THE CAR-BASED BAT MONITORING SCHEME FOR IRELAND: REPORT FOR 2007

Niamh Roche[1], Steve Langton[2] and Tina Aughney[1]

1. www.batconservationireland.org
2. stats@slangton.co.uk

CONTENTS

EXECUTIVE SUMMARY

Introduction

The first systematic car-based bat monitoring system in Europe was devised for the Republic of Ireland (ROI) in 2003 by the Bat Conservation Trust (BCT, UK) and funded by the Irish Heritage Council. The scheme has been administered by Bat Conservation Ireland (BCIreland) since 2004. The scheme has expanded year on year, funded by the National Parks and Wildlife Service (NPWS) of the Department of Environment, Heritage and Local Government (ROI). In 2006 it was extended to Northern Ireland with additional funding from the Environment and Heritage Service (EHS), Department of the Environment, Northern Ireland. The main aim of the scheme is to monitor roadside populations of common pipistrelle, soprano pipistrelle and Leisler's bat and to collect sufficient data to identify trends in bat populations, whether these are Amber or Red Alert declines, or increases.

The method involves driving a known survey route at 24kmph (15mph) with a time expansion bat detector clamped to the open window of the passenger door. Each survey route (route length is 93km) consists of 20, 1.6km transects, separated by a 3.2km gap to prevent repeat encounters with the same bats. Sounds are recorded to minidisc. Minidisc recordings are analysed by BCIreland using Bat Sound™ software. In the initial pilot study in 2003, routes were mapped and surveyed within seven, randomly selected, 30km squares. The coverage across the country has been increasing yearly and in 2007, routes had been mapped in 28, 30km blocks. Surveys are carried out in July and August by trained volunteers who are mainly staff of NPWS and EHS, and BCIreland members. Sixty seven surveyors were involved in surveying in 2007, the maximum number involved to-date.

Twenty seven survey squares were surveyed by the end of 2007. During the July and August 2007 surveys, 3014 bat encounters were recorded from 889 independent monitoring transects. The common pipistrelle was the most frequently encountered species, as in previous survey years. On average 1.77 common pipistrelle encounters were recorded during each 1.6km transect. Relative abundance of common pipistrelles was slightly higher in 2007 than 2006. The soprano pipistrelle was the second most frequently encountered species in all years except 2006. On average 0.64 soprano pipistrelle encounters were recorded from each 1.6km transect in 2007. Soprano pipistrelle encounter rates were lower in 2007 than 2006. The Leisler's bat was the third most frequently encountered bat in 2007, whereas in 2006 it was the second most frequent species. On average, 0.63 Leisler's bats were encountered during each 1.6km transect in 2007. Leisler's encounter rates were lower in 2007 than 2006. Other species such as Myotis *spp*., Nathusius' pipistrelle and brown long-eared bats are encountered by the survey in very low numbers. *Myotis* spp. were slightly more frequently encountered in 2007 than 2006 while Nathusius' pipistrelle encounters were slightly reduced in 2007 compared to 2006.

For the first time in 2007 a simple linear model was fitted to the yearly encounter rate data for each species. Initial results indicate that common pipistrelles may be on an increasing trend. No significant trend, either up or down, was determined in soprano pipistrelle encounters. Results from the model indicate that Nathusius' pipistrelles and Leisler's bats are likely to be showing an increasing trend.

Average monthly air temperature was included in REML analysis and showed a strong positive correlation with common pipistrelle activity levels. The association between soprano pipistrelle activity levels and temperature was positive and close to, but not quite, significant. Leisler's bat activity was significantly, positively related to air temperature.

Two squares in the south west were highlighted as having particularly high mean total bat encounter rates from 2004 to 2007. However, each of the two squares in question, V99 and R22, have only had four successfully completed surveys, compared with some squares with up to eight. In time, as more data becomes available, it will become clearer which squares show greatest bat activity levels. While this may vary a little from year to year, it seems likely that these will be located in the extreme south west counties such as Kerry, Cork and Limerick. A map of average total bat encounter rates from the entire country shows quite a clear gradation of bat activity, with greatest activity concentrated in the south, midlands and east, and decreasing activity levels associated with the north and coastal mid-west.

With the issue of driver and surveyor safety of primary concern, investigations were carried out to determine whether it will be feasible to reduce the time taken to complete an individual survey. Currently, each survey consists of driving a minimum of 93km in order to survey 20 1.6km transects separated by at least 3.2km. Reducing survey time may involve either cutting out the 3.2km gaps between transects and driving a continuous route for perhaps 1.5hrs, or by reducing the number of transects surveyed. There are concerns about cutting out the gaps between transects since encounter rates in particular transects tend to be somewhat consistent over time and statistically independent. It may be that by cutting out the gaps and driving a continuous route, the data already collected by the scheme would not be directly comparable. Details are given about the potential for reducing each survey to 15 or 10 existing transects, which may result in a loss of power and increase the need for extra squares to be surveyed. An analysis of Power will be carried out later in 2008 and the results published in 2009.

Other vertebrates were recorded by surveyors during each survey night and in total 383 living vertebrates other than bats were recorded from 4580km of roads in July and August 2007. The most common species was the domestic cat which accounted for 50% of all living vertebrates observed. The next most common species were foxes and rabbits. By way of contrast the most commonly recorded dead vertebrates were rabbits, followed by badgers and foxes.

INTRODUCTION

The Car-Based Bat Monitoring Scheme is a joint project of The National Parks and Wildlife Service (NPWS) of The Department of Environment, Heritage and Local Government, Republic of Ireland, The Environment and Heritage Service (EHS) of the Department of the Environment, Northern Ireland and Bat Conservation Ireland (BCIreland). This project aims to be the primary tool for monitoring roadside populations of common pipistrelle, soprano pipistrelle and Leisler's bats in Ireland. The project protocol was initially devised and piloted by The Bat Conservation Trust (BCT) in 2003 as an initiative of The Heritage Council (ROI) (Catto *et al*., 2004).

This report presents results for the 5th season of bat monitoring in the Republic of Ireland and the second season for Northern Ireland and follows earlier reports (Catto *et al.,* 2004; Roche *et al*., 2005; 2006; 2007). The format follows Roche *et al*. (2005) although revised methods of analysis and increased data availability means that there have been some changes to the annual report format for 2007.

2005 saw the first survey square to be completed in Northern Ireland. In 2006 the Environment and Heritage Service (EHS), Department of the Environment, Northern Ireland, funded the monitoring of three squares in Northern Ireland, and five squares in 2007. Results are shown in the present report.

Why Monitor Ireland's Bats?

Irish bats are protected under domestic and EU legislation. Under the Republic's Wildlife Act (1976) and Wildlife (Amendment) Act (2000) it is an offence to intentionally harm a bat or disturb its resting place. Bats in Northern Ireland are protected under the Wildlife (Northern Ireland) Order 1985.

The EU Habitats Directive (92/43/EEC) lists all Irish bat species in Annex IV and one Irish species, the lesser horseshoe bat (*Rhinolophus hipposideros*), in Annex II. Annex II includes animal species of community interest whose conservation requires the designation of Special Areas of Conservation (SACs) because they are, for example, endangered, rare, vulnerable or endemic. Annex IV includes various species that require strict protection. Article 11 of the Habitats Directive requires member states to monitor all species listed in the Habitats Directive and Article 17 requires States to report to the EU on the findings of monitoring schemes.

Ireland and the UK are also signatories to a number of conservation agreements pertaining to bats such as the Bern and Bonn Conventions. The European Bats Agreement (EUROBATS) is an agreement under the Bonn Convention and Ireland and the UK are two of the 31 signatories. The Agreement has an Action Plan with priorities for implementation. Devising strategies for monitoring of populations of selected bat species in Europe is among the resolutions of EUROBATS.

Whilde (1993), the Irish Red Data Book of vertebrates, listed all Irish populations of bats (those species that were known to occur in Ireland at the time) as Internationally Important. Two Irish species, the lesser horseshoe bat and the Leisler's bat (*Nyctalus leisleri*), were assigned IUCN European threat categories by Hutson *et al.* (2000) (VU A2c and LR: nt, respectively). VU A2c indicated that the lesser horseshoe bat population in Ireland is vulnerable to decline and such declines may be predicted for the future if there is a decline in occupancy, extent of occurrence or quality of habitat. Ireland holds important European populations of Leisler's bat (Stebbings, 1988) which was formerly categorised as LR (lower risk): nt (near threatened). The conservation status of bats in Ireland and Europe has been recently updated. The threat level for the lesser horseshoe bat is now described as near threatened for Europe and the European States (Temple and Terry 2007), but within Ireland its population is considered to have good prospects (NPWS 2007). The status of the European Leisler's bat population has been changed from nt to Least Concern (Temple and Terry 2007) and within Ireland it is considered to have good prospects (NPWS 2007). This species is still, however, infrequent in the rest of Europe compared with Ireland where it is quite common.

There has been an increase in levels of knowledge of Irish bats in the past 20 years, mainly due to increased numbers of researchers and bat workers. Despite high levels of legal protection for all species, however, until 2003 there was no systematic monitoring of any species apart from the lesser horseshoe bat. This car-based bat monitoring scheme, the Daubenton's Bat Waterways Survey which began in 2006 (e.g. Aughney *et al.,* 2007), the pilot of woodland bat monitoring (Roche and Aughney, 2007) and the brown long-eared bat monitoring scheme (Aughney and Roche, 2008) are helping to redress the imbalance and ensure countrywide coverage and monitoring of a number of species including our important Leisler's bat.

Definite conclusions from a monitoring project based on the road network, such as a car-based bat monitoring scheme, can only be made in relation to roadside habitats. Inferences from the roadside monitoring to wider bat populations can be made but are based on the assumption that population trend data collected from the roadside will mirror that of the wider population. Some caution is needed in doing this since population trends in a non-random subsample of available habitats will not necessarily be representative of the population as a whole (Buckland *et al.* 2005). Further work to assess the degree of bias in the roadside habitats may therefore be needed before extrapolating to other habitats.

Red and Amber Alerts

There are no precise biological definitions of when a population becomes vulnerable to extinction but the British Trust for Ornithology (BTO) has produced Alert levels based on IUCN-developed criteria for measured population declines. Species are considered of high conservation priority (Red Alert) if their population has declined by 50% or greater over 25 years and of medium conservation priority (Amber Alert) if their populations have declined by 25-49% over 25 years (Marchant *et al*., 1997). These Alerts are based on evidence of declines that have already occurred but if Alerts are *predicted* to occur based on existing rates of decline in a shorter time period then the species should be given the relevant Alert status e.g. if a species has declined by 2.73% per annum over a 10-year period then it is predicted to decline by 50% over 25 years and should be given Red Alert status after 10 years. Monitoring data should be of sufficient statistical sensitivity (and better, if possible) to meet these Alert levels. The 2005 report included detailed analyses of the sensitivity achieved by the car-based approach and power analysis to evaluate alternative approaches for the future. Power analysis, which was carried out on each year's data from 2003 to 2005, was not carried out in 2006 or 2007. Power analysis will be revisited using all data to 2008 and results for this will be available in the 2003-2008 synthesis report.

The Importance of Ireland's Road Network for Bats

Ireland's small roads, most of which are lined with trees and hedgerows, constitute a major network of connectivity in the landscape. Most European bat species need to fly along linear landscape features, e.g. hedgerows, walls and tree lines, when commuting from roost to foraging site and vice versa (e.g. Fairley 2001; Limpens and Kapteyn 1991). In addition, hedgerow and tree-line habitats along many roads provide a source of insect prey for bats in flight. Bat activity in other habitats adjacent to roadsides – such as rivers, lakes, bogs and forests could also potentially be examined using data from this monitoring scheme.

Road developments can potentially impact negatively on bat biodiversity. Data collected on this programme, when analysed in conjunction with roadside habitat data, will allow more informed decisions on future road network developments to be made, potentially leading to fewer negative environmental impacts associated with such developments. Data collected from this monitoring scheme also have potential applications on a national and regional basis.

Carrying out night-time survey work along roads provides an additional opportunity to survey for other vertebrates, many species of which traverse the road network or forage along it at night.

CAR-BASED BAT MONITORING

What is a Car-Based Bat Monitoring Scheme?
This protocol is a method of monitoring bats while driving. Monitoring is carried out using a bat detector which picks up the ultrasonic (high pitched) echolocation calls made by bats and converts them to a frequency audible to the human ear. For this scheme, time expansion detectors are used, which essentially make short recordings of a broad range of ultrasound and replay the sounds at a slower speed. The monitoring is carried out along mapped routes, at a specific time of year, while driving at a prescribed speed. All sounds are recorded for analysis at a later stage.

Overall Aims of Car-Based Bat Monitoring

1. Provide a method of monitoring that can be implemented by relatively few surveyors and that does not require highly trained individuals.
2. Provide a method of data collection that is
   - objective
   - easily repeatable
   - cost effective.
3. Ensure sufficient data is collected that will allow early recognition of Red and Amber Alert declines in certain Irish bat species' populations.
4. Record other vertebrate wildlife during the survey.
5. To extrapolate information on bat activity within survey squares to determine 'hotspot' areas, and/or areas of high bat diversity.
6. To determine population trends and allow early detection of population declines or highlight increases, if any.

Future Aims

- To correlate information on bat activity with habitat availability to determine important habitats for foraging bats in Ireland.

2007 BAT MONITORING SCHEME

The Aims of this Report
This fifth annual report is an essential tool to disseminate the results to volunteers who diligently mapped survey routes and carried out survey work for many hours at night time. In addition, the yearly report aims to provide a reference source for policy and decision makers. This fifth yearly report compares the data available for the five years surveyed to-date.

For some species, trends in populations seem to be already becoming apparent. For others, large yearly fluctuations make this task more difficult. However, yearly activity levels are presented and graphical comparisons can be made. This report illustrates results from different squares around the country and examines activity distributions of the different species. Temperature data has also been included in the analysis.

Identification of Sites of Importance
Other than the Annex II listed lesser horseshoe bat for which large roosts are designated Special Areas of Conservation, there are no guidelines or criteria that can be used as a reference to indicate whether bat activity levels are particularly high (or low). This report highlights survey squares where consistently high bat activity has been recorded, based on mean encounter rates from 2004 to 2007. As data collection continues, criteria defining sites of importance are likely to become better established.

Interpretation of Bat Encounter Data
Following the discovery of echolocation in the 1950's and the subsequent development of bat detectors, there has been a vastly increased level of investigation of bat species worldwide. Bat detectors are a non-invasive method of establishing presence or absence of bats in a certain area and depending on detector type and /or observer skill, can allow identification of the species present (Elliott 1999). The present monitoring project, which requires volunteers to drive a set route at 24km per hour while recording bats using a time expansion detector, results in the collection of bat sounds that are recorded to minidisc and subsequently analysed using sonogram analysis software. From this, the bats present on a particular transect can be identified to species level (in most cases) and the number of encounters with each species per unit time or unit distance can be established. This method of data collection allows for cross comparisons in encounter rates between survey dates, between years and between survey areas. Inter-species comparisons are restricted to those species that emit similar calls at a similar loudness. The encounter rate of Leisler's bats, for example, cannot be compared directly with those of common pipistrelles since Leisler's bats

are much louder and can be detected at a greater distance compared with pipistrelles. Trends can be extrapolated over time to determine whether a population is increasing or in decline.

Encounter rates cannot be assumed to directly reflect numbers of bats. It is possible that a single bat could be recorded more than once on the same transect, although methodology has been devised to minimise the risk of repeat encounters from the same individual (Catto *et al.* 2004). For this reason, to consider the encounter rates as a direct indication of individual bats would be inaccurate and overestimate bat numbers. Encounter rates per unit time are used to indicate bat activity levels in the results section of the present report.

Factors Causing Variation in Bat Activity

Many factors may lead to variation in bat activity, these include:

- ***Air temperature***. Insect prey availability drops in low temperatures (e.g. Taylor, 1963; Williams, 1940; Wellington, 1945).
- ***Wind speed and direction***. Aerial insects swarm to the lee of windward (which could determine which side of a road the bat will fly along) (e.g. Lewis and Stephenson 1966) and bats tend to concentrate their activities closer to tree lines during high wind speeds (Verboom and Spoelstra 1999).
- ***Roost occurrence along a transect***. Buildings tend to be situated along roads and bat roosts are often found in buildings.
- ***Habitat availability***. This may not be a source of major year to year variation but overall abundance of different habitat types and, possibly, trends in hedgerow maintenance may affect bat abundance in different areas/squares.
- ***Lighting***. White street lighting can attract insects and subsequently some species of bat, while causing a decline in others (e.g. Rydell, 1992).
- ***Timing of survey work***: Seasonal and during the night.
- ***Driving speed*** – the effects of variations in driving speed were been examined using field experiments in 2005 and 2006. To reduce the impact of driving speed on results the data is now presented in bat encounters per unit time. See Roche *et al.* (2007) for details.
- ***Irish Bats and Climate Change*** - Overall, 2007 was another year with higher than average temperatures, mean air temperatures were just over one degree above normal compared with the 1961-1990 period. It was the warmest year on record in the Valentia and Malin Head observatories. The impact of man-made greenhouse gas emissions on the world's climate has become of particular concern in the past 10 years and the knock-on effect on vulnerable species of conservation concern is also of importance. For Ireland, continued increases in air temperature around the country, if they occur, are likely to impact on invertebrate availability for Ireland's bat species. In general, aerial insect abundance increases with temperature. Depending on other population limiting factors which are largely unknown, generalist foragers that are not confined to specific habitats, such as common pipistrelles, may be among the species most likely to show corresponding increases in population as a result of increased air temperature. The effects of climate change on population trends of more selective foragers, such as those that select specific habitats, will be much more difficult to predict. With increasing temperatures it is possible that new bat species will migrate and become residents in Ireland. Other factors that may affect bats include changing conditions for hibernation, increased storm events and/or windspeeds, increased rainfall and land use changes for example food or fuel crops being grown in areas previously dominated by pasture.

