Bats: counting inside roosts

Version 1.0

This specification was prepared by Jane Sedgeley in 2012.

Contents

Department of Conservation
Te Papa Atawhai

Synopsis

This technique is useful for counting bats roosting in caves and buildings but is unsuitable for counting bats inside trees. Bats roosting inside caves and buildings may hang in conspicuous positions either alone, or in small or large densely packed clusters and are usually counted using one of two techniques:

1. **Direct counts of small clusters of bats**
   A torch or headlight is used to illuminate clusters of bats and a direct headcount is made. A spotlight and binoculars may be necessary if bats are roosting high above the ground. Noise and lights must be kept to a minimum to reduce disturbance and prevent the bats exiting the roost during the daytime. Ideally, a red filter should be used over the light source to reduce disturbance. Alternatively, an infrared still camera or video camera with a zoom can be used and bats counted from the image (Fig. 1).

2. **Surface area estimates**
   Surface area estimates are suitable for estimating numbers of bats roosting in large clusters, particularly when coupled with measures of mean packing density. Packing density for several bats species has been estimated in 1000s bats/m^2 (Thomas & LaVal 1988; McCraken 2003). However, it is unlikely that densities approaching this will ever be recorded for New Zealand bat species and the technique is not discussed further.

The advantage of directly counting bats inside roosts is that counts are conducted during the day. Almost all other inventory and monitoring methods are conducted at dusk or during the night. Counting bats inside roosts is a useful technique for surveying sites that cannot be visited at night, i.e. those located in remote areas or those where the access is unsafe after dark. However, the technique has very limited application. The interiors of many roosts are inaccessible for counting, and bats may roost in crevices and out of sight. Therefore, this technique can only be used to count bats roosting in conspicuous positions in accessible and open roost sites.

This technique can be used for a simple inventory of presence/absence and monitoring occupancy of known roosts over time. Counting bats inside a roost may give a reasonably accurate assessment of the number of bats using a roost in the daytime, but it cannot be necessarily assumed all bats present are visible. In certain circumstances the technique may be suitable for monitoring if bats routinely roost in areas where they are visible and repeat counts can be standardised (O'Donnell 2002). Counts of bats inside a roost can be compared with counts of bats exiting a roost to obtain a more accurate count of the total number of bats using the roost at the time. See 'Bats: exit counts at bat roosts—simple visual counts' (docdm-590804) for more details.

Roost count data can be difficult to interpret if data is used to try and obtain accurate one-off estimates of population size or to monitor population trends over time. Members of long-tailed bat colonies are frequently spread among several communal roosts and many solitary roosts on any one day. Therefore, unless all roosts are known and are counted simultaneously, roost counts will always underestimate the total population size by an indeterminate, and usually considerable, amount. Numbers of bats using a roost 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 and accounted for in any analyses. Various studies have shown that roost counts are poor estimators for monitoring population trends over time because changes in average roost counts did not always reflect changes in the population (e.g. case study A in ‘Bats: exit counts at bat roosts—simple visual counts’—docdm-590804). However, counts of the average number of long-tailed bats roosting inside Grand Canyon Cave near Piopio, North Island did not vary significantly from year to year (O’Donnell 2002) and neither did average survival estimated from mark-recapture (Pryde et al. 2006). These results imply a good correlation between indices and population trends in this instance.

Counting bats inside roosts is a technique mostly applicable for inventory and monitoring of long-tailed bats because they occasionally roost in both caves and buildings. There are no current records of lesser short-tailed bats roosting in these structures, but their remains have been found in several caves, indicating they have used caves as roost sites in the past.

