends over time, interpretation should be cautious. Before counts derived from exit counts can be used for monitoring, it is important to establish and understand the relationship between numbers of bats seen emerging from roosts and the total population size.

Nowhere has it been demonstrated that there is a consistent correlation between numbers of long-tailed bats or lesser short-tailed bats emerging from a roost and actual population size. For example, exit counts of lesser short-tailed bats from individual roosts in the Eglinton Valley seem to underestimate total population size by 50% to > 90%. For more details, see table 1 in the 'Bats: trapping at roosts—estimating population size' (docdm-590819), and O'Donnell et al. (1999).

If surveyors are confident that all roosts occupied on a night have been counted simultaneously, and this assumption can be fulfilled for all future monitoring sessions, then roost exit counts may reflect actual population size. However, the chance of finding all roosts occupied in a population, and repeating that effort over time is remote because both New Zealand bat species move roosts frequently and not all bats occupy a single roost on any one night. For example, long-tailed bats in Eglinton Valley, Fiordland, occupied roosts for an average of 1–2 nights, and each colony circulated around > 150 trees. They occupied, on average, > 7 communal roosts each night and an unknown number of solitary roosts (O'Donnell & Sedgeley 2006).

Recently, lesser-short-tailed bats have been tagged using Passive Integrated Transponder tags (PIT tags), also known as microchips. Automatic readers and data loggers have been used successfully to record the number of bats with tags using roost sites. If this information (number of bats with tags emerging at dusk) is used in conjunction with exit counts (total number of bats emerging), a coarse, one-off population estimate can be calculated (e.g. Lincoln-Petersen Estimator; see the method 'Bats: trapping at roosts—estimating population size' (docdm-590819). Recent research is also using mark-recapture methods to estimate trends in numbers of long-tailed bats in populations and examining whether there are any relationships with roost counts (e.g. Pryde et al. 2005). If, in the future, these methods are demonstrated to provide consistent indices of the number of bats in a population, more detailed statistical analysis of population trends may be possible. These types of analyses require specialist skills, and conservation managers would need to seek advice on the best ways to analyse counts. Because it is not possible to standardise all aspects of monitoring sessions between years, statistical modelling procedures that distinguish between variation in counts resulting from variability in environmental or sampling conditions and the actual variation in activity levels of bats between years will be required (e.g. McCullagh & Nelder 1989; Walsh & Harris 1996; Barry & Welsh 2002; Borchers et al. 2002).

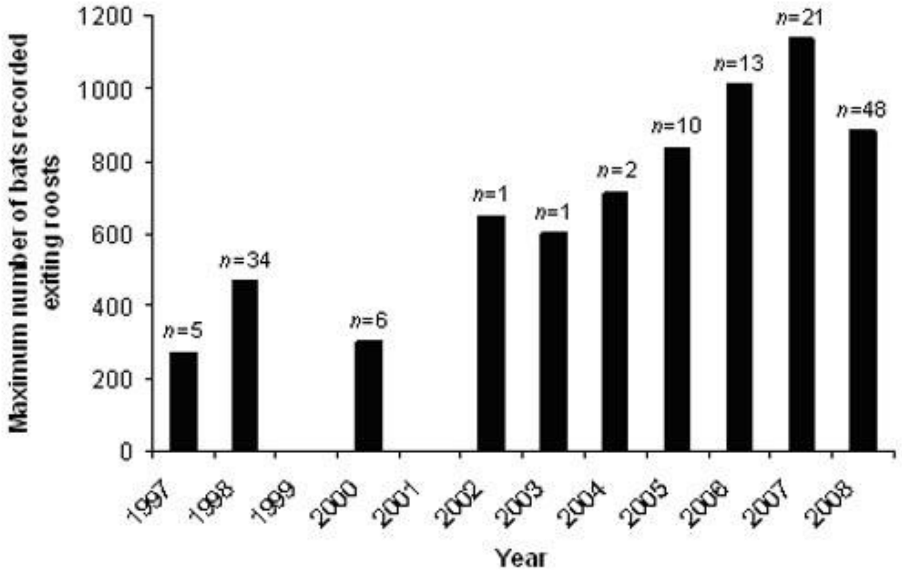

Figure 4. The maximum number of lesser short-tailed bats exiting roosts during summer (January to March) in the Eglinton Valley, from 1997 to 2008. No counts were undertaken in 1999 and 2001. The number of roosts sampled (*n*) is shown for each year.