Weather in July-August 2007

July and August are generally the warmest two months of the year in Ireland, with average air temperature for the entire country in the region of 15°C. However, July 2007 was the first month since March when average air temperatures did not exceed the thirty year average. Particularly high rainfall was recorded from much of Leinster in the same month. August 30 year means vary from 14˚C to 15.5˚C but August 2007 was also a wet month and air temperatures did not exceed the 30 year mean. All weather data derived from www.meteireann.ie.

METHODS USED

This car-based bat monitoring method was designed by The BCT in 2003. To date much bat monitoring work has been done in other countries by foot-based trained volunteers (e.g. the UK National Bat Monitoring Programme (NBMP)) but in Ireland, a paucity of trained bat workers until 2006 has meant that such monitoring work has not been feasible. The car-based method ensures that large areas can be covered in one night and the use of a time-expansion detector means that volunteers do not need to be highly skilled in bat identification to collect the data accurately.

Training of surveyors has been carried out in summer prior to Survey 1 each year. In June and July 2007, training of new and existing surveyors by BCIreland was carried out at Belfast, Killarney, Cootehill and Glenveagh. Training materials were updated and a tailor-made training CD was supplied. In 2007, 27 surveyors, including members of BCIreland, staff of NPWS, staff of the EHS, along with field work partners, carried out surveys of a mapped route within a defined 30km ***Survey Square***. Two routes were newly mapped in 2007 (C72 and J33), the remainder had been mapped in 2003 to 2006. Adjustments were made to a number of existing routes. Every route covered 20 x 1.609km (1 mile) ***Monitoring Transects*** each of which was separated by a minimum distance of 3.2km (2 miles). Surveyors were then asked to carry out the survey on two dates, one in mid to late July (Survey 1, S1) and one in early to mid-August (Survey 2, S2). Transect coverage began 45 minutes after sundown. Each of the 1.609km transects was driven at 24km (15 miles) per hour (at night) while continuously recording from a time expansion bat detector on to minidisc.

Minidiscs were forwarded to BCIreland for analysis.

Each track was downloaded to Bat Sound™ and calls were identified to species level where possible. Species that can be identified accurately using this method are the common, soprano and Nathusius' pipistrelles (*Pipistrellus pipistrellus, P. pygmaeus, P. nathusii*). Pipistrelle calls with a peak in echolocation between 48kHz and 52kHz were recorded as 'Pipistrelle unknown' because they could be either common or soprano pipistrelles. Leisler's bat (*Nyctalus leisleri*), a low frequency echolocating species, can also be easily identified using this method. Occasional calls of *Myotis* bats were recorded but these are noted as *Myotis* spp. since they could belong to one of a number of similar species – Daubenton's, whiskered, Natterer's or Brandt's bat (*Myotis daubentonii, M. mystacinus, M. nattereri, M. brandtii*). Occasional social calls of brown long-eared bats (*Plecotus auritus*) are also recorded.

For quality control purposes a number of randomly selected .wav files from 2007 were forwarded to Jon Russ of The BCT for comparative analysis.

Statistical analysis

For overall yearly trends, a Generalised Linear Model (GLM) with a Poisson error distribution (see Glossary) has been applied to the data. Confidence intervals are generated by bootstrapping at Survey Square level (Fewster *et al*. 2000, see Glossary and Appendix I), as used in GAM analysis (see Glossary and Appendix I). This approach essentially means that the number of encounters per survey square is modelled using log of the total number of recording intervals as an offset (Offset see Glossary) but allows use of a Poisson error distribution.

Detailed methodology is given in Appendix I.

Additional GLM analysis was also carried out in 2007 to investigate the possibility of reducing the length of time spent surveying and the effects this may have on the scheme's robustness.

Other Vertebrates

Other vertebrates were also recorded by surveyors. In 2006 and 2007 surveyors were asked to note all vertebrates including cats on their record sheets. In addition, observers had the facility to record whether each specimen was living or dead and whether each was observed during or after the transect. This means that recorders were observing living and dead vertebrates, other than bats, along a 93km (58mile) route on each survey evening.

RESULTS

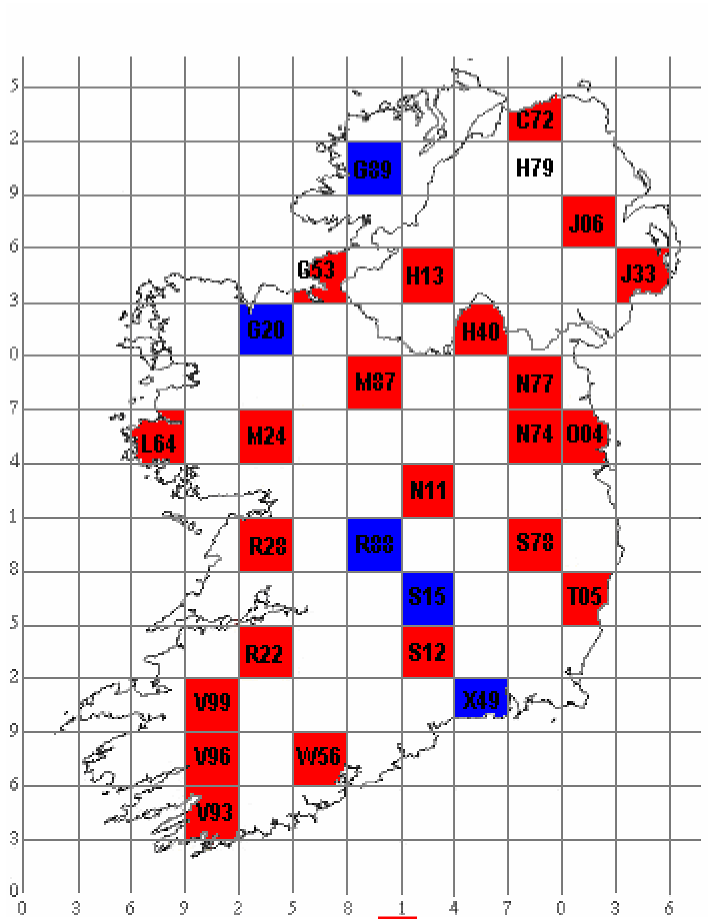

Figure 1. Squares in which surveys were carried out in 2007. Red indicates those 30km squares in which surveys were repeated. Blue squares were surveyed once in July. Squares with codes but not highlighted were surveyed in previous years but not in 2007.

Squares Covered in 2007

Seven teams participated in the 2003 pilot scheme and 17 survey routes were surveyed in 2004. Twenty one squares were surveyed in 2005. An additional five squares were surveyed in 2006, bringing the total number of surveyed squares to 26 throughout the island. Equipment for 28 squares was disseminated in 2007 and surveys were carried out in 27 of these.

Survey work in 2007 was carried out from mid-July to the beginning of August and a repeat survey was carried out in mid-August. The median date of the first survey in 2007 was 25/7/07 (compared with 24/7/06, 26/7/05 and 20/7/04 for previous survey years). The median date of the second survey was 15/8/07 (compared with 13/8/06, 15/8/05 and 13/8/04 for previous survey years).

Of the 27 squares that were surveyed in 2007, 22 of these were repeated (a total of 49 night's field work), see Figure 1. This represents 1576km of monitoring transects driven and approximately 220hrs of survey time. Limited or no data were available from transects collected on four survey routes due to problematic detectors or leads (R22 Surveys 1 and 2, T05 Survey 1, H40 Survey 2). Surveying in one square (R88 Survey 2) was abandoned at the start due to equipment problems. In general, the quality of data collected in 2007 was very good. Full datasets were available from 24 routes in July and 20 routes in August, all of which were repeat surveys. Squares that were surveyed in 2007 cover much of the Republic of Ireland, stretching from Donegal to Killarney to Wexford. The four squares in Northern Ireland that were surveyed in

2007 cover parts of Fermanagh/Tyrone, Antrim and Londonderry and include the new northerly square C72 along the coast of Londonderry.

In total, 3014 bat encounters were recorded during the July and August 2007 surveys, from 889 independent monitoring transects. This compares with 3211 bat encounters from 887 transects in 2006 and 1691 encounters in 2005 from 608 monitoring transects. Note that the total number of bat encounters does not necessarily equate to that number of individual bats since bats may be recorded more than once during a transect and/or recorded in July and again in August.

The mean time taken to complete a route (93km/58miles) in 2007 was 240 minutes (SD = 51.96, max = 386minutes, min = 131minutes). This compares with averages of 243, 237 and 233 minutes in 2006, 2005 and 2004, respectively. The mean time taken to complete a monitoring transect (1.609km/1mile) varied between survey routes. On average it took 259 seconds to complete a transect in 2007 compared with 263, 280 and 273 seconds in 2006, 2005 and 2004, respectively. As the time expansion detector system only samples for 1/11th of the time, there was an average total sampling time of 23.5 seconds per monitoring transect in 2007. Also, for every monitoring transect covered 0.146km (0.091 miles) were actually surveyed (i.e. 1/11th of the distance).

Dataset Generated

The data shown in Table 1 below illustrates the overall number of times a bat call was recorded to minidisc during the 2007 surveys (with the previous 3 years for comparative purposes). Note that the results in Table 1 of both Roche *et al.* (2005) and Roche *et al.* (2006) showed erroneous information which is corrected in Table 1 below.

Table 1: Raw bat encounter data, per 1.609km/1 mile transect, not corrected to encounters per km or per hour, Car-based Bat Monitoring Scheme 2007. Average number of bats reflects the average number of bat encounters observed during each 1.609km/1 mile transect travelled. Total Number of Transects = 889, in 2007, for all species. Also included is data for 2004 (total number of transects (n) =577 for pipistrelle and *Myotis* spp., total bats; n=597 for Leislers), 2005 (n=608), 2006 (n=887). Note that the detector records for just 1/11th of the time spent surveying so to determine the actual number of bat encounters per km this must be divided by 0.146 (the total distance sampled for each 1.609km transect).

Encounters per 1.6km transect	Common pipistrelle	Soprano pipistrelle	Pipistrelle unidentified	Myotis spp.	Leisler's bat	Nathusius' pipistrelle	Total Bats
Average in 2004	1.905	0.695	0.443	0.050	0.511	0.000	3.621
Average in 2005	1.344	0.574	0.266	0.035	0.544	0.001	2.781
Average in 2006	1.701	0.652	0.271	0.029	0.892	0.033	3.620
Average in 2007	1.77	0.639	0.253	0.036	0.631	0.015	3.390
Minimum in 2007	0	0	0	0	0	0	0
Maximum in 2007	18	13	8	9	32	2	36
Standard Dev. 2007	±2.785	±1.329	±0.67	±0.346	±1.997	±0.137	±4.385
TOTAL ENCOUNTERS 2007	**1582**	**571**	**226**	**32**	**561**	**13**	**3014**

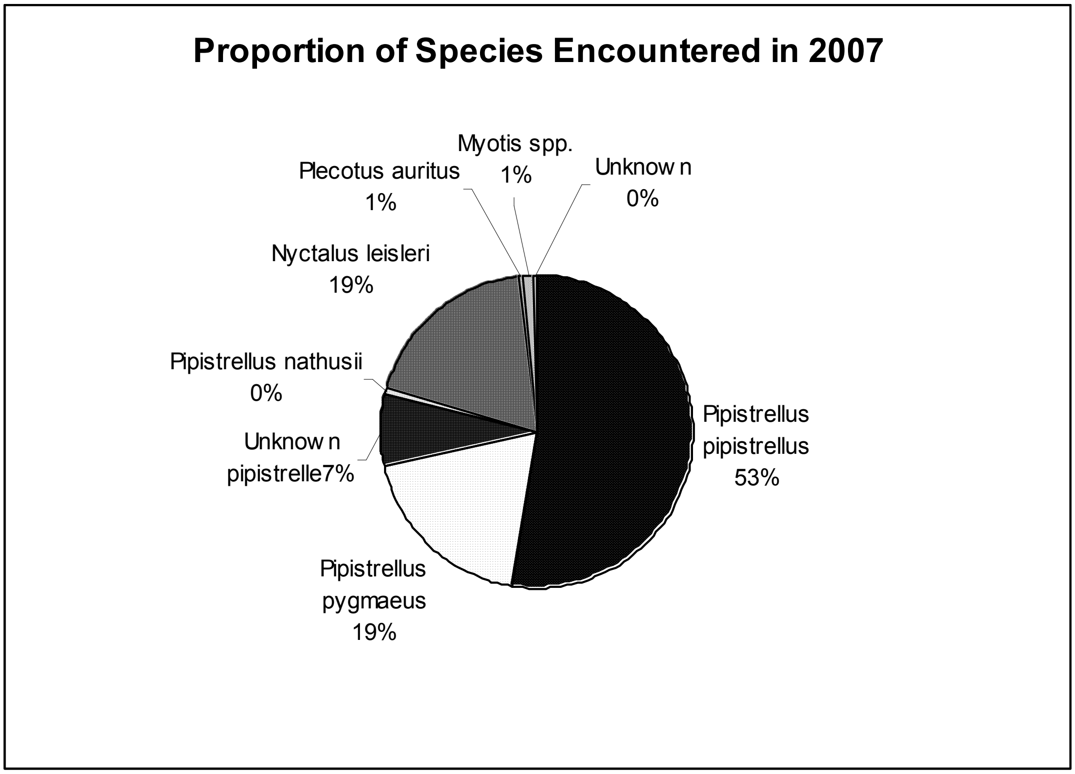

Figure 2: Proportion of species encountered during the 2007 survey. 'Other' refers to a number of calls that could definitely be ascribed to bats but could not be identified to species or species group. A separate category for *Plecotus auritus* (brown long-eared bat) social calls has been added this year. Excepting social calls of Leisler's bats and brown long-eared bats, which are unlikely to be mistaken for those of other species, bat social calls were noted during sonogram analysis but are not included in the above pie chart or in any statistical analyses.

Bat Encounters per Hour

From 2005, results were presented as number of encounters per hour of detector sampling time. Comparable results for 2007 are shown in Table 2 below.

Table 2: Average number of bat encounters per hour for each survey square, Survey 1, 2007 (number of 1 mile transects (n) = 20 for each survey unless otherwise stated). Ppip = *Pipistrellus pipistrellus*, Ppyp = *Pipistrellus pygmaeus*, Pipun = Unidentified pipistrelle echolocating between 48 and 52kHz, Pnath = *Pipistrellus nathusii*, Nl = *Nyctalus leisleri*, Myotis = *Myotis* spp., Total = total number of encounters for all species. Means derived from total number of encounters divided by total time spent sampling by the time expansion detector, corrected to 1hr.

SURVEY 1 2007	**Ppip/hr**	**Ppyg/hr**	**Pipun/hr**	**Pnath/hr**	**Myotis/hr**	**Nl/hr**	**BLE/hr**	**Total/hr**
C72$^{(n=15)}$	4.22	4.22	1.05	0.00	0.00	1.05	0.00	10.55
G20	2.78	6.96	3.48	0.00	0.00	4.87	0.00	18.78
G53	1.53	2.30	0.00	0.00	0.00	5.36	0.00	9.19
G89	16.35	11.15	2.97	0.74	0.74	4.46	2.23	38.65
H13	13.51	6.76	3.38	0.00	0.00	2.53	0.00	26.18
H40$^{(n=18)}$	20.27	23.47	6.40	0.00	0.00	6.40	0.00	56.53
J06	13.32	9.52	3.17	0.63	0.00	19.03	0.63	47.58
J33$^{(n=19)}$	13.70	14.56	6.00	0.00	0.00	0.00	0.00	34.26
L64	0.00	2.30	0.77	0.00	0.77	0.00	0.00	3.83
M24	17.88	6.22	4.66	0.00	0.00	0.78	0.00	29.54
M87$^{(n=19)}$	3.44	2.58	0.00	0.00	0.00	6.01	0.00	12.03
N11	54.97	4.10	9.85	0.82	0.00	0.00	0.82	70.56
N74$^{(n=19)}$	71.17	3.31	3.31	0.00	0.00	12.41	0.00	91.03
N77	35.18	13.91	4.09	0.00	0.00	16.36	0.00	70.36
O04	27.04	2.70	4.51	0.00	0.00	6.31	0.00	41.46
R22[*]	29.68	6.18	5.57	0.00	1.24	10.00	0.62	51.32
R28	15.15	12.98	6.49	0.00	0.00	8.66	0.00	44.00
R88	48.27	8.18	0.82	0.00	0.00	11.45	0.00	68.73
S12	68.96	21.16	3.92	0.00	0.78	23.51	0.00	118.33
S15	11.27	0.00	0.00	0.00	0.00	1.61	0.00	12.88
S78	36.36	5.32	5.32	0.00	0.00	15.96	0.00	62.97
V93	44.72	19.05	10.77	1.66	1.66	22.36	0.00	100.21
V96	38.11	14.66	8.06	0.00	0.00	19.05	0.73	81.34
V99	53.95	5.10	2.92	0.00	0.73	37.18	0.00	100.62
W56	36.09	12.26	2.72	0.00	0.00	2.72	1.36	55.15
X49$^{(n=19)}$	19.47	3.00	0.75	0.00	0.00	6.74	0.00	30.71
Average	**26.71**	**8.63**	**3.82**	**0.15**	**0.19**	**9.39**	**0.23**	**49.42**

[*] R22 is not included in the overall averages or population trend analyses since the detector was on a different time expansion setting so data is not directly comparable with other squares.

