Irish Bat Monitoring Schemes

Annual Report for 2010

Aughney T., Roche N., Langton S. (2011)

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1.0 Executive Summary

This annual report provides information on Bat Conservation Ireland's monitoring schemes:

● Car-Based Bat Monitoring Scheme (All Ireland)
● All Ireland Daubenton's Bat Waterway Monitoring Scheme

Overall, better weather conditions prevailed through the 2010 than the previous survey season, and a considerable body of bat survey work was completed. Training courses were held at 14 locations as part of the All Ireland Daubenton's Bat Waterway Monitoring Scheme.

For the Car-Based Bat Monitoring Scheme 66 individuals participated in surveys of 28 squares around the island. Overall bat encounter rates for this survey were higher than in 2009, particularly for the common pipistrelle and Leisler's bat. The soprano pipistrelle declined from 2008 and 2009 levels. GAM models of smoothed trends over time were applied to car-based bat monitoring data. For the common pipistrelle, despite declines in 2008 and 2009, an increase in 2010 appears to have somewhat stabilised the downward trend since 2007. Although the soprano pipistrelle has declined for two consecutive years, its overall trend still appears to be on a stable or slightly increasing trajectory. The Leisler's bat increased in 2010 and the population appears to be increasing, despite yearly oscillations. Nathusius' pipistrelle trend analysis was carried out with presence absence data this year, rather than count data. The Nathusius' pipistrelle, the brown long-eared bat and *Myotis* spp. are still, however, encountered in very small numbers by this scheme, so any attempt to investigate trends in these species' populations is confounded by very wide error bars.

In total, 285 living vertebrates other than bats were observed by car-based bat monitoring surveyors in 2010; 57% of these were cats. Rabbits were second most frequent at 9%, and dogs came third accounting for another 9% of records. Cats encounter rates decreased slightly in 2009 but observations (per hour) of this species increased again in 2010.

In 2010, 181 volunteer teams participated in the All Ireland Daubenton's Bat Waterway Monitoring Scheme. In total, 211 waterway sites were surveyed in all 32 counties. Of these sites, 193 were surveyed twice. This constitutes the highest number of completed surveys in any year to-date. Over 20,000 'Sure' Daubenton's bat passes were recorded on 196 waterway sites (93%). Binomial Model analysis showed that several factors influence the proportion of survey spots with bat activity along waterways, such as daily rainfall, waterway width, air temperature and start time of the survey. Daubenton's bat numbers showed evidence for a decline from 2006 to 2008 but in 2009 and 2010 numbers appeared to have recovered a little. A Binomial GAM (smoothed trend line) was also used to plot yearly data and this method will continue to be used for future assessments of Daubenton's bat trends.

2.0 GENERAL INTRODUCTION

2.1 Why Monitor Ireland's Bats?

Bats constitute a large proportion of the mammalian biodiversity in Ireland. Nine species of bat are known to be resident in Ireland and form almost one third of Ireland's land mammal fauna. Bats are a species rich group widely distributed throughout the range of habitat types in the Irish landscape. Due to their reliance on insect populations, specialist feeding behaviour and habitat requirements, they are considered to be valuable environmental indicators of the wider countryside (Walsh *et al.,* 2001).

Irish bats are protected under domestic and EU legislation. Under the Republic of Ireland'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 similarly 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 lists 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 Agreement on the Conservation of Populations of European Bats (EUROBATS) is an agreement under the Bonn Convention and Republic of Ireland and the UK are two of the 32 signatories. The Agreement has an Action Plan with priorities for implementation. One of the current priorities is to produce guidelines on standardised bat monitoring methods across Europe. Battersby (2010), in a recent EUROBATS publication outlines various methods for surveillance and monitoring of bats.