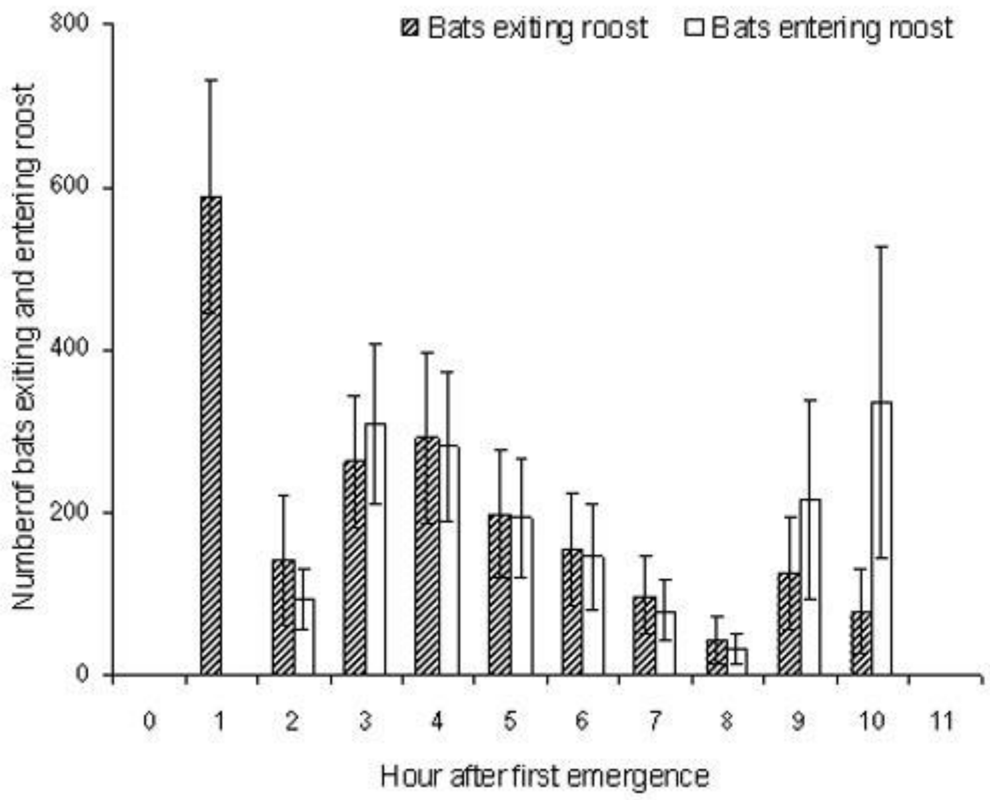

Figure 5. Activity throughout the night at communal lesser short-tailed bat roosts on Codfish Island during summer (*n* = 6 video nights, 4 different roosts). Results are presented as number of bats exiting and entering per hour after first bat emergence, and are expressed as means ± SE.

Case study A

Case study A: estimating population size of lesser short-tailed bats at Rangataua Forest, Central North Island, New Zealand

Synopsis

Infrared cameras and video recorders were used to count bats at roost sites to estimate minimum population size of lesser short-tailed bats in Rangataua Forest, central North Island as part of a monitoring project and a PhD study (Lloyd 2002).

Sampling design and methods

Counts were undertaken in October and November when numbers of bats using roosts are considered to be most stable. Active roost sites were located by attaching radio-transmitters on up to 15 bats, in a random sample of different sex, age and reproductive classes and following the bats to communal roost trees. Attempts were made to video all (or as many as possible) active roosts simultaneously over several days. The numbers of bats exiting all simultaneously occupied roosts were summed to give a total per night. The minimum population estimate was simply the largest number of bats recorded on any one night over the sampling period.

Results

Counts were conducted from 1995 to 1999 and in 2002. Minimum population estimates are summarised in Fig. 6. Table 1 provides a detailed example of results for 2002. The 2002 survey was undertaken in November, and roosts were located by following six radio-tagged bats. Five roosts were videoed simultaneously to estimate total population size. The maximum number of bats recorded on any one night was 3338 bats (Specht 2002).