Table 3: Average number of bat encounters per hour for each survey square, Survey 2, 2007 (number of 1 mile transects (n) = 20 for each survey unless otherwise stated). Ppip = *Pipistrellus pipistrellus*, Ppyp = *Pipistrellus pygmaeus*, Pipun = Unidentified pipistrelle echolocating between 48 and 52kHz, Pnath = *Pipistrellus nathusii*, Nl = *Nyctalus leisleri*, Myotis = *Myotis* spp., Total = total number of encounters for all species. Means derived from total number of encounters divided by total time spent sampling by the time expansion detector, corrected to 1 hr.

SURVEY 2 2007	Ppip/hr	Ppyg/hr	Pipun/hr	Pnath/hr	Myotis/hr	Nl/hr	BLE/hr	Total/hr
C72 (n=19)	4.83	3.86	0.97	0.00	0.97	4.83	0.00	15.45
G53 (n=16)	4.06	7.10	3.04	0.00	3.04	1.01	0.00	18.25
H13 (n=11))	23.04	10.41	4.46	0.00	2.23	8.92	0.00	49.05
H40	9.91	36.80	4.25	0.00	0.00	9.91	1.42	62.27
J06	13.79	8.43	2.30	2.30	0.00	25.28	0.00	52.85
J33	20.39	12.74	5.10	0.85	0.00	0.85	0.00	39.93
L64	0.00	2.36	0.79	0.00	0.00	0.79	0.00	3.93
M24	14.93	21.22	8.64	0.00	0.00	1.57	0.00	46.36
M87	13.27	0.78	0.78	0.00	0.78	1.56	0.00	17.17
N11	51.26	15.12	7.56	0.00	0.00	3.36	0.00	77.30
N74 (n=19)	31.31	3.30	2.47	0.00	0.00	10.71	0.82	48.62
N77	41.82	14.99	5.52	0.00	0.79	21.30	2.37	86.79
O04	45.94	5.10	1.70	0.00	0.00	3.40	0.00	56.15
R22*	52.43	23.63	8.86	0.00	0.00	0.00	2.22	64.35
R28	21.05	13.79	2.18	0.00	0.00	2.18	0.00	39.20
S12	41.14	15.03	3.96	1.58	0.79	9.49	0.00	72.79
S78	35.40	9.99	3.63	0.00	0.00	12.71	0.00	61.73
T05	31.92	3.71	4.45	1.48	0.00	1.48	0.00	43.05
V93	48.74	29.25	13.81	0.00	8.12	31.68	2.44	134.05
V96	26.26	18.97	4.38	0.00	2.19	29.18	0.73	81.71
V99	51.99	3.25	0.81	0.00	0.81	15.44	0.00	72.30
W56	57.31	16.74	5.80	0.00	1.29	10.95	0.00	92.08
Average	**28.02**	**12.04**	**4.12**	**0.30**	**1.00**	**9.84**	**0.37**	**55.76**

Table 4: Average number of bat encounters per hour for all surveys, 2007. Ppip = *Pipistrellus pipistrellus*, Ppyp = *Pipistrellus pygmaeus*, Pipun = Unidentified pipistrelle echolocating between 48 and 52kHz, Pnath = *Pipistrellus nathusii*, Nl = *Nyctalus leisleri*, Myotis = *Myotis* spp., Total = total number of encounters for all species. Means derived from total number of encounters divided by total time spent sampling by the time expansion detector corrected to 1 hour.

All Surveys 2007	Ppip/hr	Ppyg/hr	Pipun/hr	Pnath/hr	Myotis/hr	Nl/hr	BLE/hr	Total/hr
Overall Mean	**27.31**	**10.19**	**3.96**	**0.22**	**0.56**	**9.60**	**0.29**	**52.32**
Standard Deviation	19.30	7.91	2.99	0.53	1.34	9.39	0.65	31.12
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.83
Maximum	71.17	36.80	13.81	2.30	8.12	37.18	2.44	134.05

* R22 is not included in the overall averages or population trend analyses since the detector was on a different time expansion setting so data is not directly comparable with other squares.

Common pipistrelle, *Pipistrellus pipistrellus* in 2007

The overall average number of *Pipistrellus pipistrellus* encounters per hour was 26.71 during Survey 1 in 2007 (see Table 2) compared with 28.02 (see Table 3) during the second survey. The overall average number of common pipistrelle encounters per hour for both months was 27.31 (see Table 4). This compares with an overall average of 25.8 encounters per hour in all surveys 2006.

Common pipistrelles were the most frequently encountered species during the monitoring scheme in 2007 and in all survey years to-date.

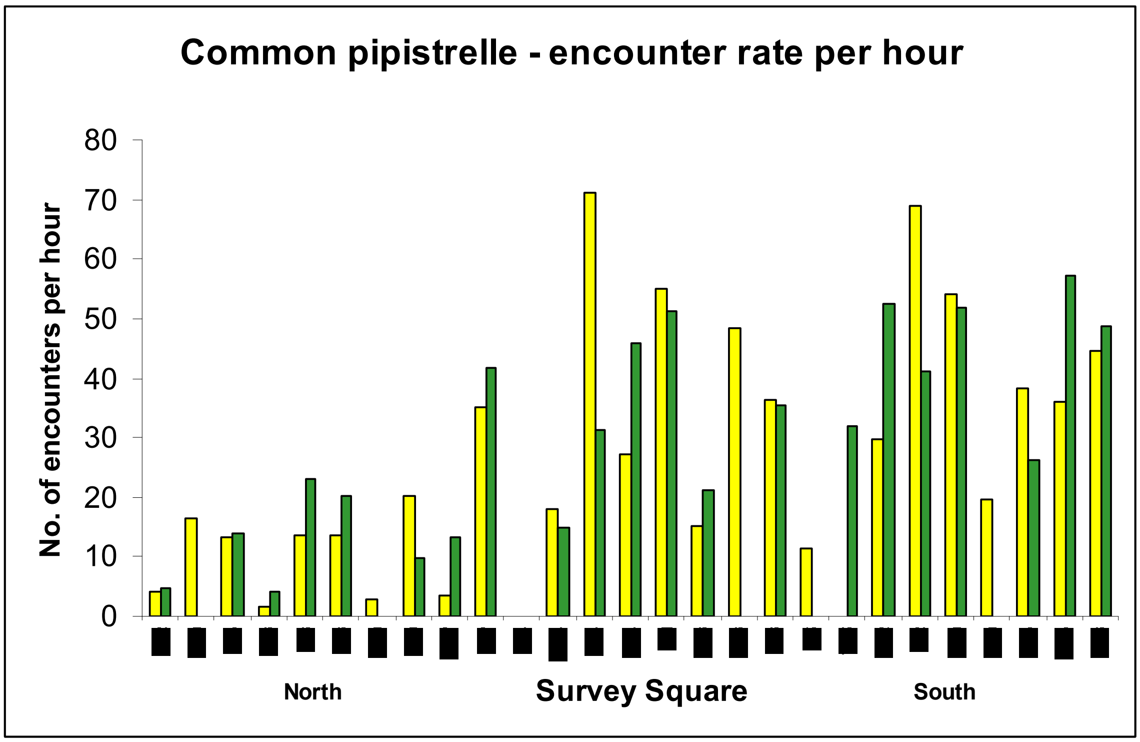

Figure 3: Average number of common pipistrelles, *Pipistrellus pipistrellus*, encountered (i.e. picked up on the detector and recorded to minidisc) per hour during July (Survey 1) and mid-August (Survey 2) in 2007. Yellow bars indicate results from Survey 1; green bars indicate results from Survey 2.

Particularly high common pipistrelle encounter rates were observed during the first survey in N74, S12 and N11, and during the second survey in W56. In L64, Connemara, no common pipistrelles have been confirmed from 2005 to 2007, the three years when surveys have been carried out in that square. Encounter rates were generally lower in northern and western squares, with some exceptions, for example, X49 and S15, which are southern squares where few common pipistrelles were recorded. Low levels of activity were observed in C72, G20, G53, M87 and S15, among others.

For common pipistrelles there is substantial variation in encounter rates between Survey Squares. 2007 continued the previously observed trend of greater common pipistrelle abundance in the south and south eastern parts of the country. This was examined in greater detail in 2006 (see Roche *et al.* 2007). This geographic difference can be seen illustrated in Figure 3 above, where bars to the left represent squares in the north and those to the right are situated progressively more southerly. Squares on the same latitude (e.g.

L64, M24, N74 and O04) are arranged westernmost first.

Figure 4 below also provides an illustration of this variation across the country. Some of the squares in County Kerry V99 and V93, and the midlands, N11 and R88, are highlighted with particularly high levels of common pipistrelle activity.

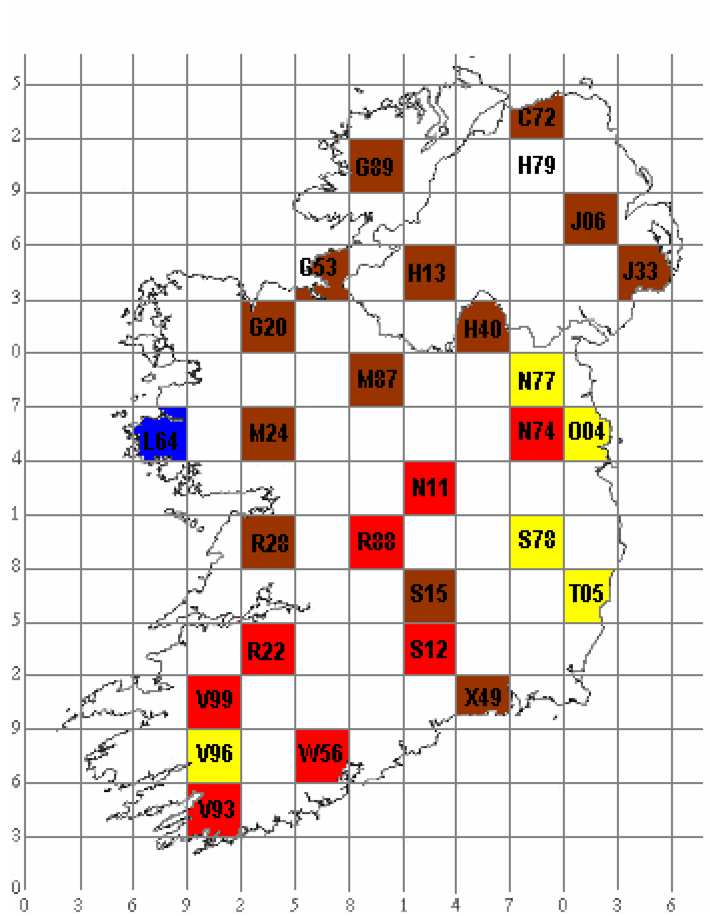

Figure 4: Survey squares colour coded according to common pipistrelle encounter rates (per hour). Map represents data from an average of the two surveys (where two are available), 2007. The overall average rate of common pipistrelle encounters for 2007 was 27.31/hr. Squares are not highlighted if no data is available.

Absent.
Encounter rate $>0\leq20hr^{-1}$
Encounter rate $>20\leq40hr^{-1}$
Encounter rate $>40hr^{-1}$

Additional information from REML models shows that transect number is also a highly significant factor correlating with common pipistrelle abundance and fitting a complex curve suggests that this is because numbers are generally lower than average in the first few transects of each survey. This suggests that start time is an important factor for the surveys. For further details see Figure 19.

Yearly Activity

Figure 5 below shows mean common pipistrelle passes per survey, adjusted to represent the situation if all surveys had the average number of 0.32ms recordings.

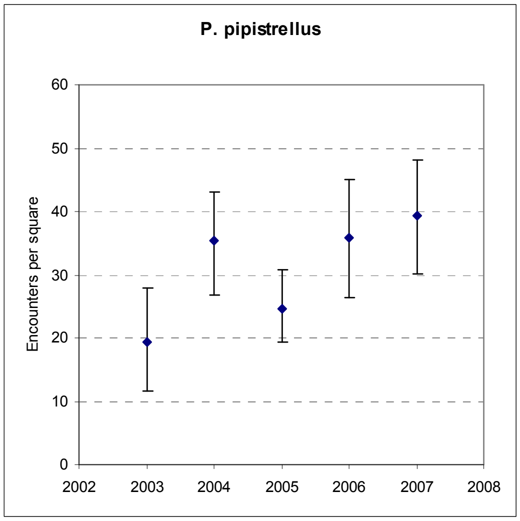

Figure 5: Results of the GLM model for encounters of common pipistrelles per survey. Bars are 95% bootstrapped confidence limits.

Results of the GLM model, in which encounter rates are adjusted to allow for site effects, show that 2007 had the highest average common pipistrelle encounters per survey of all survey years since 2003. In 2003, lower encounter rates may have arisen from later survey dates, lower number of survey squares and an earlier starting time. 2007 was the first year when the yearly common pipistrelle encounter rate deviated from an oscillating pattern. It is worth noting that the trend graph (Figure 5) shows the encounter rate for 2004 as lower than 2007. While this seems at odds with the results shown in Table 1 and others the discrepancy arises as a result of the different squares surveyed in 2004 compared with 2007. In 2007, more squares in the north were included in the data compared with 2004 when squares were confined to the Republic and, even then, mainly the south and midlands were surveyed. The GLM model adjusts the encounter rate to account for these site effects, hence the encounter rate for 2004 appears lower than what was actually recorded.

While year 5 of the survey is a little early to determine trends a simple linear model was fitted to the data. For common pipistrelles the lower and upper bootstrap confidence limits were positive. This could, with caution, indicate an increase in common pipistrelle encounters over time. Exact trends will only be determined with more years' data, however.

Temperature Analysis

Mean monthly temperatures for July and August from climatological stations within or closest to each survey square in the Republic (data was not available from the UK Met Office at the time of analysis) were included in REML analysis with common pipistrelle encounter rates per hour (logged) from each square for the years 2004 to 2007.

A significant positive relationship was found between common pipistrelle activity levels and temperature when data for all ROI squares were included (coefficient (log scale) = 0.024, se = 0.0112, p = 0.034).

Soprano pipistrelle, *Pipistrellus pygmaeus,* in 2007

The overall average number of *Pipistrellus pygmaeus* encounters per hour was 8.6 during Survey 1 in 2007 and 12.4 during Survey 2 (2006: 9.9 in Survey 1, 9.6 in Survey 2), see Tables 2 and 3. The overall average number of soprano pipistrelle encounters per hour for both months was 10.2 (9.75 encounters per hour in 2006), see Table 4.

The soprano pipistrelle was the second most frequently encountered species during the monitoring scheme in 2007. In all previous survey years, except 2006, soprano pipistrelles were also second most frequently encountered species.

Particularly high encounter rates were observed in 2007 in H40 (both Surveys) and V93 (Survey 2) (see Figures 6 and 7). Particularly low levels of activity were observed in S15 (where the species was absent during the survey carried out in July), M87 and L64 (both surveys). The soprano pipistrelle was the only pipistrelle species confirmed in L64 from 2005 to 2007, the three years when surveys have been carried out there. See figure 6 for a graphic comparison of encounter rates in different survey squares during each survey.

In other years, encounter rates for this species tended to be somewhat higher in certain western survey squares. In 2006 REML modelling indicated that this negative relationship between encounter rates and grid reference eastings was not quite significant (p=0.09). There was no relationship between soprano pipistrelle abundance and northings (p=0.852) (Roche *et al*. 2007). In 2007, the map of different soprano pipistrelle encounter rates does not appear to provide evidence to support the western survey square hypothesis (see Figure 7). Low encounter rates seem to be widely distributed around the country and high encounter rate squares appear to the concentrated in the south of the island, with some additional high encounter rate squares in the north east. Trends in this species' relative distribution may become more apparent with time.