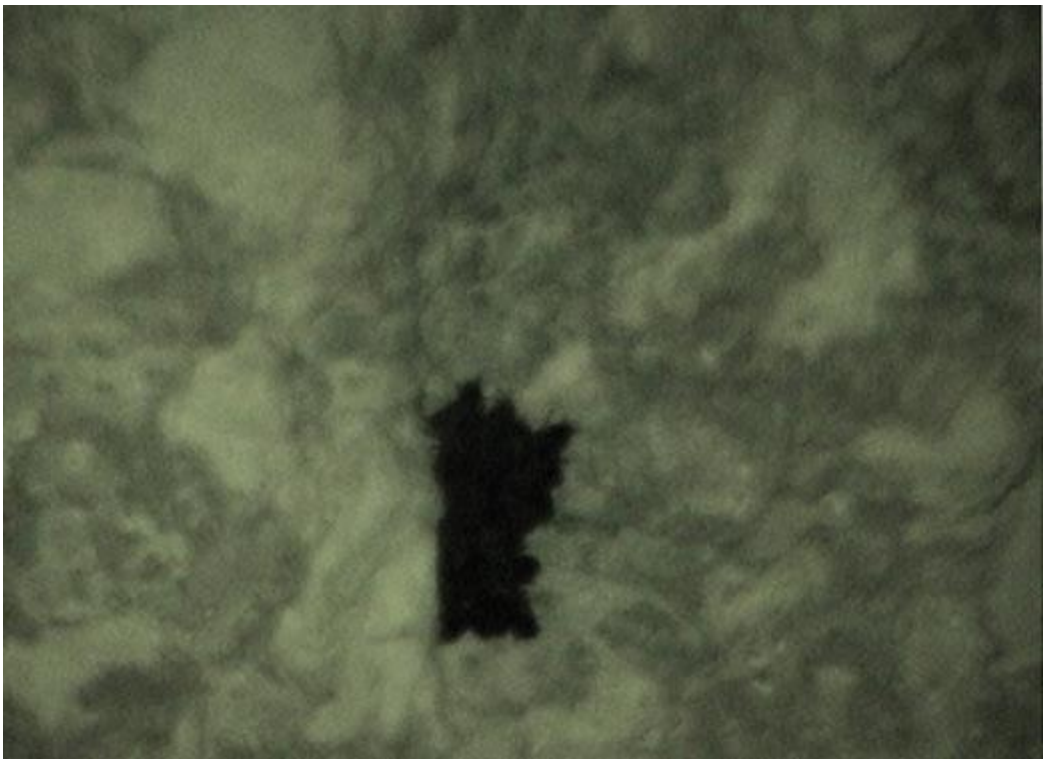

Figure 1. Photograph of a cluster of roosting long-tailed bats on the ceiling of Grand Canyon Cave (c. 50 m from ground). The image is a still photograph taken from an infrared video camera tape. Higher quality can be achieved with a still camera and zoom lens.

Assumptions

- All bats using a roost are visible, or that numbers of visible bats are in some way proportional to the number using the roost.

Advantages

- The technique does not require highly skilled staff.
- The technique does not necessarily require expensive equipment.
- Taking a photograph or digital image allows counts to be checked later without additional disturbance to the bats.
- It is easy to calibrate the numbers of bats counted inside a roost by counting the number of bats exiting a roost at dusk. For example, 'Case study A' illustrates that counts of bats inside Grand Canyon Cave were not significantly different from counts of exiting bats (O'Donnell 2002).
- Bats are counted inside the roost during daytime. Therefore the technique is useful for sites in remote locations or sites that are inaccessible at night.

Disadvantages

- This technique has very limited application, as the inside of most trees is inaccessible for counting. This method is really only suitable for counting relatively small clusters of bats roosting in accessible and open caves and buildings.
- There is potential for disturbing bats while counting them. Several studies have shown that sound and light disturbance can adversely affect energy expenditure in bats, especially during winter.
- Not all bats in the roost might be visible during the count. Exit counts may help calibrate the internal count, but not all bats may exit the roost.
- Counts at communal roosts are generally poor estimators of total population size. Studies in the UK and in New Zealand have shown that using roost counts for monitoring purposes is problematic because changes in average roost counts do not always reflect changes in population size (Walsh et al. 2001; Pryde et al. 2005).

Suitability for inventory

- This technique can be used for a simple inventory of presence/absence at known roost sites (roost occupancy).
- Counting bats inside a roost may give a reasonably accurate assessment of the number of bats using a roost in the daytime. For example, counts of bats roosting inside Grand Canyon Cave were not significantly different to counts of bats exiting (O'Donnell 2002). However, it cannot be assumed all bats are visible, and detectability will vary among different types of roosts.
- Roost counts are usually poor estimators of total population size. Members of a bat colony or population are always spread among several communal roosts and a large number of solitary roosts on any one night. For example, the maximum long-tailed bats recorded roosting inside Grand Canyon Cave underestimated total population size (1874 different bats were caught and banded at the cave, 1998–2003) (Pryde et al. 2006).
- 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.