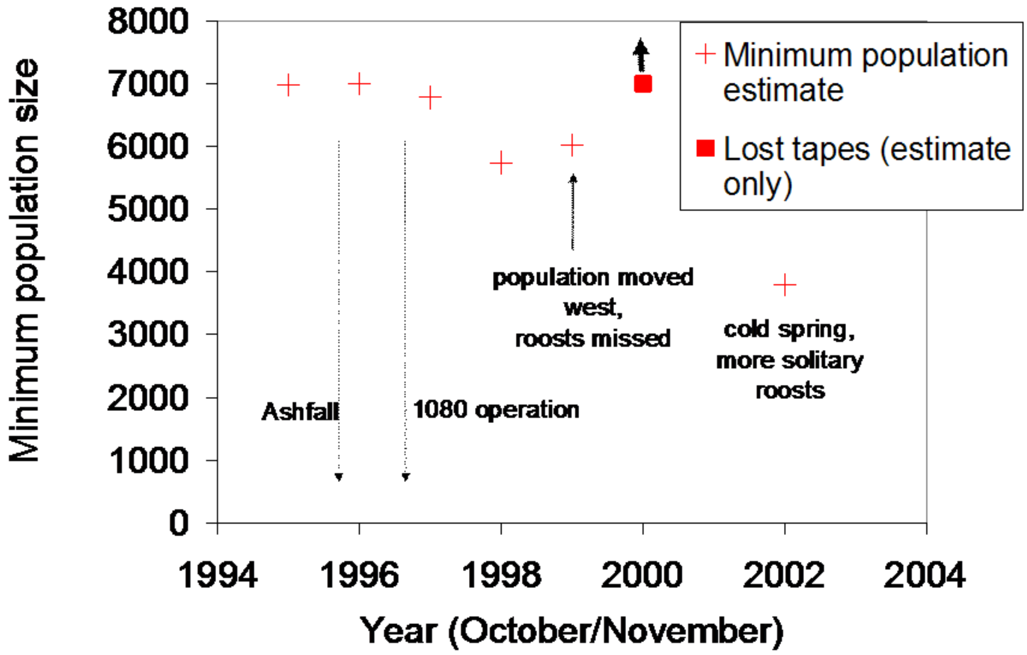

Figure 6. Graph showing lesser short-tailed bat roost counts in Rangataua Forest from 1994 to 2002. This graph illustrates some of the technical problems encountered while collecting population data, and problems with interpreting results and assessing population trends over time. Sampling effort varied from year to year, so it is not known whether the lower population estimate observed in 2002 is the effect of fewer roosts being sampled or cold weather affecting roosting behaviour of the bats. (This graph was originally produced by H. Keys using data collected by B. Lloyd and DOC Ōhakune staff.)

Table 1. Example of using simultaneous counts of lesser short-tailed bats exiting several roost sites to estimate minimum population size. The estimate of minimum population size is simply the maximum number of bats recorded on any one night over the sampling period. In 2002 this was 3338 bats (Specht 2002).

	Number of bats exiting from five different roosts					
Date	**1**	**2**	**3**	**4**	**5**	**Total**
6/11/02	0	128	Failed	Failed	0	128
7/11/02	280	Failed	1695	0	0	1975
8/11/02	294	207	1744	0	0	2245

9/11/02	960	109	1713	0	556	3338
10/11/02	883	0	1282	0	385	2550
11/11/02	794	0	1490	0	273	2557
12/11/02	676	0	1646	0	181	2503
13/11/02	282	0	Failed	0	226	508
14/11/02	149	0	1763	0	274	2186
15/11/02	341	0	1306	0	1620	3267

Limitations and points to consider

The lesser short-tailed bat population in Rangataua Forest was intensively monitored from 1995–1996 by a team dedicated to this task. The population estimate was stable over this period. From 1998 onwards, the population was less intensively managed because there were insufficient resources and personnel to have a team dedicated solely to bat work. In 2000, the videotapes and equipment were stolen, and in 2002 cold weather may have affected counts. Therefore, from these data we do not know whether the lower population estimate observed in 2002 is the effect of fewer roosts being sampled, cold weather affecting roosting behaviour of the bats (i.e. where a larger proportion of the population may have been in solitary roosts), or a true population decline (Fig. 6).

Population estimates derived from roost counts are always difficult to interpret. For example, even if all known roost sites are videoed simultaneously, it is impossible to know whether all active communal roosts used by the population have been found. Additionally, a proportion of the population will always roost solitarily. Bats will move between known sites and unknown sites during the sampling period. Minimum population estimates derived from roost counts will always be directly correlated to sampling effort and the number of roosts found during the sampling period. Therefore, trying to interpret data when sampling effort varies from year to year is problematic.