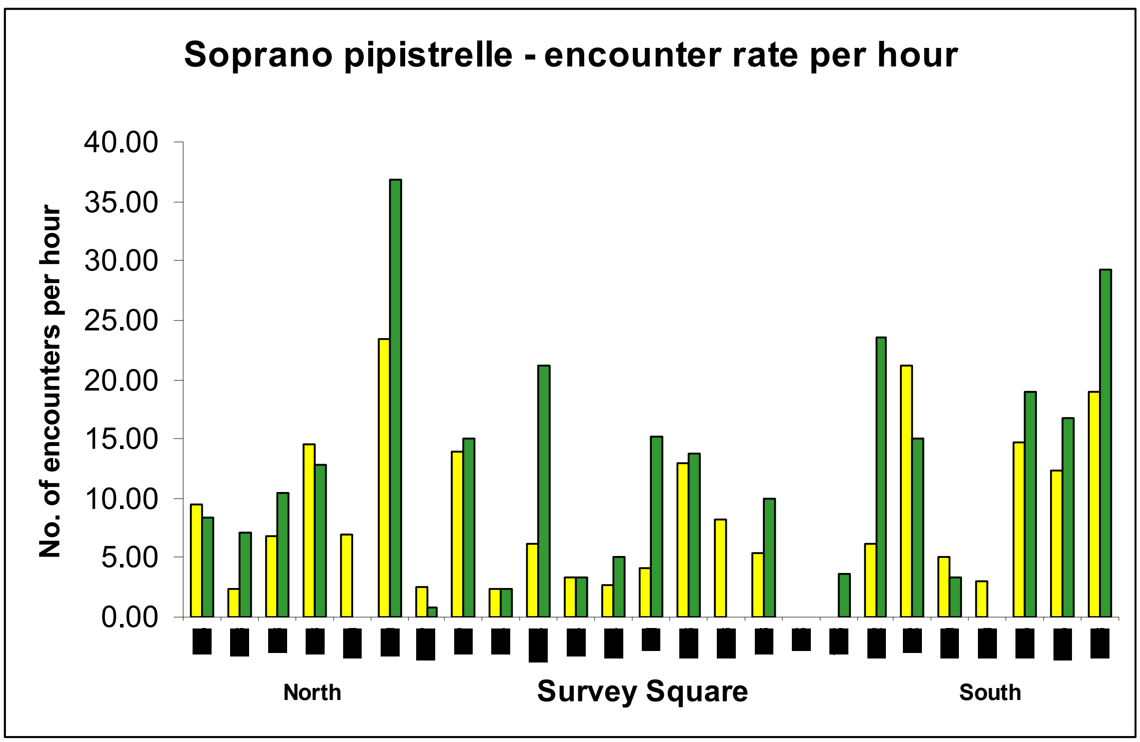

Figure 6: Average number of soprano pipistrelles, *Pipistrellus pygmaeus*, encountered (i.e. picked up on the detector and recorded to minidisc) per hour during July (Survey 1) and mid-August (Survey 2) in 2007. Yellow bars indicate results from Survey 1; green bars indicate results from Survey 2.

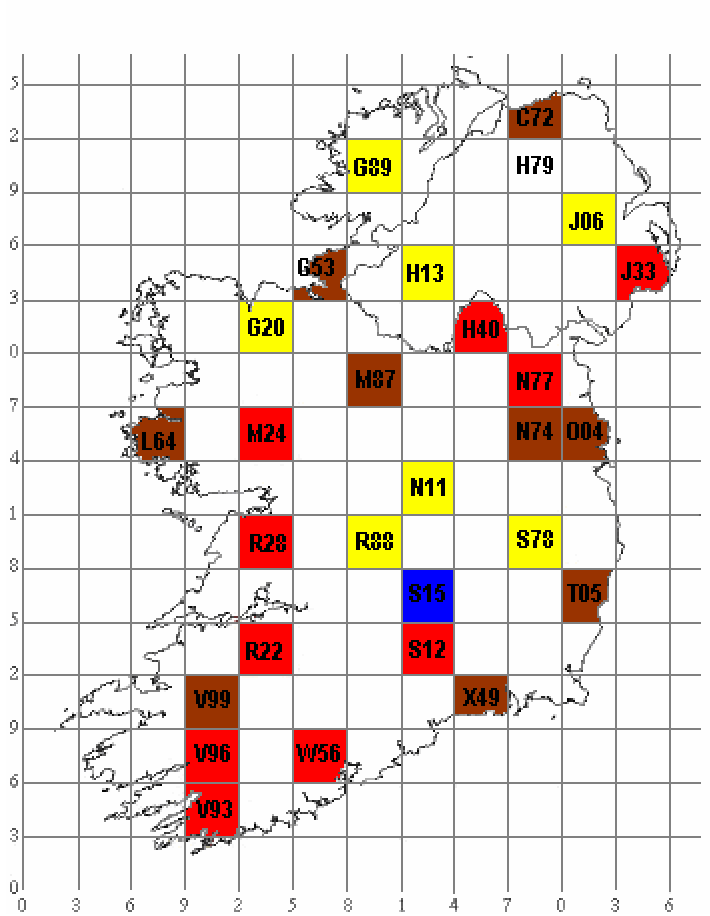

Figure 7: Survey blocks colour coded according to soprano pipistrelle encounter rates (per hour). Map shows average data from both surveys, 2007 (where two are available). The overall average rate of soprano pipistrelle encounters for 2007 was 10.2hr^{-1}. Squares are not highlighted if no data is available.

- Absent (Survey 1 was carried out in S15 in 2007).
- Encounter rate/km >0≤6hr^{-1}
- Encounter rate/km >6≤12hr^{-1}
- Encounter rate/km >12hr^{-1}

Yearly Activity

Figure 8 shows mean soprano pipistrelle encounters per survey, adjusted to represent the situation if all surveys had the average number of 0.32ms recordings. The encounters per survey are also adjusted to account for site effects.

The recorded encounter rate for soprano pipistrelles was slightly higher in 2007 compared with 2006 (e.g. Table 1), but when site and other effects are allowed for, using GLM, year 2007 had, in fact, slightly lower average soprano pipistrelle encounters per survey than 2006 (see Figure 8). In 2003, particularly low encounter rates may have arisen from slight differences in methodology as described for common pipistrelles above.

2007 was the first year when an oscillating pattern was not evident in soprano pipistrelle encounter rates. Trends in soprano pipistrelle abundance are still not apparent. When a simple model with a linear trend over time is applied to the data, bootstrapped confidence limits span zero so it is not yet apparent if the encounter rate is increasing, decreasing or stable.

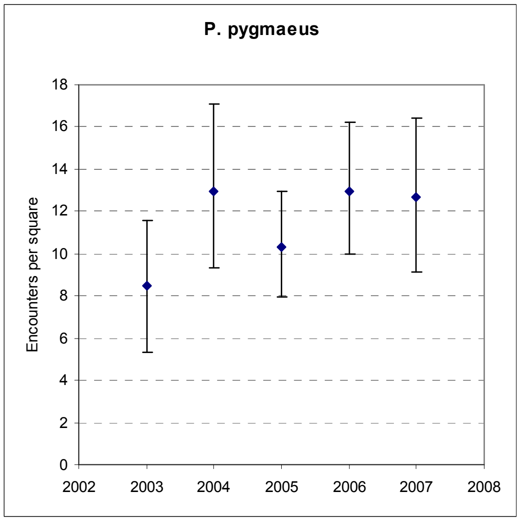

Figure 8: Results of the GLM model for encounters of soprano pipistrelle per survey. Bars are 95% bootstrapped confidence limits.

Temperature Analysis
Mean monthly temperatures for July and August from climatological stations within or closest to each survey square in ROI were included in REML analysis with soprano pipistrelle encounter rates from each square for the years 2004 to 2006.

A close to significant, positive relationship was found (coefficient (log scale) = 0.017, se =0.009, p=0.067) between soprano pipistrelle activity levels and temperature when data for all ROI squares were included.

Leisler's bat, *Nyctalus leisleri*, in 2007

The overall mean number of *Nyctalus leisleri* encounters per hour for 2007 was 9.39 in Survey 1 and 9.84 in Survey 2 (see Tables 2 and 3). This compares with 17.4 during Survey 1 2006 and 10 during Survey 2 2006. The overall average for both months in 2007 was 9.6 (see Table 4).

Particularly high Leisler's bat encounter rates were observed in V99 (Survey 1), V93 and V96 (Survey 2), and J06 (Survey 1) (see Figure 9). Low encounter rates were recorded from J33, L64, M24, S15 and T05.

Apart from high encounter rates in J06 and N77, there appears to be a general rise in Leisler's bat activity in more southern squares.

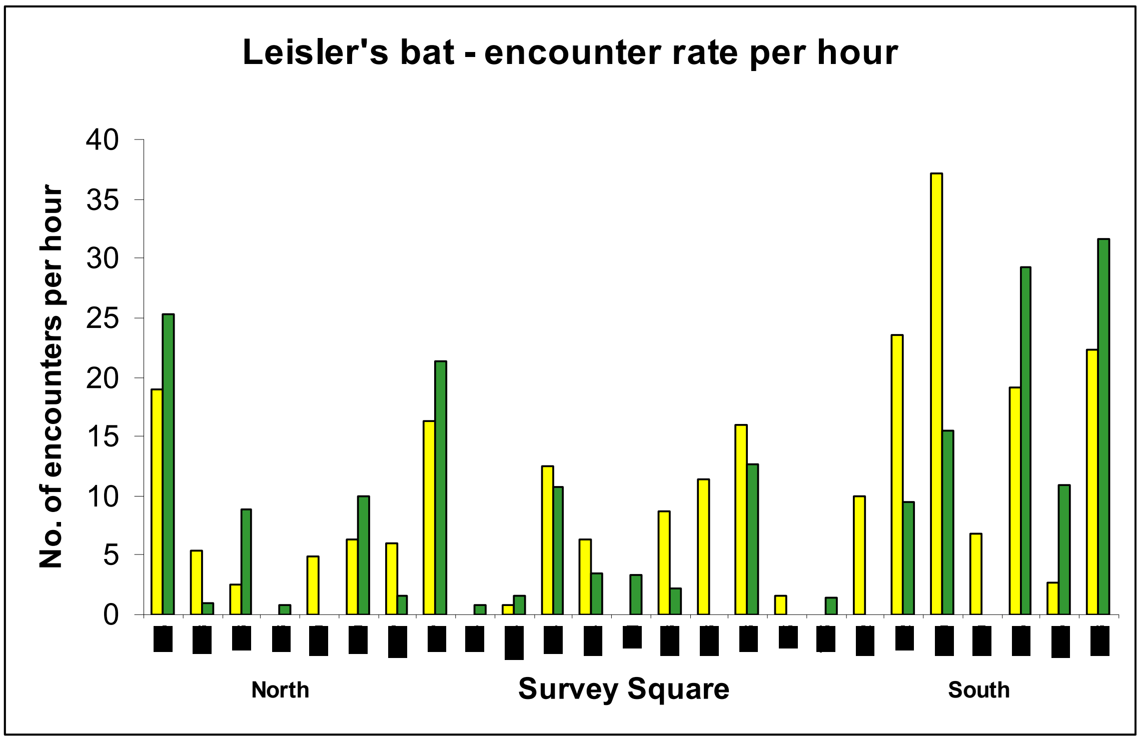

Figure 9: Average number of Leisler's bats, *Nyctalus leisleri*, encountered (i.e. picked up on the detector and recorded to the minidisc) per hour during July (Survey 1) and mid-August (Survey 2) in 2007. Yellow bars indicate results from Survey 1; green bars indicate results from Survey 2.

.

Figure 10 provides an indication of particularly high encounters rate survey squares for 2007. The colour coding indicates a southern and eastern distribution for the bat, although it was encountered in all survey squares around the island. The easterly and southerly activity distribution of Leisler's bat was confirmed by REML analysis in the report for 2006 (Roche *et al*. 2007).

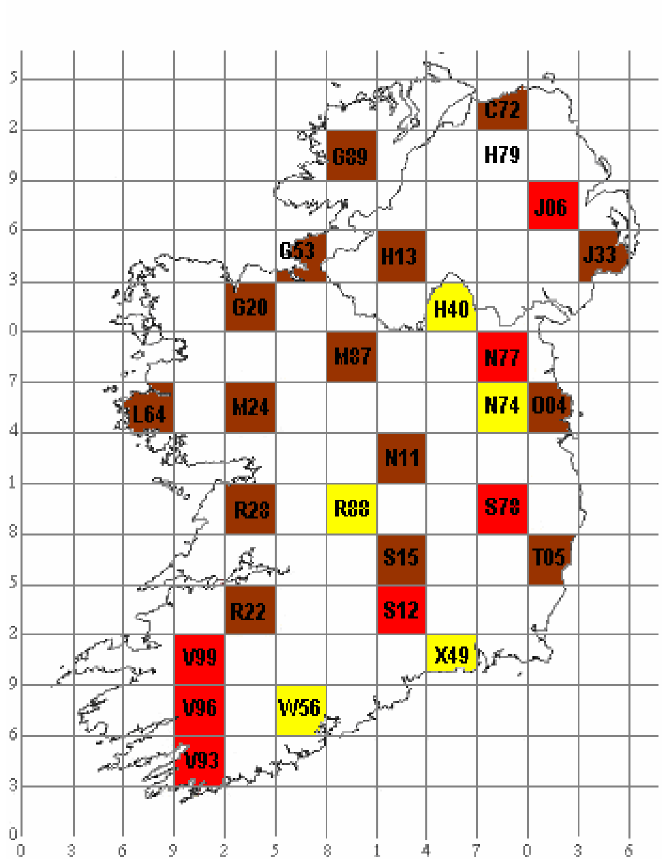

Figure 10: Survey blocks colour coded according to Leisler's bat encounter rates (per hour). Map represents average data from both Survey 1 and Survey 2 2007 where data from two surveys are available. The overall average rate of Leisler's bat encounters for 2007 is $9.6hr^{-1}$. Squares are not highlighted if no data is available. Note a change in scale from the same figure in the 2006 report (Roche *et al.* 2007) due to an overall decline in encounter rates in 2007.

- Absent.
- Encounter rate/km $>0\leq6hr^{-1}$
- Encounter rate/km $>6\leq12hr^{-1}$
- Encounter rate/km $>12hr^{-1}$

Yearly Activity

Figure 11 shows mean Leisler's bat encounters per survey, adjusted to represent the situation if all surveys had the average number of 0.32ms recordings. The mean is also adjusted to allow for site effects.

The year 2006 had higher average Leisler's encounters per survey than any survey year to date. 2007, by comparison, saw a decrease in encounters. In 2003, particularly low encounter rates may have arisen from slight differences in methodology as described for common pipistrelles above.

Figure 11 below indicates that Leisler's bat abundance may be showing an increasing trend. A simple linear model was fitted to the data to allow an initial examination of trends and the lower and upper bootstrapped confidence intervals for Leisler's bat were both greater than zero. This implies that Leisler's may be on an increasing trend but this will only be verifiable in future survey years. The increasing trend is strongly influenced by high numbers encountered in 2006.

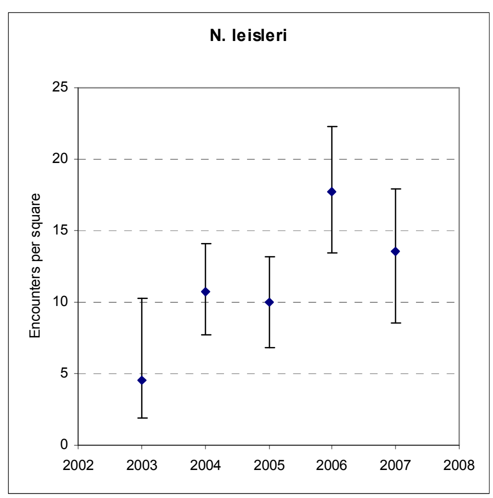

Figure 11: Results of the GLM model for encounters of Leisler's bats per survey. Bars are 95% bootstrapped confidence limits.

Temperature Analysis

Mean monthly temperatures for July and August from climatological stations within or closest to each survey square in ROI were included in REML analysis with Leisler's bat encounter rates from each square for the years 2004 to 2006.

A highly significant positive relationship was found between Leisler's bat activity levels and temperature when data for all ROI squares were included (coefficient (log scale) = 0.032, se = 0.0089, $p<0.001$).

Nathusius' pipistrelle, *Pipistrellus nathusii,* in 2007
This species was recorded for the first time by the car monitoring scheme in 2005 in square N77, the North-East. This species is known to be resident in Northern Ireland and, while it has been recorded in the Republic, its status there is somewhat unclear. By 2005 it had been recorded by detector as far south as Killarney National Park (C. Kelleher *pers. comm.*).

The car-based bat monitoring results for 2006 saw a dramatic increase in Nathusius' pipistrelle encounters across the country. While some of these occurred in newly surveyed squares in Northern Ireland, where Nathusius' pipistrelles may be expected to occur, additional recordings of the species were made in squares that had been surveyed for a number of years prior to 2006 but where the species had not previously been recorded. R22, S78, T05, N11 and V96 were among the first squares mapped and surveyed in 2003 and most have been surveyed every year since, but Nathusius' pipistrelle was recorded in each in 2006 for the first time.

In 2007 the Nathusius' pipistrelle was encountered in additional squares but it was not observed in all of the squares where it was encountered in 2006. Overall, the mean encounter rate for the species was 0.13 per hour in Survey 1 and 0.3 per hour in Survey 2, 2007. This compares with 2006 means of 0.67 in Survey 1 and 0.3 for Survey 2. The overall mean encounter rate was 0.22 for 2007.

The average number of Nathusius' pipistrelle encounters per hour per square for each survey is not plotted because of the low number of occurrences.

Most of the records for Nathusius' pipistrelles from the 2006 car-based bat monitoring scheme were located in the eastern half and the south west of the island. In 2007, however, the species was also recorded in Donegal – square G89 in the north-west, see Figure 12 for details of absence/presence in both 2006 and 2007.

Despite an overall low encounter rate with Nathusius' pipistrelle by the car monitoring scheme, Figure 13 does indicate an upward trend for the species. When a simple model is fitted to the data, with a linear trend over time, bootstrapped confidence intervals for Nathuisus' pipistrelle are positive (both upper and lower intervals). This implies a significant increase, but this can only be confirmed when data has been collected for a longer period.

Also of interest is the breakdown of results for different squares. While Northern Ireland is known as a stronghold for this bat and J06, in particular, has had Nathusius' pipistrelle passes on all surveys to-date, the encounter rates for different squares in the Republic where the bat has been recorded can, in fact, be similar to the encounter rate to squares in Northern Ireland. For example, in J06 (2007), the average encounter rate per hr of Nathusius' pipistrelle was 1.47. In T05, Wicklow/Wexford, the average encounter rate with the species was 1.48 (in 2007). Other average encounter rates varied from 0.41 to 0.83. In J33, the other Northern Ireland square where the species was recorded in 2007 the encounter rate for the species was 0.42. While these results imply that the overall abundance of the Nathusius' pipistrelle is still very low throughout the island, compared to the other pipistrelle species, they also suggest that in some locations where it does occur in the Republic, it could potentially be as common as in the most abundant locations in the North.