Suitability for monitoring

In some situations, where bats routinely roost in areas where they are visible and repeat counts can be standardised, counts of bats inside can be used to monitor trends in roost use of a particular roost over time (i.e. for how many years the roost is occupied, and by how many bats). For example, Grand Canyon Cave near Piopio, North Island has been used by long-tailed bats for nearly 50 years and was monitored for 8 years (O'Donnell 2002).

Collecting adequate roost count data to obtain minimum population estimates or to detect changes in populations is generally impractical and expensive in terms of time and human resources, and resulting data is difficult to interpret:

- The majority of long-tailed bat roosts are in tree cavities. Long-tailed bats seldom occupy tree roosts for more than 1–2 days.
- Members of a bat colony or population are usually spread among several communal roosts and a large number of solitary roosts on any one day.
- These behaviours make it almost impossible to locate all long-tailed bat roost sites in an area and impractical to count at all known roost sites. 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. Trying to interpret data when sampling effort varies from year to year is problematic.
- 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 and accounted for in any analyses.
- It is difficult to interpret simple counts from roosts. These counts are generally highly variable, often fluctuating nightly, seasonally and yearly, thus making statistical interpretation of raw count data problematic (Walsh et al. 2001).

A study in the Eglinton Valley has shown that counts of long-tailed bats exiting tree roosts were poor estimators for monitoring population trends over time because changes in average roost counts did not always reflect changes in the population (case study A in 'Bats: exit counts at bat roosts—simple visual counts'—docdm-590804). However, counts of the average number of bats roosting inside Grand Canyon Cave near Piopio, North Island did not vary significantly from year to year (O'Donnell 2002) and neither did average survival estimated from mark-recapture (Pryde et al. 2006). These results imply a good correlation between indices and population trends in this instance.

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 conducting and interpreting the roost counts. Roosts are generally found by catching a bat, attaching a transmitter and following it back to its roost. However, it may be possible to locate bat roosts in caves and buildings by following up historical and anecdotal records and checking the sites for bat sign.

Skills required for finding roosts by catching bats and using radio-tracking

Workers must be able to:

- Demonstrate a basic level of bushcraft and be comfortable working at night.
- 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. The section ‘Catching bats’ in the ‘DOC best practice manual of conservation techniques for bats’ (docdm-131465) contains information on trap construction and how to place traps to optimise capture rates.
- Handle bats competently and humanely.
- Be able to identify species of bat; age, sex, and measure bats.
- 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).
- Attach radio transmitters and use radio-tracking to follow tagged bats and locate their communal roosts (see ‘Trapping bats at roosts: estimating survival and productivity’—docdm-590867).

Skills used to find roost sites using field sign

- Good observational skills. Observers need the ability to distinguish between sign (e.g. droppings, bones, food remains, staining) left by bats from that of other animals. See ‘Bats: roost occupancy and indices of bat activity—field sign’ (docdm-590882) for more information.

Skills required for conducting counts inside roosts

With minimal training anyone can conduct direct visual counts of long-tailed bats exiting roosts. Workers need to:

- Have reasonable observational skills
- Be able to visually identify long-tailed bats
- Be able to operate a spotlight, camera and a video recorder
- Be comfortable with working in the dark, and at times working alone

Resources

The counting technique can be comparatively low in technology and resources. All that is required are one or two observers, notebooks and a good light source. Bat detectors may be useful to locate bats using large roost sites, and cameras or video recorders may be useful as an alternative technique for counting larger numbers of bats.

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' (docdm-146272).

The minimum attributes to record will depend on the aims of the study. If the aim is simply to document how many bats are inside the roost, observers only need to record the total number visible and the following details:

- Date
- Observer name and contact details
- Roost type and location details (e.g. place name, name of cave or building, address of building)
- GPS coordinates
- Description of where the bats are roosting within the structure (a drawing or sketch may be useful)
- Technique:
  - Direct count (with or without binoculars)
  - Count from a photograph or image
- Time of count
- External ambient temperature
- Temperature inside roost
- Weather conditions (cloud cover, wind, rain)
- Number of clusters and number of bats in each cluster
- Number of solitary bats
- Total number of bats inside roost
- Details of land ownership—owner contact details and access agreements should be recorded for each roost site. Many caves and buildings are likely to be located on private land and will usually require access permissions.