References for case study A

Lloyd, B.D. 2002: The ecology and molecular ecology of the New Zealand lesser short-tailed bat *Mystacina tuberculata*. PhD thesis, Massey University, Palmerston North.

Specht, P. 2002: Short-tailed bat census 2002. Unpublished report. Department of Conservation, Ōhakune Field Centre, Ōhakune.

Full details of technique and best practice

Types of camera and recorder systems in use

A wide variety of cameras, infrared light sources and recorders have been used successfully to record bats emerging from roosts. Infrared light emitting diodes (LEDs) are often housed in the camera unit surrounding the lens and can be supplemented with additional (and separate) infrared light sources to increase the brightness of the image or area illuminated. A range of cameras and lenses have been used, including those with standard and wide-angle lenses. Long-tailed bat roost exit holes are frequently high off the ground, and consequently cameras and lights need to be attached with brackets and clamps onto the roost tree. For roosts near the ground, such as for many lesser short-tailed bat roosts, cameras and lights can simply be mounted on tripods.

The capabilities of various types of camera and light sources vary enormously and this will affect how far from the roost hole the equipment needs to be placed. Therefore, some advice should be sought if trying to build a system from scratch. One of the most important considerations for lighting is to use infrared diodes that are invisible to bats. Not all are invisible to animals, but those rated at 900 nm should be.

The most common types of video recorders used in systems developed by the DOC Electronics Workshop are the Panasonic 12 V video recorder (Fig. 7) and the Sony Video-Walkman (Fig. 8). The Panasonic video recorder (AG-1070DC) has time-lapse capability which gives options of recording 3 h (normal play), 6 h (long play), 12 h (time lapse) and 24 h (time lapse) of footage onto standard 180 min VHS videotapes. These units also have built-in timers that are menu driven and easy to programme. Panasonic video recorders are relatively large and require fairly large 24 Ah or 36 Ah batteries. One 24 Ah battery will run the camera, lights and video recorder for approximately 12 h, i.e. one night of time-lapse 12 h recording, or several nights if the video recorder is programmed to only record for 2 or 3 hours each night. The Sony Video-Walkman is much smaller and more compact. It takes 8 mm Video-8 tapes and can be run off 6.5 Ah batteries. This video recorder does not usually have time-lapse capability, but timers can be built into the system. The video recorder, camera and lights are usually housed in a durable waterproof housing (e.g. ‘Pelican’ brand cases) with standardised waterproof ‘Amphenol’ brand plug and socket connectors (Figs 7 and 8).

Figure 7. Panasonic 12 V video recorder (AG-1070DC), housed inside a ‘Pelican’ brand case with standardised waterproof ‘Amphenol’ brand plug and socket connectors for the camera and lights.

Figure 8. Sony Video-Walkman housed inside a ‘Pelican’ brand case with standardised waterproof ‘Amphenol’ brand plug and socket connectors for the camera and lights. An additional timer system has also been wired inside the case.

Hand-held digital cameras and video recorders (e.g. Sony Handycam) and infrared spotlights are also commonly used for counting bats at roost sites. The range of models available on the market changes frequently. These video cameras are very small, provide good quality images and can be used for taking stills. The best results are obtained if one or more additional light sources are used with the commercially available hand-held video cameras, particularly if a roost is > 10 m off the ground. Hand-held recorders do not have time lapse facilities, and digital videotapes or DVDs usually only last for 1–2 hours. For counting bats at a roost for longer periods, someone needs to sit with the equipment and change the tape when required. The DOC Electronics Workshop has developed timers and waterproof housings for some models (Fig. 9).

Figure 9. Small hand-held video camera with waterproof housing.

At the time of writing the DOC Electronics Workshop brought out a new recording system (see 'SD recorder info sheet'—docdm-138039). It includes a small security recorder that records MPEG files to an SD card (the same card as those found in most digital cameras). The card can be downloaded to a computer and the files played using Windows Media Player. A housing has been developed that will be a direct replacement for the old VHS systems—cameras, batteries and lighting can simply be plugged in provided they have the plugs and sockets set up to the DOC standard (Fig. 10). Power consumption is about a quarter of the VHS recorders, giving the option of running 3 or 4 days off a 40 Ah battery or daily changes with a much smaller battery. Small solar panels may be an option now in sunny sites. The system also includes a sensor mode which can turn the unit on only during activity so you could potentially leave the unit running for weeks on one battery if you had a suitable sensor.