Whilde (1993), in the Irish Red Data Book of vertebrates, listed most Irish populations of bats (those species that were known to occur in Ireland at the time of publication) as Internationally Important. The Red Data List for Mammals in Ireland has been updated (Marnell *et al*., 2009) and most of the bat species, including common pipistrelle (*Pipistrellus pipistrellus*), soprano pipistrelle (*P. pygmaeus*), Daubenton's bat (*Myotis daubentonii*) and brown long-eared bat (*Plecotus auritus*) are currently considered of Least Concern. All of these species are monitored using one of the BCIreland monitoring schemes. One of the species included in BCIreland's monitoring, the Leisler's bat (*Nyctalus leisleri*), is, however, considered Near Threatened. It has been assigned this threat status because Ireland is considered a world stronghold for the species (Mitchell-Jones *et al*., 1999). The status of the European Leisler's bat population is Least Concern (Temple and Terry 2007). This species is still, however, infrequent in the rest of Europe compared with Ireland where it is quite common.

2.2 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. In addition, the data should also be able to pinpoint population increases should these occur (for more details on Power analysis for Car-Based Bat Monitoring see Roche *et al*., 2009 and for the Daubenton's Waterways Survey see Aughney *et al.,* 2009).

2.3 The Monitoring Schemes

Despite high levels of legal protection for all species, until 2003 there was no systematic monitoring of any species apart from the lesser horseshoe bat in Ireland. To redress this imbalance The Car-Based Bat Monitoring Scheme was first piloted in 2003 and targets the two most abundant pipistrelle species (common and soprano pipistrelles) and the Leisler's bat (Catto *et al*., 2004). These species are relatively easy to detect and distinguish from each other on the basis of echolocation calls. The car based survey makes use of a broadband bat detector which picks up a range of ultrasound which can be recorded in the field and analysed post-survey. This method therefore allows survey work to be carried out by individuals with little or no experience in bat identification since identification is completed post survey work.

The car-based monitoring scheme was followed in 2006 by the All Ireland Daubenton's Bat Waterways Monitoring Scheme (e.g. Aughney *et al.,* 2007). This scheme follows a survey methodology devised by the Bat Conservation Trust (BCT UK). Narrow band, heterodyne detectors are used so volunteers who conduct the survey are trained in the identification of the Daubenton's bat prior to field work. Surveyors count the number 'bat passes' of this bat species for 4 minutes at each of the ten fixed points on linear waterways. The onset of this scheme was a very significant development in bat monitoring here since it represented the first large-scale recruitment of members of the Irish public to bat conservation-related work.

More recently, in 2007, a brown long-eared bat monitoring scheme was piloted and has since run for a 3-year monitoring period (Aughney *et al*., 2011). This project concentrates on counts of brown long-eared bats at their roosts and is conducted by individuals with a greater level of experience in bat identification than is necessary for the Daubenton's or car-based surveys. This survey protocol involves at least two counts per annum (May to September) using three potential survey methods depending on the structure, access and location of bats within, and emerging from, the roost. A full report on the brown long-eared roost monitoring scheme is provided in a separate report (Aughney *et al.,* 2011).

The Car-Based Bat Monitoring Scheme and All Ireland Daubenton's Bat Waterway surveys are all-Ireland schemes. The brown long-eared roost monitoring has, so far, been based in the Republic of Ireland only. Regular monitoring under BCIreland management is, therefore, in process for five of the Annex IV bat species for the Republic of Ireland, and for four species in Northern Ireland. Additional BCT UK Field Surveys are also undertaken in Northern Ireland. Data collected from those surveys feed into the BCT's UK reporting mechanisms.

2.4 Weather in Summer 2010

July was the first month of 2010 which was dominated by weather patterns associated with Atlantic depressions. Slow-moving frontal systems brought heavy falls of rain at times, while most days were cloudy but mild. Rainfall totals for July were above normal everywhere and were more than twice the average at some stations; it was the fourth successive July with rainfall totals much in excess of normal over most of the country. Unlike previous years, however, the relatively dry weather of the preceding months of 2010 and consequent high soil moisture deficits helped to prevent significant flooding during this month. Heavy falls in the period around the middle of the month were often associated with thunderstorms. Most stations recorded between 15 and 21 wet days during the month (days with 1mm or more rainfall), compared with the normal range for July of between nine and 13.

Mean monthly air temperatures were near normal in the south, but were around half a degree higher than normal at most stations. There was little variation in either daily maximum or minimum values during the month, with few very warm days. Mean maximum temperatures were close to normal, but the generally cloudy conditions kept mean minimum values over a degree higher than normal generally. July sunshine totals were below normal everywhere, the first relatively dull month of 2010.