Minimum attributes can be recorded in the field on a standardised bat recording sheet (see 'Blank field sheet: roost counts'—docdm-131425). The blank reverse side of the form could be used to sketch the roost and provide information on the location of the exit hole and the best places to stand to observe the bats.

Other attributes

Researchers conducting a monitoring programme at Grand Canyon Cave were also interested in documenting exactly which parts of the cave were used by the roosting bats. This type of data may be useful for management purposes such as designating areas for protection. Surveyors at Grand Canyon Cave routinely recorded the location of all bats seen during the counts.

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.

Summarise the results in a spreadsheet or equivalent. Arrange data as ‘column variables’, i.e. arrange data from each field on the data sheet (date, time, location, plot designation, number seen, identity, etc.) in columns, with each row representing the occasion on which a given survey plot was sampled.

If data storage is designed well at the outset, it will make the job of analysis and interpretation much easier. Before storing data, check for missing information and errors, and ensure metadata are recorded.

Storage tools can be either manual or electronic systems (or both, preferably). They will usually be summary sheets, other physical filing systems, or electronic spreadsheets and databases. Use appropriate file formats such as .xls, .txt, .dbf or specific analysis software formats. Copy and/or backup all data, whether electronic, data sheets, metadata or site access descriptions, preferably offline if the primary storage location is part of a networked system. Store the copy at a separate location for security purposes.

Roost count results are best summarised in a spreadsheet (e.g. Excel). Columns in the spreadsheet should include all data recorded on the original field sheet because the influences of 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, counts could be recorded in the DOC bat database. Each DOC conservancy should have a separate Excel spreadsheet for this purpose. Access rights are 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. 2).

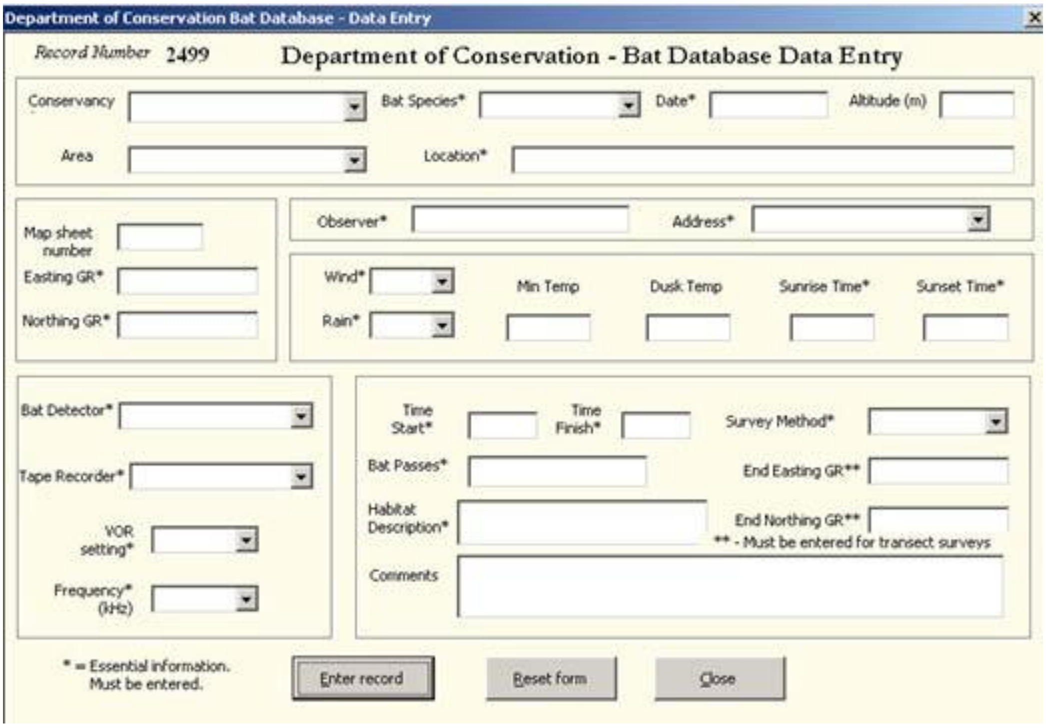

Figure 2. Screenshot illustration of data entry page from the DOC bat database.