The SD recorder system was trialled at lesser short-tailed bat roosts in the Eglinton Valley in the summer of 2008. Image quality varied and was dependent on the quality of SD card used, the types of camera and lights that were used, and which recording settings were selected. In general, image quality was not as good as those derived from VCR and digital videotape recorders and therefore not ideal for detailed behavioural studies. However, the images derived from SD card recorders are perfectly adequate for inventory and monitoring purposes, i.e. counting bats, and are also good enough for predator surveillance.

Figure 10. The DOC Electronics Workshop's new small lightweight recording system which utilises an SD card (the same card as those found in most digital cameras).

An alternative to using infrared cameras and videos to count bats leaving roosts is thermal imaging technology. This technology has been used in the USA at caves containing thousands of bats (Kunz 2003), but has not been trialled in New Zealand. Thermal imaging methods are likely to be subject to the same assumptions and generally have the same advantages and disadvantages as counts made with cameras and recorders. However, thermal imaging does have the advantage of being able to 'cover' very large roost entrances, but the technology is much more expensive.

Reviewing videotapes and SD cards

Observers are usually required to manually count bats by playing back the videotape or SD card. It is important to allocate adequate time for watching videos and counting bats because this part of the process can be very time consuming. Two techniques can be used to assist with counting large numbers of bats, rapid bursts of bats, and bats leaving and entering simultaneously:

1. Video can be reviewed at slower speeds. Some of the video recorders have options for slow playback, which makes it easier to count bats that exit rapidly. The SD card can be viewed by plugging the recorder directly into a television or by removing the SD card and watching it on a computer. The SD card is either slotted directly into the computer or into a USB adapter. The files can be played using Windows Media Player which has variable playback options (see 'Video review instructions for Media Player'—docdm-285750).

2. Tally counters commonly used for counting stock animals can be used to keep tallies of numbers of bats. They can be used to keep separate tallies of numbers exiting and numbers entering roosts. This could be done using two people, each with a tally counter—one counting departing bats, one counting incoming bats. Alternatively, one person could use a tally counter in each hand.

It is also useful to have previously prepared recording sheets with separate columns for recording exiting and entering bats (see 'Blank field sheet: roost counts'—docdm-131425). Advances in technology may make it possible to use an automatic device for counting bats on videotapes in the future.

Recommendations for conducting counts

There are currently no standardised procedures for inventory and monitoring bats at roosts using cameras and recorders. The following best practice guidelines are aimed at providing practical advice to achieve the most accurate counts.

Practical best practice guidelines for using camera and recorders to obtain counts of bats exiting roosts

- All equipment (cameras, lights, video recorders, SD recorders, batteries, connection leads, videotapes, SD cards) must be tested before use in the field.
- All users must be familiar with operating systems (setting timers, recording modes, etc.) and attachment systems (for batteries, lights, and the camera) before use in the field.
- Try out the system, i.e. run the camera and recorder for a night before putting it out into the field.

- Do not use standard lighting 'white light' to illuminate holes for filming bats because it will disturb them and they will be unlikely to emerge from the roost.
- General disturbance must be minimised at roost sites, with noise levels and torch shine kept to a minimum.
- Vegetation obscuring exit holes must only be trimmed back if absolutely necessary, and trimming must be kept to a minimum.
- To achieve accurate counts, roosts must be checked for multiple exit holes and multiple cameras and recorders used if necessary.
- To achieve accurate counts, cameras and lights must be carefully positioned so that the whole of the exit hole is in view. If filming over several nights, the first night's recording should be reviewed immediately to check whether the equipment is fully functional, and the view of the exit hole is adequate (e.g. whether there is enough illumination).
- To achieve accurate counts, recording must begin at least 30 minutes before sunset for long-tailed bats, and at sunset for lesser short-tailed bats.
- Tapes and SD cards should be watched carefully to obtain accurate counts of large numbers of rapidly exiting bats:
  - — Tapes and SD cards should be reviewed on a slow speed if necessary.
  - — Tally counters commonly used for counting stock can be used to record the number of bats exiting and entering.
  - — Record tally information on previously prepared standardised recording sheets with separate columns for exiting and entering bats (see 'Blank field sheet: roost counts'—docdm-131425).
  - — All equipment should be serviced and repaired at the end of the season.