In August when both the Car-Based Bat Monitoring and Daubenton's surveys were being carried out, rainfall amounts were generally small, especially in southern areas, while many days were sunny. There was little variation in temperatures during much of August, but a cool northerly airstream over Ireland during the last week brought mean temperatures for the month below normal at most stations.

Rainfall totals were below normal everywhere and it was a particularly dry month over Munster and south Leinster, where less than 50% of normal rainfall was recorded. Cork Airport's total of 17mm was its lowest for August since 1995. This station had only three wet days during the month (days with 1mm or more rainfall), but between eight and 14 wet days were measured at most stations, close to normal for August.

Temperatures were near or a little above normal during much of August, but cool conditions during the final week brought mean air temperatures for the month a little below normal generally, and many stations had their coolest August for 16 or 17 years. There were very few days during the month when maximum temperatures rose above 20°C, while there were no such days in some western and south-western areas. Slight ground frost developed in eastern and midland areas towards the end of the month, with many stations recording their lowest August temperatures for up to 46 years on either the 29th or 30th.

Sunshine totals were above normal everywhere and it was the sunniest August for between seven and 15 years generally. Unusually for August, the second half of the month was sunnier than the first, with some stations recording their sunniest day of the month as late as the 30th.

Despite relatively high July rainfall levels, no car-based bat monitoring surveys were cancelled during that month. A record number of Daubenton's and car-based surveys were completed in August 2010, but rainfall amounts were generally small in this month. While no car-based surveys were cancelled mid-survey due to rain but a number of car-based surveyors recorded one or more pauses while surveying to allow rain showers to pass.

All weather data derived from www.meteireann.ie.

3.0 CAR-BASED BAT MONITORING

3.1 Methods

Training of surveyors is carried out in June and early July each year. Survey teams are provided with all equipment needed for the survey including: a time expansion bat detector (Courtpan Electronic, Tranquility Transect), minidisc recorder and minidiscs, pre-stamped envelopes to return the minidiscs, instruction manuals, recording sheets, batteries, flashing beacon, thermometer and a first aid kit.

Each year survey teams complete surveys of a mapped route within a defined 30km Survey Square. Routes cover 15 x 1.609km (1 mile) Monitoring Transects each separated by a minimum distance of 3.2km (2 miles).

Surveyors are asked to undertake 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 begins 45 minutes after sundown. Each of the 1.609km transects is driven at 24km (15 miles) per hour (at night) while continuously recording from the time expansion bat detector (set to x10 time expansion) on to minidisc.

On completion of surveys, minidiscs are forwarded to BCIreland for analysis. Each track is downloaded to Bat Sound™ and calls are identified to species level where possible. Species that can be identified accurately using this method are the common pipistrelle, soprano pipistrelle, and Nathusius' pipistrelle (*Pipistrellus nathusii*). Pipistrelle calls with a peak in echolocation between 48kHz and 52kHz are recorded as 'Pipistrelle unknown' because they could be either common or soprano pipistrelles. Leisler's bat, a low frequency echolocating species, can also be easily identified using this method. Occasional calls of *Myotis* bats are 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, and M. brandtii*). Occasional social calls of brown long-eared bats are also recorded.

Additional trial recordings were made during the first survey of R88 using a HTC Desire smart phone to determine its potential usefulness in recording output from the bat detectors while simultaneously recording GPS co-ordinates.

For quality control purposes a number of randomly selected .wav files are forwarded each year to Dr Jon Russ of the BCT UK for comparative analysis.

3.1.1 Statistical Analysis

For overall yearly trends, a Generalised Linear Model (GLM) with a Poisson error distribution (see Glossary) has been applied to the data from the Car-Based Bat Monitoring Scheme. Confidence intervals are generated by bootstrapping at Survey Square level (Fewster *et al*., 2000, see Glossary), as used in Generalised Additive Model (GAM) analysis (see Glossary). This approach essentially means that the number of encounters per survey square is modeled using log of the total number of recording intervals as an offset (Offset see Glossary) but allows use of a Poisson error distribution. For Nathusius' pipistrelle trend models were constructed this year based on a binomial distribution. This is because the species sometimes occurs in the same transect on multiple occasions but there are, much more often, transects with no occurrences of this species and, therefore, a large number of zeros in the dataset.