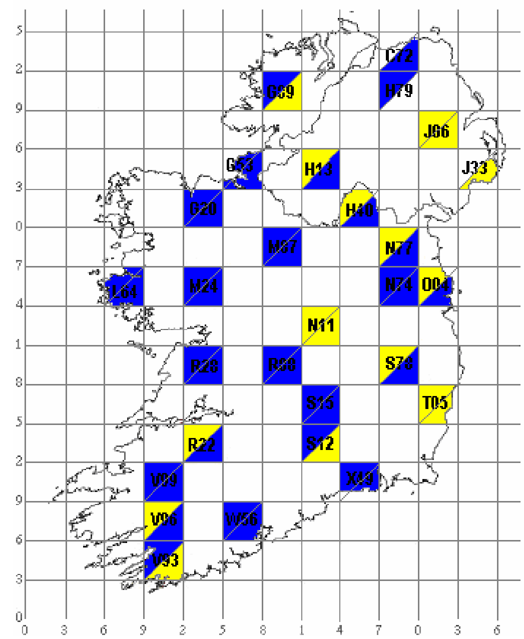

Figure 12: Survey blocks colour coded according to Nathusius' pipistrelle absence/presence in 2006 and 2007, both surveys from each year. Locations where Nathusius' pipistrelles occurred are highlighted in yellow. Blue indicates an absence of records. Each square is divided into two with the top left representing the result from 2006 and the bottom right representing the result from 2007. Where a year is not highlighted no data was available for that year (e.g. C72 2006 and H79 2007).

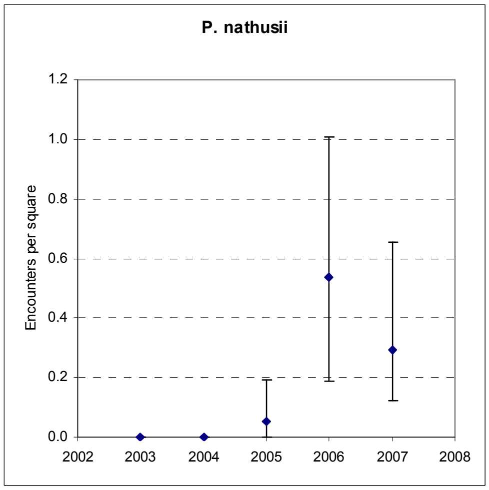

Figure 13: Results of the GLM model for Nathusius' pipistrelle encounters per survey. Bars are 95% bootstrapped confidence limits.

Myotis bats in 2007

The overall mean number of *Myotis* encounters per hour for Survey 1 in 2007 was 0.19 (see Table 2). The Survey 2 average was 1.00 encounters per hour (see Table 3). The overall average for both surveys in 2007 was 0.56 (see Table 4). This compares with the 2006 average of 0.43 encounters per hour.

The average number of *Myotis* bat encounters per hour for the two survey months is not plotted because of the low number of occurrences.

Myotis bats were recorded from 14 of the 27 squares surveyed in 2007, see Figure 14. Locations of *Myotis* bat records from the 2007 car-based bat monitoring scheme are widely distributed throughout the country.

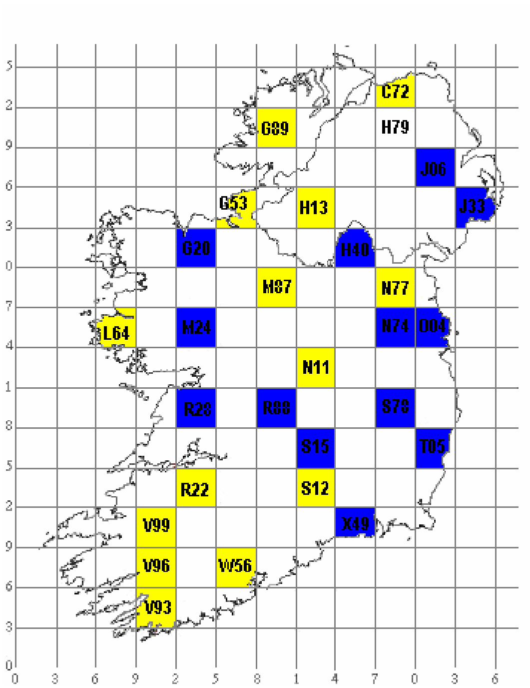

Figure 14: Survey blocks colour coded according to *Myotis* bat presence/absence in 2007, both surveys. Locations where *Myotis* bats occur are highlighted in yellow. Blue squares indicate an absence of records. Squares are not highlighted if no data is available.

Myotis bats occur in such low numbers during the car-based bat monitoring survey that little can be determined about trends, due to the large error bars surrounding each yearly estimate (see Figure 15). A simple model fitted to the Myotis data with a linear trend over time does not give any indication of trends either since the bootstrapped confidence intervals encompass zero. Should trends in Myotis encounter rates become apparent in time, these should be treated cautiously since the results for Myotis bats are likely to comprise a number of species.

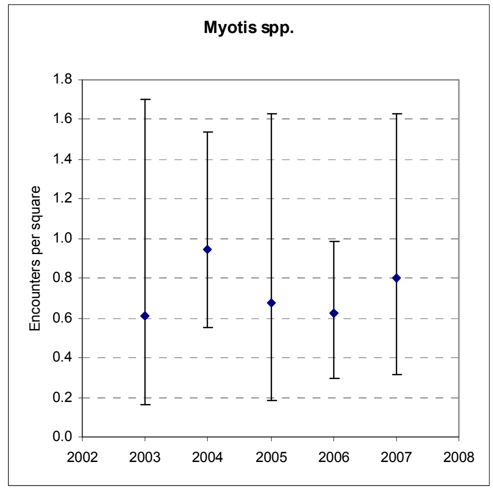

Figure 15: Results of the GLM model for *Myotis* encounters per survey. Bars are 95% bootstrapped confidence limits.

Brown long-eared bat, *Plecotus auritus*, in 2007

This species was encountered for the first time by the car monitoring scheme in 2005. The species is largely undetectable by the scheme due to its quiet echolocation calls. However, it does occasionally produce social calls of higher amplitude (loudness). These social calls were recorded on three occasions in 2005, 21 times in 2006 and 17 times in 2007. Locations of Survey Squares where the species was recorded making social calls in 2007 are shown in Figure 16.

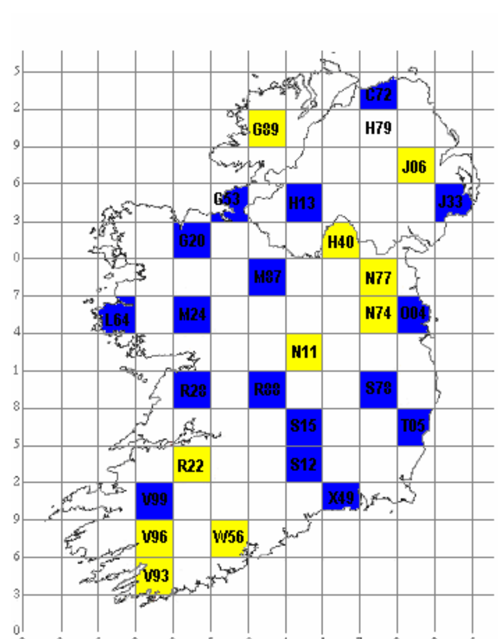

Figure 16: Survey blocks colour coded according to brown long-eared bat social call presence/absence in 2007, both surveys. Locations where brown long-eared bats occur are highlighted in yellow. Blue squares indicate an absence of records. Squares are not highlighted if no data is available.

Activity Hotspots

Average encounter rates for particular survey squares are subject to a high level of random variation during each survey. In addition, some squares (such as those in Northern Ireland) have only recently been added to the survey so a lower number of surveys have been conducted in these compared with some of the squares further south. However, as a rough exercise in determining overall encounter rates for different squares, the total number of bat encounters per hour was averaged for each square from 2004 to 2007. For some squares a full dataset is available, therefore N=8, however, for others, for example J33 and C72 which were surveyed for the first time in 2007, N=2. The following map (Figure 17) illustrates a gradation in overall encounter rates with higher encounters in the south west and a couple of midlands squares, with decreasing encounters in the north and north-west. The average total bat encounter rate per hour for all squares from 2004 to 2007 was 53.79.

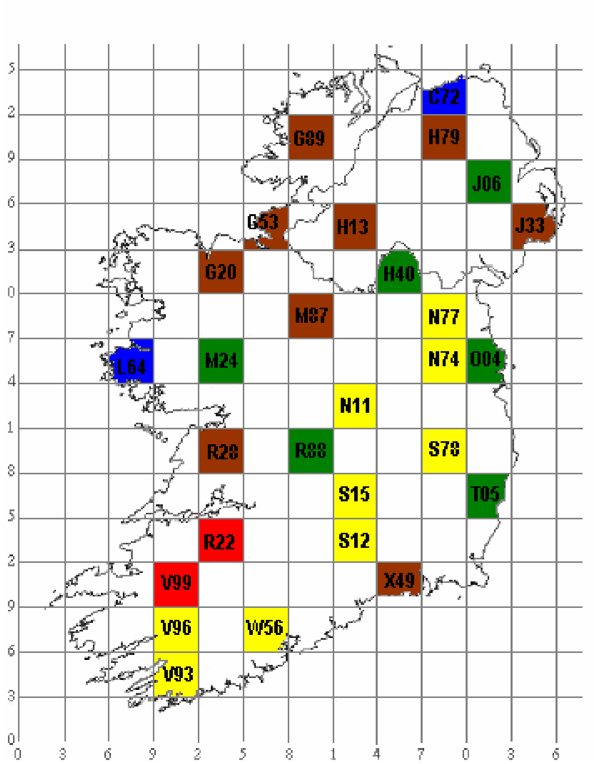

Figure 17: Survey blocks colour coded according to overall total bat encounter rates (per hour) from 2004-2007. Map represents average data from all surveys available, N=2-8 depending on the square. The overall average rate of total bat encounters for 2004 to 2007 was 53.79hr^{-1}.

Encounter rate/hr >0≤20
Encounter rate/hr >20≤40
Encounter rate/hr >40≤60
Encounter rate/hr >60≤80
Encounter rate/hr >80

According to the results shown in Figures 18, squares V99 and R22 have particularly high encounter rates. However, the total number of surveys that have been successfully conducted in these squares is quite low (V99 n=4 and R22 n=4). The square V96 almost makes it in to the top 'red' category with an average, derived from 8 surveys, of 79.22 bat encounters per hour. According to Figure 17 a number of squares in the midlands and east also have high encounter rates ('yellow' category). Lowest encounter rates, as may be expected, are found in squares along the northern and western seaboards. X49 continues to show somewhat anomalous results with consistently low encounter rates, despite its location in the south of the island. Habitat analysis may contribute to some understanding of this result.

This map should be viewed cautiously since the overall average encounter rate is likely to be foremost affected by the occurrence of the most common species, the common pipistrelle. Indeed decreasing encounter rates with higher latitudes reflects the relative distribution of the common pipistrelle (e.g. see Figure 4). Therefore, it may also be of benefit to examine bat biodiversity in tandem with encounter rates. This will be discussed in the Discussion section.

Length of Survey Time

This was the fifth year of car-based bat monitoring in Ireland. While the feedback given by most volunteers is positive and most are happy to continue surveying from one year to the next, the overall length of time taken to complete the survey is usually greater than 3.5hrs for a team of two. Some surveys take longer. In addition, some teams have a drive to and from the start and end points, further adding to their time commitment during night time when driver tiredness is a potential safety hazard. Therefore,

- to ensure safe working practices
- assuming continuing increases in oil prices
- and to minimise the carbon footprint of the scheme

a review of the survey methodology is necessary in order to devise a statistically robust way to cut down on survey times for volunteers.

Possible ways to reduce survey time include:

1. **Cutting out the two mile gaps** between transects and driving a continuous route at 24kmph, in a similar manner to the IBATS surveys across Romania and Bulgaria (e.g. see www.ibats.org.uk). This would have an added benefit in that Irish data would then be comparable to data from several monitoring projects across Europe. Data from 2003 to present would not necessarily be directly comparable with data collected in the future, however.

2. **Keeping the two mile gaps but decreasing the total number of transects surveyed**. While this would ensure that all Irish data from 2003 onwards would continue to be comparable, there is a possibility that reductions in transect numbers would result in a loss of Power. From this, a need may arise to survey extra squares each year, therefore potentially adding to administrative and equipment costs, and possibly negating any decrease in carbon emissions/fuel costs. This approach would also mean that Irish data was comparable to other European projects' data in a more limited way than 1 above.

1. Cutting out the two mile gaps

To address the first point, REML variance components were examined to get some idea of the important sources of variation and to examine the effect of some variables of interest. Figure 18 shows the relative magnitudes of the variance components. The first variance component is illustrated in dark purple at the top of each column. This variance component shows the variation between repeats within years and within transects. Since this is the lowest level of random variation, and as is usually the case with bat survey data, it is the biggest source of variation for all species, i.e. there is a high level of variation within each transect from Survey 1 to Survey 2 in the same year. The next variance component shown in Figure 18 (in pale blue) indicates year on year variation within transects. For all species the variation from year to year in a particular transect is much less than the variation in the same year for the same transect. Following this is the pale yellow variance component, 'Years within Squares', which is also low for all species and this shows that for the same square, there is consistency in encounter rates from year to year. The fourth variance component shown in dark pink is the variation between monitoring transects within squares. This is the second most important variance component for the three main species picked up by the survey; common pipistrelle, soprano pipistrelle and Leisler's (after reps.year.transect). This shows that there is more variation in encounter rates of these species at the level of the 1.6km transects than at the level of 30km squares. This also indicates that some transects have consistently higher bat encounter rates than others, perhaps suggesting that factors such as local habitat are more important than wider geographic differences. The consistency in counts from the same 1.6km transect over time, might either be due to the suitability of the habitat or the time it is surveyed, or some combination of the two. Either way, something would be lost by leaving out the two mile gaps, since counts after the change was made would not be exactly comparable with the previous ones. It might be possible to allow for the difference, particularly if it proved to be more of a time of the night effect, rather than due to habitat, but there would always be some doubt about its impact. The fifth and final variance component in Figure 18 shows the variation between squares and this is relatively high for common pipistrelles but lower for soprano pipistrelles and Leisler's bats.

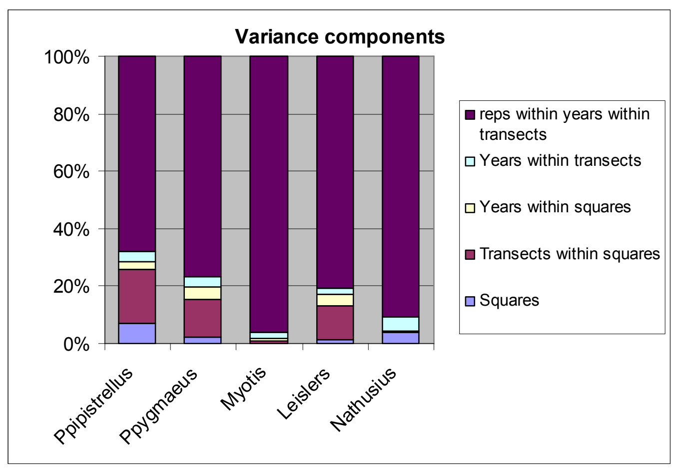

Figure 18: Relative sizes of variance components from a REML model.

2. Keeping the two mile gaps but decreasing the total number of transects surveyed.

This could be achieved by stopping after the first 10 or 12 transects on a survey route. The loss of precision that this would cause can be evaluated by deleting transects from the existing data and carrying out power analysis on the revised data. Power analysis is not, however, due to be completed again until the data from 2008 has also been collected. Therefore, to facilitate a decision on whether to change the method, an initial GLM analysis, with different numbers of transects deleted, has been carried out to look at various scenarios. Power analysis to more fully examine the effects of decreasing transect numbers will be carried out in 2008 to facilitate decisions on methodology and possible equipment requirements for the 2009 season onwards.

The GLM analysis was done with 5, 10, and 15 one mile transects remaining in each square. While 5 transects would be too small a sample size for the survey, including this small number makes it easier to see patterns where they occur. One factor that may be important is the influence of start time. For common pipistrelles, soprano pipistrelles and Leisler's there is strong evidence that bat activity increases as the survey progresses but then starts to drop off in the later transects. Figure 19 below shows the relationship between bat encounter rates (based on a REML analysis of 2003-2007 data) and transect number. The red lines are smoothed curves (GAM with 4 degrees of freedom).