Analysis, interpretation and reporting

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

This method measures:

- Presence/absence
- Presence/absence over time (roost occupancy)
- Number of bats seen

Results can be presented in a number of ways. Simple statistics for comparison can be calculated, such as maximum count (either the highest number of bats inside a roost during the sampling period, or the sum of the number of bats using roosts occupied simultaneously). Alternatively, average counts can be calculated. Raw data can be graphed and used to show daily patterns at single roosts (Fig. 3) or averaged to show seasonal patterns (Fig. 4). Simple interpretations include statements like: 'There were 58 long-tailed bats occupying Grand Canyon Cave on 4/12/2000', or 'A median number of 6.5 (± 2.3–30 IQ range) bats roosted in the cave from 1992–1999 and the maximum number of bats recorded in the cave at one time was 250'.

Counts of bats inside a roost can be compared with counts of bats exiting a roost to obtain a more accurate count of the total number of bats using the roost. See 'Bats: exit counts at bat roosts—simple visual counts' (docdm-590804) and 'Case study A' for more details.

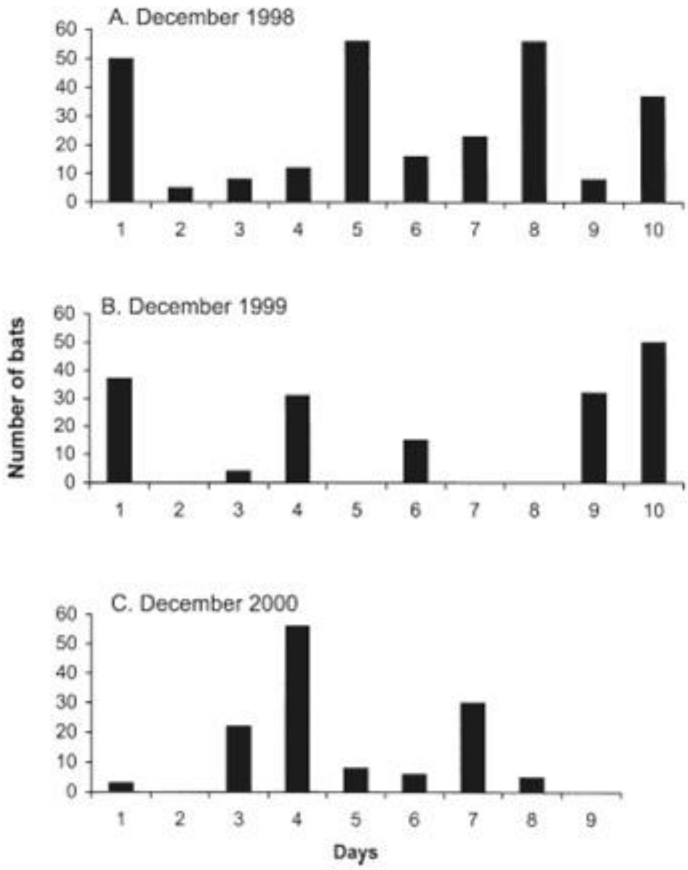

Figure 3. Examples of daily variability in number of bats roosting within Grand Canyon Cave for field trips in December 1998–2000.

Case study A

Case study A: long-term monitoring of long-tailed bats at Grand Canyon Cave

Synopsis

Almost all counts of long-tailed bats at roosts conducted in New Zealand have focused on trees roosts, but there is one notable exception. Long-tailed bats using Grand Canyon Cave near Piopio, North Island have been counted intermittently since c. 1959, and regularly since 1992 (O'Donnell 2002). Intermittent historic counts of > 300 bats were made at the cave, making it one of the largest concentrations of long-tailed bats known nationally. Clearly it was important to check if the cave was still a nationally important site and to determine population trends, especially as they might help prioritise where pest control should be undertaken in the area.

Objectives

- To determine if Grand Canyon Cave was still a significant site for the conservation of long-tailed bats.