The analysis has been carried out using the first 15 x 1.6km transects only, from 2003-2008, so that results are comparable with the reduced 2009-2010 sampling plan. All annual estimates are now predicted as if each survey had a total of 1,125 0.32s recording intervals or snapshots (i.e. 75 snapshots for each of the 15 x 1.6km transects).

Generalised Additive Models (GAMs) have been fitted to the annual means to give a visual impression of the trend over time. Curved trend lines have been applied to the data.

REML (Residual or Restricted Maximum Likelihood) models were applied to log transformed bat count data and climate variables (temperature and rainfall totals) to determine if there were any significant relationships between bat activity and these weather variables. In most cases bat count data from both surveys in a square in a year were included so results therefore compare both within square differences (e.g. more bats present on warmer nights) and between square differences (e.g. more bats present in warmer squares).

3.2 Results

No training courses were held in 2010 because all surveyors had prior experience of the survey methodology. Telephone support was, however, provided to four survey teams when they encountered problems during surveys.

Survey work in 2010 was carried out from mid-July to the beginning of August and a repeat survey was carried out in early to mid-August. The median date of the first survey in 2010 was 24th July. The median date of the second survey was 11th August.

Twenty seven squares were surveyed in July 2010 but the full complement of 28 squares was surveyed in August (see Figure 3.1). In total 1312km of monitoring transects were driven and approximately 300hrs of survey time was spent on the scheme by 66 volunteers. A full or almost complete dataset was available from all survey routes, 55 in total. Overall, the quality of data collected in 2010 was excellent. Squares that were surveyed in 2010 cover the length and breadth of the island with squares in the extreme north, west, south and east of the island included, along with a good spread of squares in the midlands.

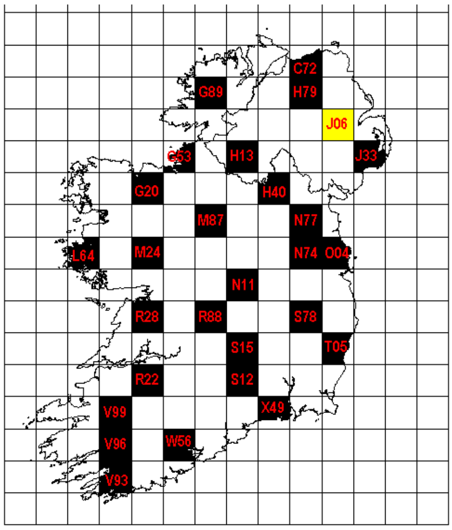

Figure 3.1: Location of 30km Survey Squares.

Black squares were surveyed twice in 2010, Yellow squares were surveyed once.

In total, 2672 bat encounters were recorded during the July and August 2010 surveys, from 816 monitoring transects. Encounter rates with the various bat species, however, (not corrected for the time spent surveying, or to allow for different distributions of survey squares in earlier years of the survey), showed an increase in Leisler's bats and common pipistrelles compared with 2009 results. Soprano pipistrelle encounter rates were slightly lower than 2009 (see Table 3.1). The proportions of species encountered (Figure 3.2) show a roughly similar picture to previous years with common pipistrelles the most abundant species accounting for almost half (44%) of all bat encounters. Leisler's bats and Soprano pipistrelles account for 25% and 21% of the total bat encounters, respectively, in 2010. Seven percent of all encounters are 'Pipistrelles Unidentified' that could be either soprano or common. Nathusius' pipistrelles, *Myotis* species and brown long-eared bats were encountered, as in previous years, in very low numbers.

Table 3.1: Raw bat encounter data, per 1.609km/1 mile transect, not corrected to encounters per km or per hour, Car-Based Bat Monitoring Scheme 2003-2010. Average number of bats reflects the average number of bat encounters observed during each 1.609km/1 mile transect travelled*.