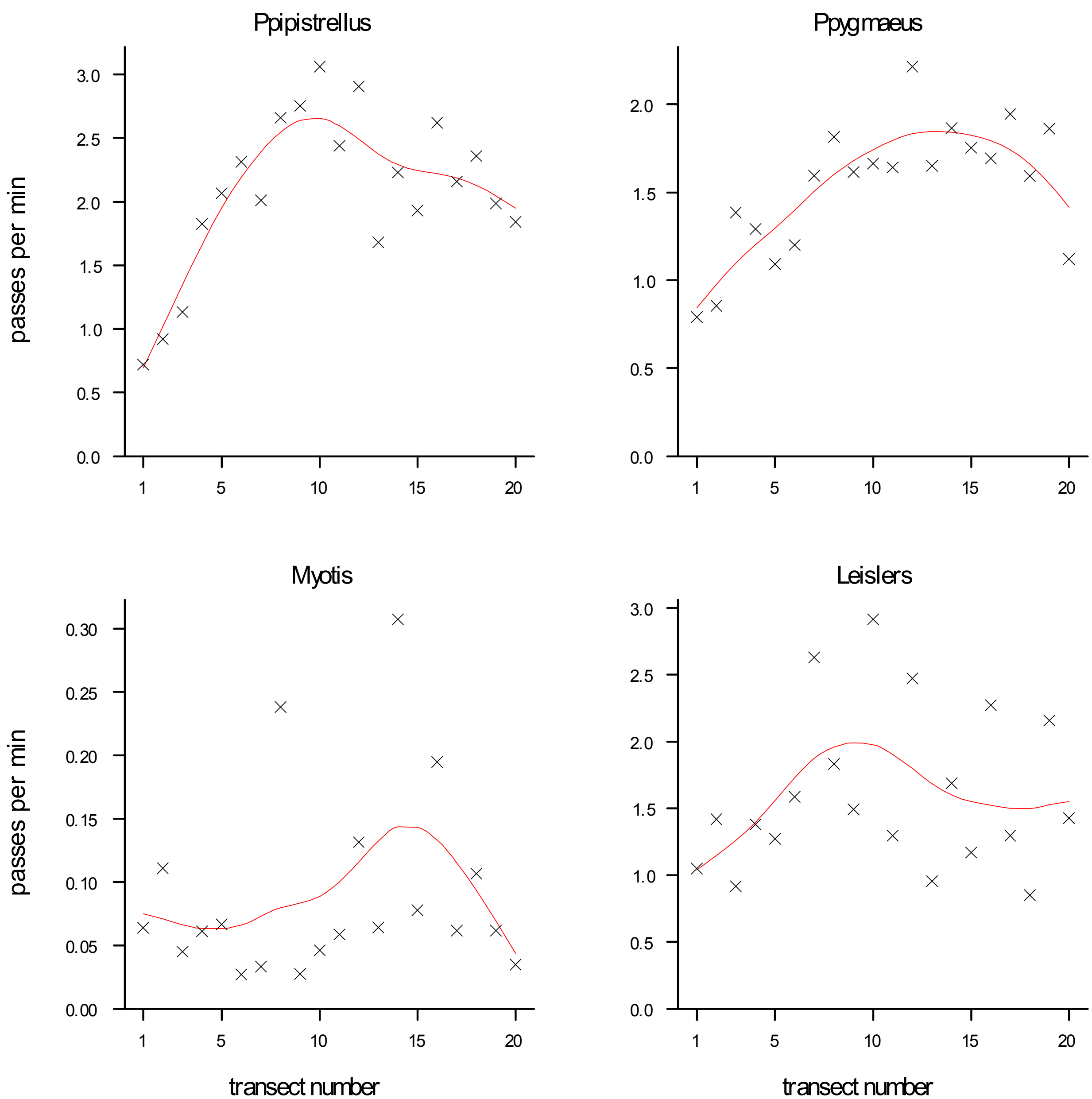

Figure 19: The relationship between bat passes and transect number, based on data from 2003 to 2007. Crosses are estimates from a REML analysis. The red line is a smoothed curve (GAM with 4 d.f.) fitted through these estimates.

Given the trends with transect numbers as shown above it might make a difference to the robustness of the data as to which transects are retained. Therefore, for a 10 ten transect option three different possibilities were examined for the three most common species:

1. Transects 1-10; i.e. driving the route as usual but stopping after the tenth.
2. Transects 6-15; i.e. starting at transect 6 and stopping after number 15. Since the results really come from the full set of transects, this assumes that the route would be started around an hour later, so that the transects are completed at the same times as previously. This might not, however, be ideal in practice.
3. Transects 11-20, starting around two hours later.

Graphs on the right of each of the following Figures (20-22) show the relative standard error (RSE; see Glossary), i.e. the standard error of the annual estimates expressed as a percentage of the estimate. A high RSE implies that the design would provide a poor estimate of trend.

Figure 20 shows the results for common pipistrelles. The first graph is a direct equivalent of Figure 5, the common pipistrelle trend graph, so the black 'all 20' line is identical to the real results. Results from 2003 have been excluded due to the low numbers of squares completed. All results have been adjusted back up to the standard 1,500 recording periods, so they are directly comparable. On the whole, the pattern of the other lines is similar to the real ('all 20') line, with the exception of the 'first 5' line, which is clearly not performing well. The dark blue 'middle 10' (i.e. transects 6-15) line is higher than the others, because this is the period when the mean number of passes was highest.

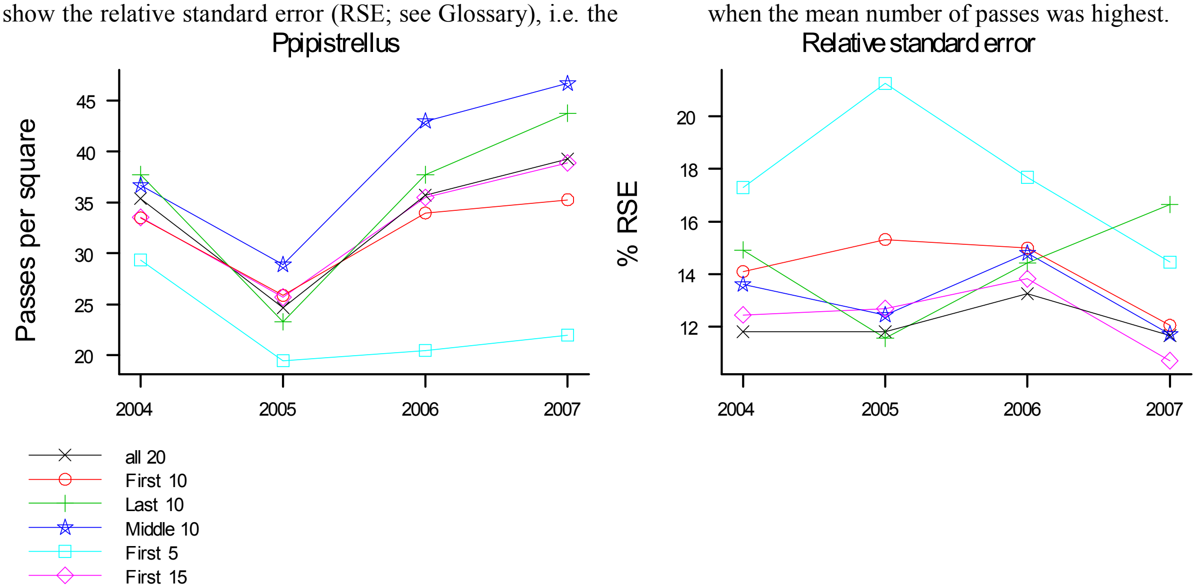

Figure 20: Simulation results for common pipistrelles. Figures are adjusted to 1,500 recording periods, so they are directly comparable, even when fewer transects are used. The figure on the left shows the change in results when the number of transects is reduced, whilst the figure on the right shows the relative standard errors of the estimates.

Figure 21 shows the results for soprano pipistrelles. The first graph in the Figure is a direct equivalent of Figure 8, the soprano pipistrelle trend graph, so the black 'all 20' line is identical to the real results. Results from 2003 have been excluded due to the low numbers of squares completed. All results have been adjusted back up to the standard 1,500 recording periods, so they are directly comparable. The results are quite similar to common pipistrelles, with the 'first 5' option again being very poor and 'first 15' very close to the full dataset results on both graphs. The red 'first 10' line shows less of an increase in 2006 and 2007 than the full results. In terms of Relative Standard Errors all three 10 transect options are quite similar. The red 'first 10' line is poor in 2004, but is good in other years. The light blue, first five transect option RSE is poor, as may be expected.

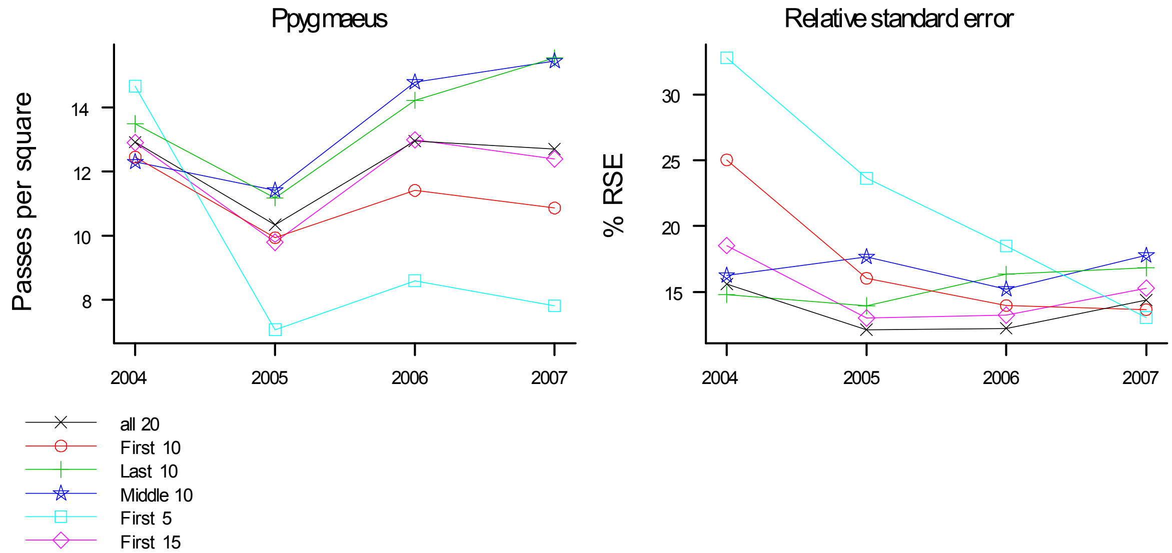

Figure 21: Simulation results for soprano pipistrelles. The figure on the left shows the change in results when the number of transects is reduced, whilst the figure on the right shows the relative standard errors of the estimates.

Figure 22 shows results for Leisler's bat. The first graph in the Figure is a direct equivalent of Figure 11, the Leisler's bat trend graph, so the black 'all 20' line is identical to the real results. Results from 2003 have been excluded due to the low numbers of squares completed. All results have been adjusted back up to the standard 1,500 recording periods, so they are directly comparable. From Figure 23 the 'First 5' result is, again, very poor, while the 'first 15' results are close to the full transect number results. The RSE results may not be quite as good as for the pipistrelles. The different 10 Transect options look quite similar in the trend graph, and for the RSEs it is difficult to draw firm conclusions due to the year to year variation.

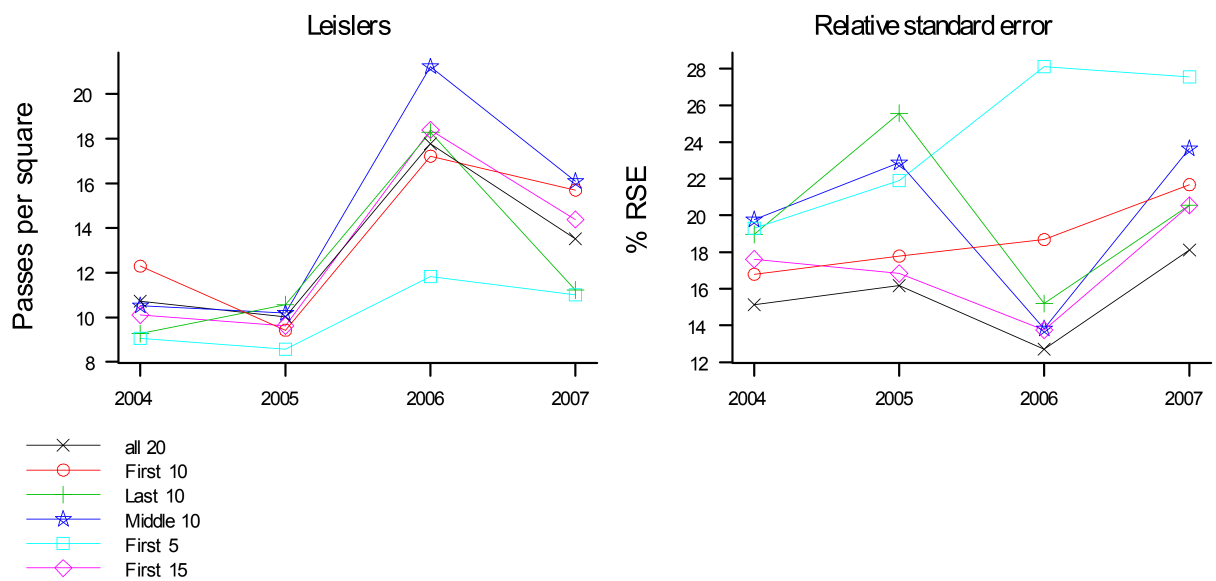

Figure 22: Simulations for Leisler's bat. The figure on the left shows the change in results when the number of transects is reduced, whilst the figure on the right shows the relative standard errors of the estimates.

OTHER VERTEBRATES

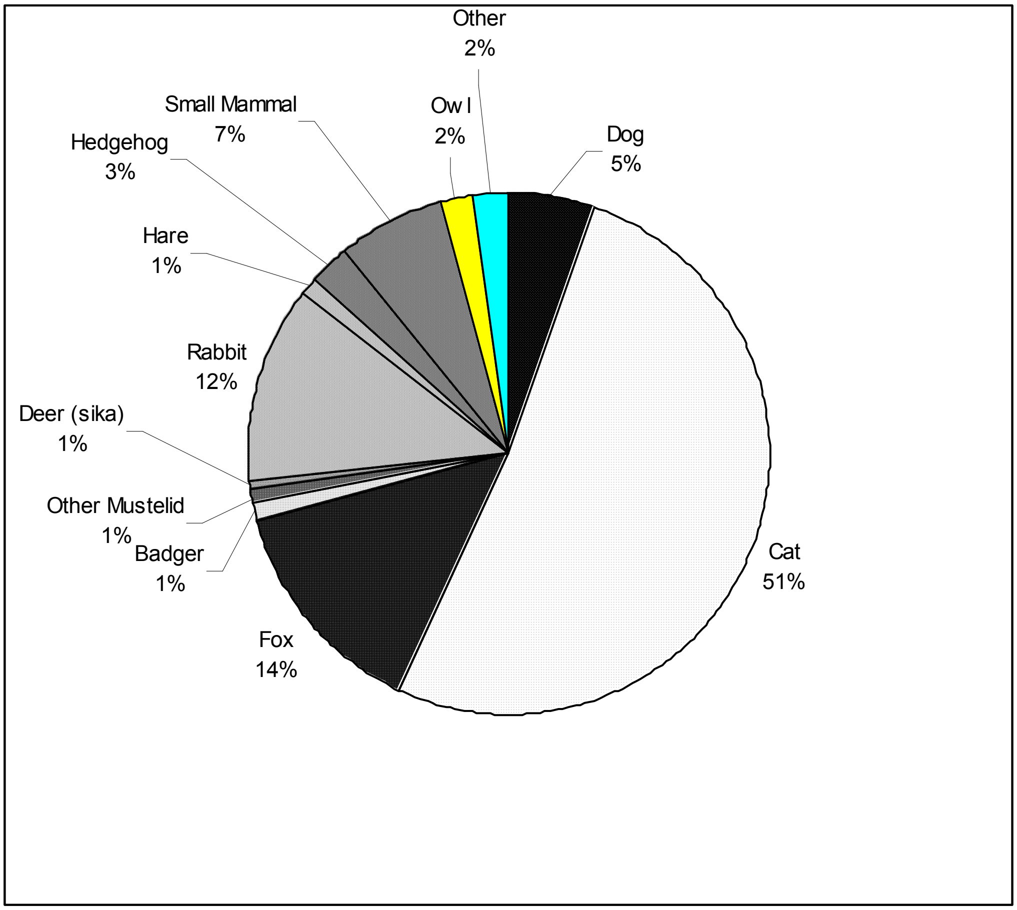

Figure 23: Living vertebrates, other than bats, observed during Survey 1 and Survey 2, 2007, n=383. ‘Small mammals’ category includes mice, rats, pygmy shrews, voles and unidentified small mammals. The ‘Others’ category includes horses, frogs and unidentified birds. The ‘Other mustelids’ category includes a stoat, mink and pine marten.

Recording of other vertebrates was carried out throughout the survey, during and between transects in 2007 and 2006. In 2007, 383 living vertebrates were recorded and in 2006, 322 living specimens were recorded. In 2005, 80 were observed and 62 in 2004. In addition 21 dead specimens were noted in 2007, compared with 28 in 2006.

In total, 4580km of roads were surveyed for vertebrates other than bats in July and August 2007. Of particular interest in 2006 and 2007 was the high number of cats observed during both surveys. Cats constituted 51% of the total living vertebrates observed in 2007 (n=198) and 50% in 2006 (n=157) (see Figure 23). By way of contrast, cats only constituted 14% of the dead specimens observed by surveyors (see Figure 24). Also of interest was the high number of foxes recorded in 2007, n=53. In 2006, dogs were the second-most frequently encountered species but in 2007 dogs came in fourth place. Rabbits were the third most frequently recorded ‘other vertebrates’ species, in both 2006 and 2007 (n=47 in 2007). One pine-marten and one mink were recorded in 2007.