- To determine if numbers of long-tailed bats using Grand Canyon Cave were stable, declining or increasing.

Sampling design and methods

Two indices of relative abundance were used to count bats using the cave: (1) the number of bats roosting inside the cave; and (2) the net number of bats exiting at dusk. Bats roosting inside the cave were counted using either a spotlight and binoculars (with strict rules so that bats were not disturbed), or infrared still photography. This technique is described in more detail in ‘Full details of technique and best practice’. Daytime counts inside the cave were undertaken once per month over 8 years from 1992 to 1999. In addition, repeat counts inside the cave were made in the middle of the night during the summer months. Simple visual counts of bats exiting the cave at dusk were made using two observers at both entrances to the cave (see O’Donnell 2002 for details).

Results

Results obtained using the two indices were not significantly different. However, monthly and daily counts were characterised by high variability. Counts varied significantly through the year but not between years (Fig. 4). Large groups of bats occurred when cave temperatures ranged from 10–13°C, suggesting that they occupied the cave when temperatures were within an optimum range (see figure 7 in O’Donnell 2002). Maximum counts were 250 long-tailed bats during the day, and 358 at night, when other bats entered the cave to ‘night-roost’.

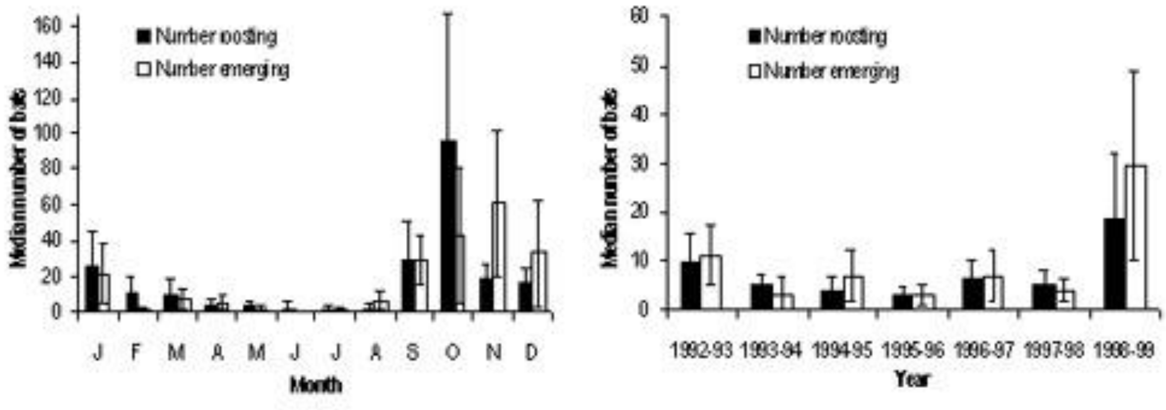

Figure 4. Monthly and annual counts of long-tailed bats using Grand Canyon Cave (reproduced from O’Donnell 2002 in the *New Zealand Journal of Zoology*).

Limitations and points to consider

Counts in caves are often thought of as a ‘census’ or ‘population count’. However, in reality they represent indices of relative abundance because not all bats that use the cave are present at one time.

Maximum numbers of long-tailed bats counted at the Grand Canyon Cave underestimated total population size. Between 1992 and 2002 a total of 792 bats were caught and banded at the cave. During the same period the highest number of bats counted roosting inside the cave during the day was 250 and the highest number seen roosting at night was 358 (O'Donnell 2002). By 2003, a total of 1874 different bats had been banded, but the cave counts never exceeded the maximum counts recorded in previous years (Pryde et al. 2006; D. Smith, pers. comm.). Nevertheless, comparing index counts between years for the same site is appropriate (providing environmental variables are taken into account), but such indices cannot be used directly for comparison with other sites.

The following conclusions were drawn from the 8-year study:

- Counts can be used as a baseline against which to judge future trends in the population at Grand Canyon Cave and contribute to national monitoring of bat populations.
- Future monitoring could focus on summer months and times when temperatures in Grand Canyon Cave were optimum for long-tailed bats to minimise variability of counts. Counts in winter yield little useful information.
- A longer time-series of counts allied with a longer series of mark-recapture data was required before it is possible to determine how well the index of counts at the cave matched trends in the actual number of bats in the wider population. A study of survivorship of banded bats at the cave indicated that the population was large and apparently stable, a conclusion similar to that of the index counts of bats emerging from the cave (Pryde et al. 2006).