Average encounters per 1.6km transect	No. of Transects (n)	Common pipistrelle	Soprano pipistrelle	Pipistrelle unidentified	Nathusius' pipistrelle	Leisler's bat	Myotis spp.	Brown long-eared	Total Bats
2003	180	1.294	0.478	N/a	0.000	0.289	0.039	n/a	2.100
2004	577**	1.905	0.695	0.443	0.000	0.511	0.050	n/a	3.621
2005	608	1.344	0.574	0.266	0.001	0.544	0.035	n/a	2.781
2006	887	1.701	0.652	0.271	0.033	0.892	0.029	0.024	3.620
2007	889	1.77	0.639	0.253	0.015	0.631	0.036	0.019	3.390
2008	927	1.686	0.768	0.294	0.006	0.739	0.029	0.002	3.537
2009	787	1.212	0.714	0.221	0.032	0.492	0.032	0.011	2.728
2010	816	1.442	0.668	0.241	0.069	0.809	0.023	0.012	3.275

* 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).
** n=577 for all species excepting Leisler's where n=597

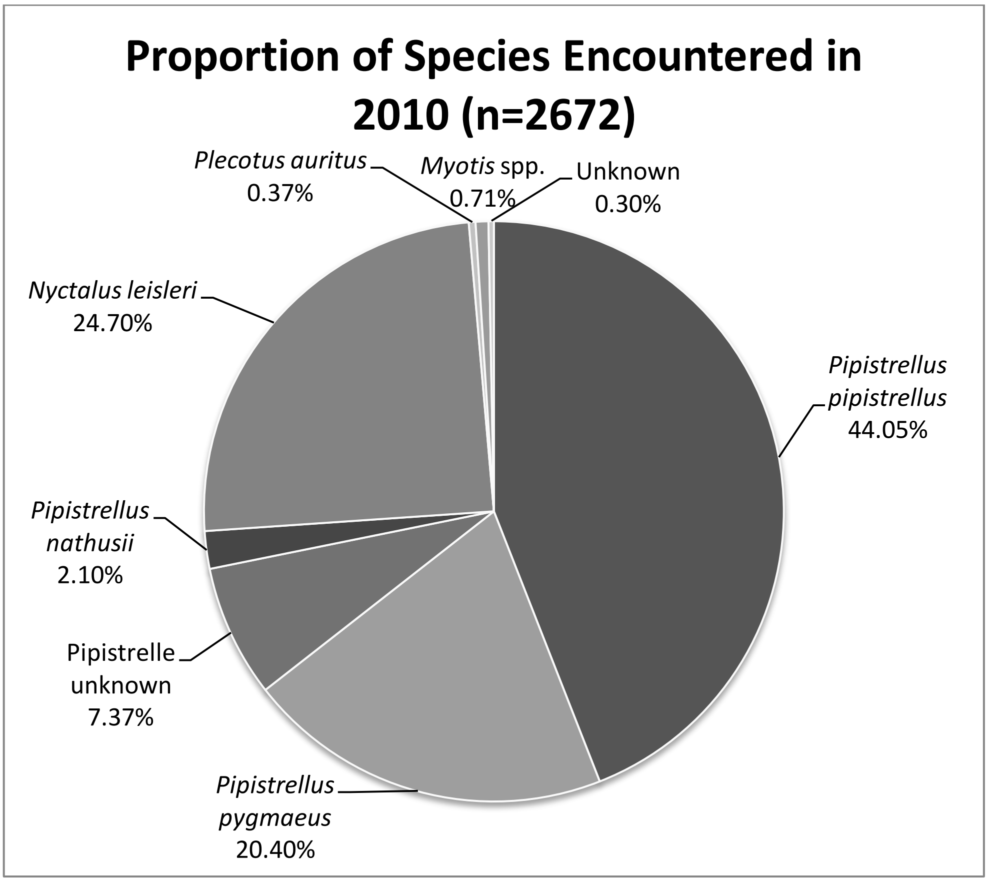

Figure 3.2: Proportion of species encountered during the survey in 2010. Total number of bat encounters, 2672. Excepting social calls of Leisler's bats and brown long-eared bats, which are unlikely to be mistaken for those of other species, bat social calls were noted during sonogram analysis but are not included in the above pie chart or in any statistical analyses.