References and further reading

Barry, S.C.; Welsh. A.H. 2002: Generalized additive modelling and zero inflated count data. *Ecological Modelling 157*: 179–188.

Borchers, D.L.; Buckland, S.T.; Zucchini, W. 2002: Estimating animal abundance. Closed populations. Statistics for biology and health. Springer-Verlag, London.

Kunz, T.H. 2003: Censusing bats: challenges, solutions, and sampling biases. In O'Shea T.J.; Bogan, M.A. (Eds): Monitoring trends in bat populations of the United States and territories: problems and prospects. U.S. Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR 2003–0003.

Lloyd, B.D. 2002: The ecology and molecular ecology of the New Zealand lesser short-tailed bat *Mystacina tuberculata*. PhD thesis, Massey University, Palmerston North.

McCullagh, P.; Nelder, J. 1989: Generalized linear models. Chapman and Hall, New York.

O'Donnell, C.F.J. 2002: Variability in numbers of long-tailed bats (*Chalinolobus tuberculatus*) roosting in Grand Canyon Cave, New Zealand: implications for monitoring population trends. *New Zealand Journal of Zoology 29*: 273–284.

O'Donnell, C.F.J.; Christie, J.; Corben, C.; Sedgeley, J.A.; Simpson, W. 1999: Rediscovery of short-tailed bats (*Mystacina* sp.) in Fiordland, New Zealand: Preliminary observations of taxonomy, echolocation calls, population size, home range, and habitat use. *New Zealand Journal of Ecology 23*: 21–30.

O'Donnell, C.F.J.; Sedgeley, J.A. 2006: Causes and consequences of tree-cavity roosting in a temperate bat, *Chalinolobus tuberculatus*, from New Zealand. In Zubaid, A.; McCracken, G.F.; Kunz, T.H. (Eds): Functional and evolutionary ecology of bats. Oxford University Press, Oxford.

Pryde, M.A.; O'Donnell, C.F.J.; Barker, R.J. 2005: Factors influencing survival and long-term population viability of New Zealand long-tailed bats (*Chalinolobus tuberculatus*): implications for conservation. *Biological Conservation 126*: 175–185.

Sedgeley, J.A. 2001: Winter activity in the tree-roosting lesser short-tailed bat, *Mystacina tuberculata*, in cold-temperate climate in New Zealand. *Acta Chiropterologica 3*: 179–195.

Sedgeley, J.A.; Anderson, M. 2000: Capture and captive maintenance of short-tailed bats on Whenua Hou and monitoring of wild bats during the kiore eradication programme winter 1998. Unpublished report, Department of Conservation, Invercargill.

Specht, P. 2002: Short-tailed bat census 2002. Department of Conservation, Ōhakune Field Centre, Ōhakune.

Walsh, A.; Catto, C.; Hutson, A.M.; Racey, P.A.; Richardson, P.; Langton, S. 2001: The UK's Bat Monitoring Programme. Department of Transport, the Environment and the Regions Contract Report CRO18.

Walsh, A.L.; Harris, S. 1996: Factors determining the abundance of vespertilionid bats in Britain: geographical, land class and local habitat relationships. *Journal of Applied Ecology 33*: 519–529.

Appendix A

The following Department of Conservation documents are referred to in this method:

docdm-132033	Bat Recovery Group contacts
docdm-590733	Bats: counting away from roosts—automatic bat detectors
docdm-590701	Bats: counting away from roosts—bat detectors on line transects
docdm-590754	Bats: counting away from roosts—visual counts
docdm-590915	Bats: counting inside roosts
docdm-590804	Bats: exit counts at roosts—simple visual counts
docdm-131260	Bats: roost occupancy and indices of bat activity—infrared beam counters
docdm-590819	Bats: trapping at roosts—estimating population size
docdm-590867	Bats: trapping at roosts—estimating survival and productivity
docdm-131425	Blank field sheet: roost counts
docdm-213179	Canterbury Conservancy bat database
docdm-131465	DOC best practice manual of conservation techniques for bats
docdm-213136	National bat database template
docdm-138039	SD recorder info sheet
docdm-146272	Standard inventory and monitoring project plan
docdm-285750	Video review instructions for Media Player