References for case study A

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.

Pryde, M.A.; Lettink, M.; O'Donnell, C.F.J. 2006: Survivorship in two populations of long-tailed bats (*Chalinolobus tuberculatus*) in New Zealand. *New Zealand Journal of Zoology 33*: 85–95.

Full details of technique and best practice

Counting technique

A standardised technique has been developed for counting long-tailed bats inside Grand Canyon Cave near Piopio in the North Island and could be adapted for use at other sites. Observers walked silently through the cave during late afternoon. A spotlight was used to identify the location of bats on the ceiling of the cave, and 10 × 50 binoculars were used to count numbers. An infrared (IR) video camera with 180 × zoom and IR spotlight (Sony DCR-TRV9E) was used more recently instead of a spotlight. Observers could hear larger groups of bats squeaking from c. 100 m away alerting them to the presence of bats. Bat detectors alerted the observers at a closer range. Deposits of fresh guano on the cave floor also alerted observers to potential roost sites above them. Usually two observers estimated bat numbers, and the average count was used in the analysis. The location and size of each group of bats was mapped, and the distance of the group into the cave from the north entrance was measured in metres.

Potential for disturbance to bats

Several studies have shown that sound and light disturbance can adversely affect energy expenditure in bats, especially during winter (e.g. Thomas 1995). Therefore, noise and lights must be kept to a minimum to reduce disturbance and to prevent the bats exiting the roost during the daytime. A pilot study at Grand Canyon Cave indicated that the spotlight did not disturb bats if it was extinguished within 5 minutes. As a rule observers shone the spotlight for 1–3 minutes. It is possible that long-tailed bats roosting in Grand Canyon may have become somewhat habituated to disturbance by both bat researchers and people visiting the cave for recreation. Caution should be used at other bat colonies that may not be as tolerant of disturbance.

Health and safety issues

DOC staff working on bats must ensure that they operate under approved health and safety hazard plans and should consult the standard operating procedure (SOP) database available on the DOC Intranet to check for appropriate procedures (e.g. working in confined spaces, roped tree-climbing, working at heights). Additionally, DOC staff must check local (area office) procedures relevant to hazard management. See the section ‘Health and safety’ in the ‘DOC best practice manual of conservation techniques for bats’ (docdm-131465) for further details. Some Australian bat workers (Armstrong & Higgs 2002) have formulated useful risk management protocols for working in confined spaces which may be worth reading.

Best practice for minimising disturbance to bats inside roosts

- General disturbance must be minimised outside roost site.
- Bat workers must be as silent as possible inside the roost, and counts must be conducted as quickly as possible.
- Illumination must only be used if really necessary, and standard lights must be extinguished within 5 minutes.
- Red filters on lights, or infrared light cameras should be used whenever possible.

Best practice for optimising survey success at Grand Canyon Cave

- Undertake monthly counts from October to December when maximum counts are recorded, and avoid counts during winter months when activity in the cave is limited.
- Count bats only during conditions suitable for the occurrence of large groups of bats (> 50 bats; cave temperature 10–13°C).

References and further reading

Armstrong, K.; Higgs, P. 2002: Draft protocol for working safely in confined spaces. *The Australasian Bat Society Newsletter 20*: 20–28.

McCracken, G.K. 2003: Estimates of population sizes in summer colonies of Brazilian free-tailed bats (*Tadarida brasiliensis*). 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.

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Thomas, D.W. 1995: Hibernating bats are sensitive to nontactile human disturbance. *Journal of Mammalogy 76*: 940–946.

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Walsh, A.; Catto, C.; Hutson, A.M.; Racey, P.A.; Richardson, P.; Langton, S. 2001: The UK's National Bat Monitoring Programme. Department of Environment, Transport and the Regions Contract Report No. CR018. The Bat Conservation Trust, London.

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-590804	Bats: exit counts at bat roosts—simple visual counts
docdm-590882	Bats: roost occupancy and indices of bat activity—field sign
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-146272	Standard inventory and monitoring project plan