Comparing the live versus dead specimen pie charts reveals quite a discrepancy in species distribution of the two. Rabbits are the third most frequent live vertebrate encountered but the most frequently encountered dead species. Also, badgers constitute 19% of the dead animals encountered compared with just 1% of the live fauna. Various reasons may account for such discrepancies, such as the fact that badger carcasses may persist for longer on the roadside, compared with small animal carcasses, as well as the possibility that these species are more at risk of road death than others, due to their behaviour and morphology. Cats, despite being the most commonly recorded live vertebrate at night, account for just 14% of the dead specimens observed.

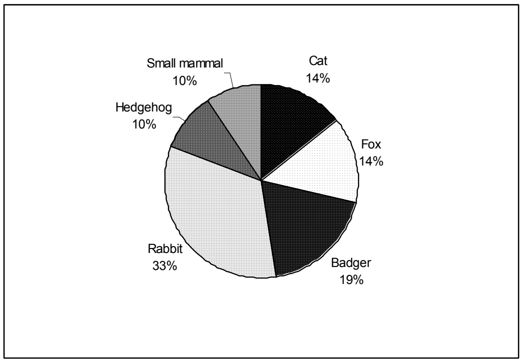

Figure 24: Dead vertebrates, other than bats, observed during Survey 1 and Survey 2, 2007, n=21. 'Small mammals' category includes mice and rats.

DISCUSSION

Common Pipistrelles

The common pipistrelle is the species most frequently encountered by the car-based bat monitoring scheme. It is distributed widely throughout the country but from 2005 to 2007 it has not been recorded from the survey square in Connemara (L64) during all surveys conducted there. This species is significantly correlated with grid reference eastings and negatively correlated with northings (Roche *et al*. 2007). It is less frequently encountered in the extreme north and north-west although it does occur there.

The species was encountered more frequently in 2007 than 2006. Results from a simple linear model fitted to the data imply that the encounter rate for this species may be on an increasing trend, although, at the relatively early stage of year five of the scheme, this needs to be verified with more years of data. The common pipistrelle has shown a significantly increasing trend from the UK National Bat Monitoring Programme Field Surveys carried out since 1998 by The BCT (Bat Conservation Trust, 2006).

Inclusion of temperature data in the analysis shows that common pipistrelle encounter rates are significantly positively correlated with temperature. Temperature in Ireland is predicted to rise by between 1.25˚C and 1.5˚C by 2040 compared with baseline data from 1961-2000 (McGrath et *al*. 2005). While the effects of temperature rise on Irish ecosystems are largely unknown it could be hypothesised that common pipistrelle encounter rates will also increase. However, since there is little understanding of the factors limiting bat populations in Ireland this could be an over simplification. Possible confounding effects preventing general increases in population as a result of higher temperatures could include increasing winter temperatures affecting hibernation and winter survival, and anthropogenic factors affecting the wider landscape, which are largely unknown.

Start time was found to be an important factor affecting common pipistrelle abundance and start time will be included in analyses as routine from 2008.

Soprano pipistrelles

Soprano pipistrelles are usually the second most frequently encountered species by the car-based bat monitoring scheme (2006 excepted). This species may not occur along roads as frequently as the common pipistrelle, or, because it has higher frequency echolocation calls, it may not be as detectable where it does occur.

Soprano pipistrelles were found in 2006 to be generally most active in squares to the west of the country, particularly north-west of the Shannon although this negative correlation with grid reference eastings was not quite significant at a 95% level (REML analysis, Roche et *al.* 2007). The weak association with western squares was not as evident in 2007 although neither was it investigated in detail in the present report.

Results from a simple linear model fitted to the soprano pipistrelle give little insight into whether the species is increasing, declining or stable. More years of data need to be collected before any conclusions can be made. In the UK the soprano pipistrelle has not yet shown any significant trend, up or down from the National Bat Monitoring Programme Field Surveys carried out since 1998 by The BCT (Bat Conservation Trust, 2006).

Activity levels of soprano pipistrelles were shown to have a close-to significant, positive relationship with air temperature. Should this relationship continue to prove significant or close-to significant perhaps an increasing trend may also be anticipated for soprano pipistrelles in the medium term. As for common pipistrelles, however, factors limiting soprano pipistrelle populations in Ireland are largely unknown and other factors such as winter survival in a changing climate and landscape changes arising as a result of climate change are almost wholly unknown as yet.

Start time was found to be an important factor affecting soprano pipistrelle abundance and start time will be included in analyses as routine from 2008.

Leisler's Bat

This species is usually the third most frequently encountered species from the monitoring scheme (excepting 2006 when it was second, see Roche *et al*., 2007). The encounter rate with Leisler's bats decreased in 2007 compared with 2006.

In 2006, REML analysis showed a significant positive association with the south of the island, and an association of borderline significance with the east of the island. This continues to be borne out by the 2007 data whereby squares with high Leisler's activity are concentrated along the south and east of the island.

Results from a simple linear model fitted to the Leisler's encounter data imply that the encounter rate for this species may be on an increasing trend, although, at the relatively early stage of year five of the scheme, this needs to be verified with more years of data. The increasing trend is strongly influenced by 2006's particularly high encounter rates. Comparable information is not available from the UK since this species is relatively uncommon there and in the rest of Europe.

Activity levels of Leisler's bat showed a highly significant positive relationship with mean air temperature. The implication for a warming climate is therefore, that Leisler's bats may also increase, however, as with other species, factors limiting the Leisler's population here are largely unknown. With a changing climate, winter survival, landscape changes and for Leisler's bat in particular, the threat of other large bat species migrating to and becoming resident in Ireland may become important elements affecting Leisler's bat populations.

Nathusius' Pipistrelle

This species was recorded for the first time by the car-based bat monitoring scheme in a square in the north-east in 2005. 2006 saw a massive increase in the number of Nathusius' pipistrelle encounters along with an increase in the number of squares where the species was recorded. While 2006 was the first year that included surveys in Northern Ireland, many of the new records for the species were derived from squares south of the border and where the species had not been previously recorded. The bat was recorded in additional squares in 2007, but was not re-recorded in all of the squares where it had been observed in 2006.

Nonetheless, results from a simple linear model applied to the yearly data imply a significant increase. More years of monitoring are required to establish this conclusively, however.

It was not possible to carry out correlation analyses with Nathusius' pipistrelle activity levels and air temperature, because its activity levels are too low. However, it is possible that rising air temperatures are in some way contributing to the currently expanding population within the island. A similar increase in Nathusius' pipistrelle abundance to that observed in Ireland in 2006 was recorded by the car-based bat survey in the UK in 2006 (Russ *et al.* 2006). The total number of encounters in the UK had decreased considerably in 2007, however (Russ *et al.* 2007).

A cursory examination of Nathusius' encounter rates shows that encounter rates in squares in the Republic are, in some cases, as high as those in parts of the North, which is often considered the stronghold of the species on the island. By implication it is predicted that there are locations in the Republic where the species is present in equally high numbers, relative to parts of Northern Ireland. This would need to be verified with more detailed field investigation, however.

***Myotis* Bats**

As in previous survey years small numbers of *Myotis* bats were encountered. No *Myotis* calls were identified to species level. Numbers of encounters with Myotis species from the car-based bat monitoring scheme are too low to determine population trends.

Brown Long-eared Bat

Social calls from this species were recorded by the car-based bat monitoring scheme for the first time in 2005. Similar numbers of encounters with the species were recorded in 2006 and 2007. The number of encounters is still too low to determine population trends, however.

Activity Hotspots

There is still quite a degree of variation in the number of surveys that have been completed in different squares around the country. As a result, it is difficult to determine whether the two highest encounter rate squares (2004-2007), V99 and R22 are really the squares with the highest bat encounters, relative to other survey squares. It is possible, that these squares have simply been surveyed on nights and years when bat numbers were particularly high.

Nonetheless the map illustrating total bat encounter rates does underline the variation in total bat encounters from south to north and east to west, with greatest bat encounters in the extreme south west of the country, high encounters along the south and midlands and in parts of the east of the country. The square X49 is a notable exception to this pattern. Poor habitat may be the reason behind low encounters here, however, habitat has not yet been examined in detail.

Particularly low encounters have been recorded in L64 Connemara, and C72 in the north coast of Derry. The square C72 was surveyed for the first time in 2007 but encounter rates would not be expected to increase significantly in coming survey years, given the location of the square on the northern seaboard.

As data from future surveys becomes available it seems most likely that squares in the extreme south west such as V99, V96 or R22 will continue to be considered the most bat-abundant although some other squares in the east coast may also be particularly important.

It is possible that the high encounter rate squares reflect, in the main, squares with high common pipistrelle encounter rates since this is the most common species picked up by the scheme. As a result, it may be beneficial to examine bat encounter rates and diversity in the next annual report by applying a biodiversity index such as the Simpson Index to the average results for each square. The Simpson Index takes into account the number of species present as well as the relative abundance of each species. An illustrative map of indices for each square may provide an interesting comparison to the hotspot map in the present report.

Reducing Survey Time

Statistically, there are some concerns about removing the two mile gap in between transects and driving a continuous route, even though this would make the Irish scheme comparable to some of the other European monitoring schemes. This is because while counts for different transects are variable, the counts for the same transects tend to be somewhat consistent. This may be due to habitats, location or the time transects are surveyed or a combination of these. The present survey covers a very large geographic area on account of the two mile gaps between each transect. Among the habitats covered by the survey are upland lakes and blanket bog, upland conifer plantation, lowland river valleys, coastal areas, raised bog, improved grasslands and hedgerow boundaries.

The possibility of a reduction in transect number as a methodology change to reduce survey length, fuel costs and the carbon footprint of the survey, was examined. If a minor reduction in the number of transects is sufficient to account for driver tiredness/safety issues, then just doing the first 15 transects may be a good option, with little loss of precision in the results. Results are, however, much more variable with 10 transects, and it is difficult to draw firm conclusions between the three options (transects 1-10, transects 6-15 or transects 11-20). Simply doing the first 10 transects may be favourable because of its simplicity and halving the survey time. Only doing 10 transects is likely to cause a significant decline in precision however, so more squares would have to be surveyed in order to compensate. Power analysis should provide details for how many more. Cutting the survey to 10 transects would reduce the average survey time from 240 minutes to 120 minutes. Loss of Power is of concern however, so it may also be worth considering doing twelve transects, if 15 is too many.

In the case of reducing transect numbers, the Irish data would still, however, not be directly comparable to much of data being gathered in the rest of Europe. This is because in most other countries a continuous transect is driven for an hour and half or thereabouts, rather than 1.6km transects with 3.2km gaps. Sound analysis is usually carried out in 5 minute chunks but it is possible to pinpoint bat locations using GPS data.

The value of standardising a car-based methodology across Europe is debatable given the different species compositions found along roadsides in different parts of the continent.

Should cutting the transect number be found to be the best option to decrease survey time, there may be ways to improve the Power of the data without resorting to increasing the number of squares.

The Dutch Mammal Society (VZZ) began a trial car-based bat monitoring scheme in 2007 during which surveyors used an Anabat, frequency division, bat detector (J. Dekker *pers.comm.*). Among the advantages of this system is the fact that the sound data is downloaded on to a compact flash card in the detector, so a recording device is no longer necessary. In addition, recordings are made continuously without the loss of 10/11ths of the data. This should mean that more bat encounters are collected compared with an equivalent amount of time spent surveying with a Time Expansion detector. This should have implications for Power, in other words it should be possible to achieve similar or greater power despite a reduced survey time.

There are some examples of large scale methodological or equipment changes within other monitoring projects. The BTO switched from CBC to BBS methodology in 1990's, but collected data by both methods over several years to allow the two series to be merged together (e.g. Baillie *et al.* 2002). Within the BCT's UK NBMP Noctule-Serotine-Pipistrelle field survey there has been a gradual shift from heterodyne to frequency division detectors and this change has been adjusted-for within the GLM/GAM statistical framework, something which should be feasible for the Irish car survey (S. Langton *pers.comm.*).

PROPOSALS FOR 2008

Methodology

Continue as at present surveying each square twice yearly. Further analysis of power will be carried out in 2008 to determine the possibilities for reducing the length of time surveying. It is proposed that this will be carried out during in winter 2008 so that the results will be ready in advance of the 2009 field season. Since two Anabat bat detectors are available to BCIreland these should be used during car surveys in at least two squares in 2008 and the results collected from the Anabat compared with time expanded data from the same surveys. This may give some indication as to whether it would be worthwhile switching to Frequency Division detectors in the coming years in order to boost Power of the data, possibly in combination with a shift to fewer transects.

Volunteer Training and Feedback

Training will take place as in 2007 and volunteers will be reminded of survey start times via email.

Feedback will take the form of a 'thank you' email listing numbers of bat encounters and a breakdown of species recorded on each square.

Habitat Use

Land classifications for Ireland and possible methods of examining habitat associations of different bat species should be examined in 2007-8.

Statistical Analysis

Power analysis will be redone in 2008 to determine the robustness of the data in detecting Amber or Red Alert declines in the three target populations. In addition, various transect reduction scenarios will be examined using Power Analysis to determine how appropriate, or otherwise, it would be reduce the length of time surveying by using this method.

Climate Change and Irish Bats

This issue has the potential to change the composition and dynamics of the Irish bat fauna within a relatively short timeframe. In order to be able to determine with some accuracy the likely impacts of continuing climate change on Irish bat species, including those species targeted by car-based monitoring, detailed modelling of bat activity and weather data needs to be carried out. While some of this can be carried out within the context of present GLM models, to achieve greater understanding, year-round studies of activity of different species is needed but is beyond the scope of the present car-based bat monitoring project. For the car-based bat monitoring survey, mean monthly temperatures from the Republic of Ireland and Northern Ireland need to be included in yearly statistical analysis from 2008.

ACKNOWLEDGEMENTS

We would like to thank each of the 67 people who devoted long and antisocial hours to map and survey routes throughout the country.

Tina Aughney
Eric Bann
Chris Barron
Eileen Biggane
Sinéad Biggane
Shaun Boyle
Daniel Buckley
Stephen Carters
Donna Cassidy
Jimi Conroy
Miriam Crowley
Reggie Cunningham
Guy Dalton
Paschal Dower
Catherine Farrell
Fiona Farrell
Leonard Floyd
Kathryn Freeman
Emma Glanville
Gareth Grindle
Clare Heardman
Karl Higgins
Rob Holloway
Rebecca Jeffrey
Gerry Kelly
Annette Lynch
Deirdre Lynn
David Lyons
Bella Lysaght
Liam Lysaght
Pauli Lysaght
Seppie Lysaght
Fidelma Maher
Ferdia Marnell
Kate McAney
Eddie McCourt
Annie McCourt
Larry McDaid
Lee McDaid
David McDonagh
Juliet McDonnell
Barbara McInerney
Melina McMullan
Michael McNamara
Robbie Miller
Irene O'Brien
Mark O'Callaghan
Áine O'Connor
Seamus O'Connor
Tim O'Donoghue
Sylvia O'Hehir
Denis O'Higgins
Ciarán O'Keeffe
Elaine O'Riordáin
Chris Peppiatt
Gráinne Roche
Niamh Roche
Lorcan Scott
Ger Stanton
Georgina Thurgate
Dave Tierney
Kathryn Turner
Fernando Valverde
Alyn Walsh
Chris Wilson
Jane Woodlock
Cathy?

Thanks also to

- Staff of NPWS in particular Naomi Kingston, Deirdre Lynn and Ferdia Marnell.
- Staff of the Environment and Heritage Service in particular John Milburne.
- Jon Russ of the BCT.

REFERENCES

Aughney, T., Langton, S. and Roche, N. (2007). All-Ireland Daubenton's Bat Waterway Survey 2006, Irish Bat Monitoring Programme. Bat Conservation Ireland. Report submitted to The National Parks and Wildlife Service.

Aughney, T. and Roche, N. (2008). Brown long-eared bat *Plecotus auritus* Roost Monitoring 2007, Irish Bat Monitoring Programme. Bat Conservation Ireland. Report submitted to The National Parks and Wildlife Service.

The Bat Conservation Trust (2006). The National Bat Monitoring Programme: Annual Report 2005. BCT, London.

Baillie, S.R., Crick, H.Q.P., Balmer, D.E., Beaven, L.P., Downie, I.S., Freeman, S.N., Leech, D.I., Marchant, J.H., Noble, D.G., Raven, M.J., Simpkin, A.P., Thewlis, R.M. & Wernham, C.V. (2002) *Breeding Birds in the Wider Countryside: their conservation status 2001*. Research Report 278. BTO, Thetford.

Buckland S.T., Magurran A.E., Green R.E. and Fewster R.M. (2005). Monitoring change in biodiversity through composite indices. *Philos. T. Roy. Soc. B.* **360**: 243-254.

Catto C., Russ J., Langton S. (2004). *Development of a Car Survey Monitoring Protocol for the Republic of Ireland*. Prepared on behalf of the Heritage Council by the Bat Conservation Trust UK. The Heritage Council, Ireland.

Elliott P. (1998) Ultrasonic bat detectors: a beginners' guide. *Journal of Biological Education* 32: 1.

Fairley J. (2001). *A Basket of Weasels*. Northern Ireland.

Fewster R.M., Buckland S.T., Siriwardena G.M., Baillie, S.R. and Wilson J.D. (2000). Analysis of population trends for farmland birds using generalized additive models. *Ecology*. **81** 1970-1984.

Hutson A.M., Mickleburgh S.P. and Racey P.A. (2000). *Microchiropteran bats: global status survey and conservation action plan.* IUCN/SSC Chiroptera Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Lewis T. and Stephenson J.W. (1966). The permeability of artificial windbreaks and the distribution of flying insects in the leeward sheltered zone. *Annals of Applied Biology*, **58**: 355-363.

Limpens, H.J.G.A. and Kapteyn, K. (1991). Bats, their behaviour and linear landscape elements. *Myotis*, 29: 39-48.

McGrath, R., Nishimura, E., Nolan, P., Semmler, T., Sweeney, C. and Wang, S. (2005). Climate Change: Regional Climate Model Predictions for Ireland. *Environmental Protection Agency, ERTDI Report Series.* No. 36.

Marchant J.H., Wilson A.M., Chamberlain D.E., Gregory R.D. and Baillie S.R. (1997). *Opportunistic Bird Species – Enhancements for the Monitoring of Populations*. BTO Research Report No. 176. BTO, Thetford.

NPWS (2007). Article 17 Conservation Status Assessments of Habitats and Species Listed under the Habitats Directive (92/43/EEC).

Roche N. and Aughney T. (2007). Pilot Scheme for Monitoring Woodland Bats in the Republic of Ireland. Bat Conservation Ireland. Report submitted to The National Parks and Wildlife Service.

Roche N., Catto C., Langton S., Aughney T. and Russ J. (2005). Development of a Car-Based Bat Monitoring Protocol for the Republic of Ireland. *Irish Wildlife Manuals*, No. 19. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin.

Roche N., Langton S., Aughney T. and Haysom K. (2006). *The Car Based Bat Monitoring Scheme for Ireland: Report for 2005*. Bat Conservation Ireland.

Roche N., Langton S., Aughney T. and Russ J. (2007). *The Car Based Bat Monitoring Scheme for Ireland: Report for 2006*. Bat Conservation Ireland.

Russ J., Briggs P. and Wembridge D. (2007). *The Bats and Roadside Mammals Project. Final Report on the Third Year of Study*. The Bat Conservation Trust and the Mammals Trust UK.

Russ J., Catto C. and Wembridge D. (2006). *The Bats and Roadside Mammals Project. Final Report on the Second Year of Study*. The Bat Conservation Trust and the Mammals Trust UK. The Bat Conservation Trust UK and The Mammal Society.

Rydell J. (1992). Exploitation of insects around streetlamps by bats in Sweden. *Functional Ecology*. **6**: 744-750.

Stebbings R.E. (1988). *Conservation of European Bats*. Christopher Helm, London.

Taylor L.R. (1963). Analysis of the effects of temperature on insects in flight. *Journal of Animal Ecology*, **32:** 99-117.

Temple H.J. and Terry A. (2007). *The Status and Distribution of European Mammals*. Office for Official Publications of the European Communities, Luxembourg.

Verboom B. and Spoelstra K. (1999). Effects of food abundance and wind on the use of tree lines by an insectivorous bat, *Pipistrellus pipistrellus*. *Canadian Journal of Zoology*. **77**: 1393-1401.

Wellington W.G. (1945). Conditions governing the distribution of insects in the free atmosphere. *The Canadian Entomologist*, **77**: 7-15.

Whilde A. (1993). *Irish Red Data Book 2: Vertebrates*. HMSO, Belfast.

Williams C.B. (1940). An analysis of four years captures of insects in a light trap: Part II. The effects of weather conditions on insect activity; and the estimation and forecasting of changes in the insect population. *Transactions of the Royal Entomological Society of London*, **90**, 227-306.

GLOSSARY OF TERMS

Bootstrapping
This is a method for estimating the sampling distribution of an estimator by resampling with replacement from the original sample. In the context of population indices the resampling is done for entire sites and ensures that confidence limits and significance levels are unaffected by any temporal correlation in the data. It also allows for the effects of 'overdispersion' which occurs when data are more variable than expected from a Poisson distribution.

Covariate
This is a variable that is possibly predictive of the outcome under study. A covariate may be of direct interest or be a confounding variable or effect modifier.

Doppler Effect
Apparent change in frequency of a sound (measured in kilohertz, kHz) as a result of movement, either of the source or the observer. The apparent frequency of a sound increases as the source of the sound moves towards an observer or the observer move towards it and decreases as the source moves away from an observer or the observer moves away from it.

GLM
Generalised Linear Model: a generalisation of ordinary regression and analysis of variance models, allowing a variety of different error distributions and different link functions between the response variable and the explanatory variables. The models used here have a Poisson error distribution and a logarithmic link.

GAM
Generalised additive model: these models allow a smooth, non-parametric curve to be fitted to an explanatory variable, within a GLM. In estimating population indices they are used to smooth out year-to-year variation (Fewster *et al*. 2000).

Offset
A covariate with a fixed slope of 1.0, in this case implying that the total count doubles if the number of recording intervals doubles.

Poisson Distribution
The Poisson distribution is a discrete probability distribution. It expresses the probability of a number of events occurring in a fixed time if these events occur with a known average rate, and are independent of the time since the last event. It is frequently used as the basis of statistical models of counts of organisms or events.

Power Analysis
Analysis of the power (probability) to reject a false null hypothesis. A test with high power has a large chance of rejecting the null hypothesis when this hypothesis is false. In the case of the present project the null hypothesis would state that that there is no decline in bat populations. Power is measured as a percentage, and greater power reflects the increased likelihood of detecting a declining trend (as outlined for Red or Amber Alerts). The power analysis carried out for the present project is one-tailed (i.e. examines a declining trend only) at P=0.05 (which is equivalent to P=0.l for a two sided test).

REML
Restricted (or residual) maximum likelihood (REML) is a method for fitting linear mixed models. In contrast to conventional maximum likelihood estimation, REML can produce unbiased estimates of variance and covariance parameters. This method assumes the data are normally distributed.

Relative Standard Error
The standard error of an estimate expressed as a proportion of the percentage of the estimate. Also known as the coefficient of variation.

APPENDIX I

Methods

Training workshops to explain the project to new surveyors and demonstrate the equipment were carried out in June and July 2007 in Belfast, Killarney, Cootehill and Glenveagh.

During training workshops volunteers/NPWS/EHS staff are presented with an information pack which includes an outline of the protocol for the car survey, a distribution map showing twenty randomly generated 30km² survey blocks, a map showing part of an overall route with examples of monitoring transects, a list of sunset times for areas within the Republic of Ireland and Northern Ireland, guidelines for using the minidisc recorder, and two recording sheets, one to record transect details and one to record survey information. In addition, each surveyor is equipped with maps, a minidisc recorder, a stereo connecting lead, a bat detector (Tranquillity Transect), a car window mounting clamp, a thermometer, a first aid kit and a flashing beacon. A training CD is also provided. This demonstrates sounds that surveyors should be able to hear while surveying, sounds that indicate problems with equipment, bat sounds and other sounds that surveyors may encounter during the survey.

The car transect method is employed to monitor bat activity within twenty 1.609 km (1 mile) monitoring transects along a selected survey route within randomly generated 30km² squares. Time expansion bat detectors are used to assess bat activity along the route and bat calls are recorded onto a minidisc recorder.

Each surveyor is assigned at least one 30 km² survey square and asked to choose a suitable survey route within each block comprising of twenty 1.609 km (1 mile) monitoring transects spaced 3.218 km (two miles) apart. Details of the transect route are recorded by the surveyor on the appropriate form and highlighted on the maps provided.

Each survey square is driven in July. A repeat survey is carried out in mid-August 2007. The bat detector is positioned at 45° to the rear of the car in the horizontal plane and 45° to the vertical plane as previous work had shown that this angle minimised background noise and interference. Surveying begins 45 minutes after sunset and volunteers are required to drive at 24kmph along each monitoring transect, recording bat activity via the bat detector onto the minidisk recorder. This low speed was chosen because low speeds reduce background noise and the effect of Doppler shifts on recorded calls (for details see Catto *et al.* 2004).

Sonographic analysis

Time expansion audio data is transferred to a computer hard drive as separate *.wav files representing the numbered tracks (20 files, one for each monitoring transect) on the minidisc using the software Win Nmd (v1.2x, Christian Klukas). Occasionally, multiple tracks are recorded for each monitoring transect and these are joined into a single *.wav file using the software program AddAWav (v1.5, Geoff Phillips). Using Bat Sound

(Pettersson Elektronik AB) software, bats are categorised into species from the measured parameters of their echolocation calls.

Each adjacent 320ms time expanded sequence is treated as an independent sample, and therefore species occupying adjacent 320ms sequences are treated as separate individuals. It is occasionally possible to identify more than one individual of the same or different species within a single 320 ms sequence.

The REML models are fitted using the average number of passes per minute for each 1.6km long monitoring transect. The small number of instances where the monitoring transect contains less than 50 0.32 second recording periods are excluded, as the models suggest that these produce abnormally low counts. No attempt has been made to fit models to the *Myotis* spp. data (or to the indeterminate pipistrelles) as there is far too little data to permit sensible modelling.

APPENDIX II

Results

Descriptive Statistics

The tables below show some simple descriptive statistics for each year. Transects with less than 50 0.32ms recordings have been excluded as these may produce some atypical values.

Table A.1: Descriptive statistics

a) Common pipistrelle

		Statistics per mile transect			Statistics per 0.32ms recording			
year	Total passes	n transects	mean passes	% with passes	n	n with	% with passes	passes per min
2003	217	173	1.25	50.3	13225	217	1.64	3.00
2004	1055	545	1.94	57.4	41542	1023	2.46	4.80
2005	811	596	1.36	52.2	47170	798	1.69	3.23
2006	1506	880	1.71	52.7	67314	1443	2.14	4.24
2007	1567	880	1.78	53.9	65312	1489	2.28	4.49
All years	5156	3074	1.68	53.6	234563	4970	2.12	4.15

b) Soprano pipistrelle

		Statistics per mile transect			Statistics per 0.32ms recording			
year	Total passes	n transects	mean passes	% with passes	n	n with	% with passes	passes per min
2003	82	173	0.47	24.9	13225	82	0.62	1.15
2004	386	545	0.71	34.3	41542	377	0.91	1.71
2005	333	596	0.56	31.5	47170	329	0.70	1.32
2006	573	880	0.65	33.4	67314	562	0.83	1.55
2007	566	880	0.64	32.2	65312	550	0.84	1.62
All years	1940	3074	0.63	32.4	234563	1900	0.81	1.53

c) 50 kHz pipistrelle

		Statistics per mile transect			Statistics per 0.32ms recording			
year	Total passes	n transects	mean passes	% with passes	n	n with	% with passes	passes per min
2003								
2004	247	545	0.45	29.2	41542	247	0.59	1.12
2005	159	596	0.27	20.0	47170	159	0.34	0.63
2006	239	880	0.27	18.6	67314	238	0.35	0.67
2007	225	880	0.26	17.7	65312	221	0.34	0.65
All years	870	2901	0.30	20.6	221338	865	0.39	0.74

d) *Myotis* spp.

		Statistics per mile transect			Statistics per 0.32ms recording			
year	Total passes	n transects	mean passes	% with passes	n	n with	% with passes	passes per min
2003	7	173	0.04	2.9	13225	7	0.05	0.11
2004	28	545	0.05	4.4	41542	28	0.07	0.12
2005	21	596	0.04	2.3	47170	21	0.04	0.08
2006	26	880	0.03	2.4	67314	26	0.04	0.07
2007	32	880	0.04	2.5	65312	32	0.05	0.09
All years	114	3074	0.04	2.8	234563	114	0.05	0.09

e) Leisler's bat

		Statistics per mile transect			Statistics per 0.32ms recording			
year	Total passes	n transects	mean passes	% with passes	n	n with	% with passes	passes per min
2003	52	173	0.30	15.6	13225	52	0.39	0.72
2004	295	565	0.52	23.2	43087	293	0.68	1.31
2005	314	596	0.53	21.6	47170	314	0.67	1.24
2006	787	880	0.89	27.6	67314	769	1.14	2.26
2007	557	880	0.63	20.3	65312	547	0.84	1.56
All years	2005	3094	0.65	22.9	236108	1975	0.84	1.61

f) Nathusius' pipistrelle

		Statistics per mile transect			Statistics per 0.32ms recording			
year	Total passes	n transects	mean passes	% with passes	n	n with	% with passes	passes per min
2003	0	173	0.00	0.0	13225	0	0.00	0.00
2004	0	565	0.00	0.0	43087	0	0.00	0.00
2005	1	596	0.00	0.2	47170	1	0.00	0.00
2006	29	880	0.03	2.2	67314	28	0.04	0.08
2007	13	880	0.01	1.2	65312	13	0.02	0.04
All years	43	3094	0.01	1.0	236108	42	0.02	0.03

g) Brown long-eared bat (not separately recorded before 2007)

		Statistics per mile transect			Statistics per 0.32ms recording			
year	Total passes	n transects	mean passes	% with passes	n	n with	% with passes	passes per min
2003								
2004								
2005								
2006								
2007	17	880	0.02	1.4	65312	17	0.03	0.05

POISSON GLMS
As in previous years, a Generalised Linear Models with a Poisson error distribution has been fitted, but using bootstrapping at the square level to generate confidence limits. The number of passes per survey has been modelled, using the log of total number of 0.32s recordings per survey as an offset, which effectively does something very similar to analysing the passes per minute, but allows use of a Poisson error distribution. The trend graphs (Figures 5, 8, 11, 13, and 15 in the main report) show mean passes per survey, adjusted to allow for the differing numbers of 0.32s recordings.

Trends
While the number of survey years is still low and it is early to do any testing of the trends, to give some idea of whether these are significant, a simple model with a linear trend over time has been fitted. Bootstrap confidence limits for this linear slope are shown in Table A.2 below. For soprano pipistrelles and *Myotis* species the confidence limits span zero (i.e. the upper value is positive, the lower negative), indicating that it is not possible to state whether the line is going up or down. However, for common pipistrelles, Nathusius' pipistrelles and Leisler's bats the lower limit is also positive, implying a significant increase. It is necessary to be cautious about these results, however, given the year to year variation and the small sample size in 2003.

Table A.2:

	Common pip	Soprano pip	*Myotis* spp.	Leisler's bat	Nathusius' pip
Estimate	0.11	0.05	-0.02	0.17	0.61
95% lower	0.05	-0.07	-0.35	0.04	0.03
95% upper	0.17	0.16	0.27	0.28	1.41

.

APPENDIX III: Other Wildlife
Table A.3: Live vertebrates, 2007

	Dog	Cat	Rabbit	Deer (sika)	Fox	Rat	Mouse	Badger	Hare	Hedg ehog	Owl	Shrew	Unid Small Mammal	Pine marten	Otter	Mink	Other
C72 - 1		6			5				1								
C72 - 2					1		1	1									
G20 -1		3	1			1											
G53 - 1		7	3				1	1									
G53 - 2		3			1		1										
G89 - 1																	
H13 - 1		9	1		2												
H13 - 2		7			3									1			
H40 - 1	1	4	1				1										
H40 - 2	2	1								1			1				
J06 - 1																	
J06 - 2																	
J33 - 1					4												
J33 - 2		5			4		1	1									
L64 - 1		2					2								1		
L64 - 2	1	1															
M24 - 1		5	2										1				
M24 - 2	1	5															1
M87 - 1		2	2														
M87 - 2		7			4												
N11 - 1		1	5		1	1											
N11 - 2			1		1												
N74 - 1	1	11	2		1					2							
N74 - 2		7			2												
N77 - 1	1	11	3		1												1
N77 - 2		4	1		1		1			1		1	1			1	
O04 - 1	3	5	2			1						1					3
O04 - 2	2	9	1				1	1	1	1							2
R22 - 1			2		2												
R22 - 2					1												
R28 - 1	2	1			1				1								
R28 - 2		1									2						
R88 - 1	2	5			1		1										
S12 - 1		6			2		1										
S12 - 2	2	6	3				1										

	Dog	Cat	Rabbit	Deer (sika)	Fox	Rat	Mouse	Badger	Hare	Hedgehog	Owl	Shrew	Unid Small Mammal	Pine marten	Otter	Mink	Other
S78 - 1		13	3	1	1	1	1				2						1
S78 - 2		13	5		1				1								
T05 - 1			1							1							
T05 - 2		4	1			1				1	1						
V93 - 1		3								1							
V93 - 2		2			3												
V96 - 1		1	2														
V96 - 2	1	4		1	1								1				1
V99 - 1		5															
V99 - 2		5								1							
W56 - 1		1	3		2												
W56 - 2		5	1		2												
X49 - 1	1	8	1		5		1	1		1	2						
Total Alive	**20**	**198**	**47**	**2**	**53**	**5**	**14**	**5**	**4**	**10**	**7**	**2**	**4**	**1**	**1**	**1**	**9**

Table A.4: Dead vertebrates, 2007

	Cat	Rabbit	Fox	Rat	Mouse	Badger	Hedgehog
G53 - 1	1						
H13 - 2						1	
J33 - 2			1			1	
M24 - 2				1			
N11 - 1		1					
N77 - 1		1					
O04 - 1		1					
R28 - 2						1	
S78 - 2		1					
T05 - 1			1				
T05 - 2	1	1	1				
V93 - 1							2
V93 - 2		1					
V96 - 2		1					
V99 - 2	1						
W56 - 1					1		
W56 - 2						1	
Total Dead	**3**	**7**	**3**	**1**	**1**	**4**	**2**