Overall encounter rates varied between squares and between surveys, however, in general the squares with highest encounter rates were found in the east and south of the country. These included squares R22 and V99 in 2010, both of which averaged over 100 bat encounters per hour. J06, located in Northern Ireland, but which was only surveyed once in August, was also one of the highest encounter rate squares in 2010. Encounter rates per hour for each survey in each square are shown in Appendix 1, Tables A1.1 and A1.2 with the overall average shown in Table 3.2 below.

Table 3.2: Average number of bat encounters per hour for all surveys, 2010. 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 2010	Common pipistrelle	Soprano pipistrelle	Pipistrelle unknown	Nathusius' pipistrelle	Leisler's bat	Myotis spp.	Brown long-eared	Total/hr
Overall Mean	22.701	10.063	3.689	1.098	12.262	0.328	0.193	50.155
Standard Deviation	±16.079	±8.467	±3.034	±7.601	±12.78	±0.679	±0.414	±30.234
Minimum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maximum	68.439	36.884	13.469	56.410	58.815	2.642	1.227	143.295

3.2.1 Smart Phone Recordings

Sonogram analysis has been carried out on the recordings from the HTC phone compared with the Edirol digital recorder and results showed that 17.5% fewer bats were recorded by the HTC phone. The breakdown of species recorded by each is shown in Table 2.1. While for most species the results are broadly comparable the discrepancy is greatest between the soprano pipistrelle (Ppyg) results recorded from the two methods.

Table 3.3: Comparison of results from HTC phone recordings and normal digital recorder during survey of R88, 19th July 2010.

	Ppip	Ppyg	Pun	Leis	Myo	Total
HTC	21	*8*	1	3	0	33
Normal	23	*12*	2	2	1	40

3.2.2 Common pipistrelles, Pipistrellus pipistrellus

3.2.2.1 2010 Results

The overall average number of common pipistrelle encounters per hour was 21.6 during Survey 1 in 2010 and 23.7 in Survey 2. The overall average number of common pipistrelle encounters per hour for both survey periods was 22.7 (see Table 3.3). This figure is higher than that recorded in 2009 (18.99) but lower than figures recorded in other survey years: 25.87 in 2008, 27.31 in 2007 and 25.8 in 2006.

Common pipistrelles were the most frequently encountered species during the monitoring scheme in 2010 and in all survey years to-date. Figure 3.3 illustrates low, medium and high encounter rate squares for common pipistrelles in 2010 for each of the surveyed 30km squares. As in previous years this map shows lower common pipistrelle encounter rates further north and north-west while squares with the highest encounter rates are located in the south and east of the country. No common pipistrelles were recorded from square L64, Connemara, as in previous years.

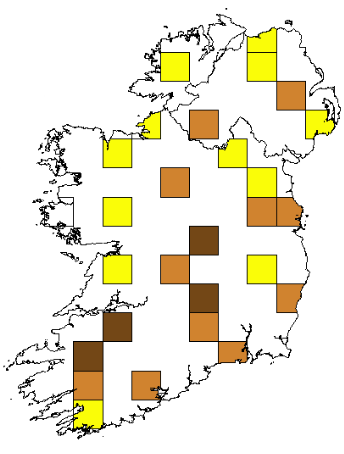

Figure 3.3: Survey squares colour coded according to common pipistrelle encounter rates (per hour) in 2010. The overall average rate of common pipistrelle encounters for all squares in 2010 was 22.7hr^{-1}.

Absent.

Encounter rate >0≤20hr^{-1}

Encounter rate >20≤40hr^{-1}
Encounter rate >40hr^{-1}

3.2.2.2 Trends

Figure 3.4 shows the results of a Generalised Linear Model applied to the car-based bat monitoring data for the common pipistrelle, along with Generalised Additive Model smoothed curves. Common pipistrelles increased in the first few years of the survey to a high in 2007. Levels dropped in 2008 and 2009 but in 2010 increased again resulting in a levelling of the GAM curve.

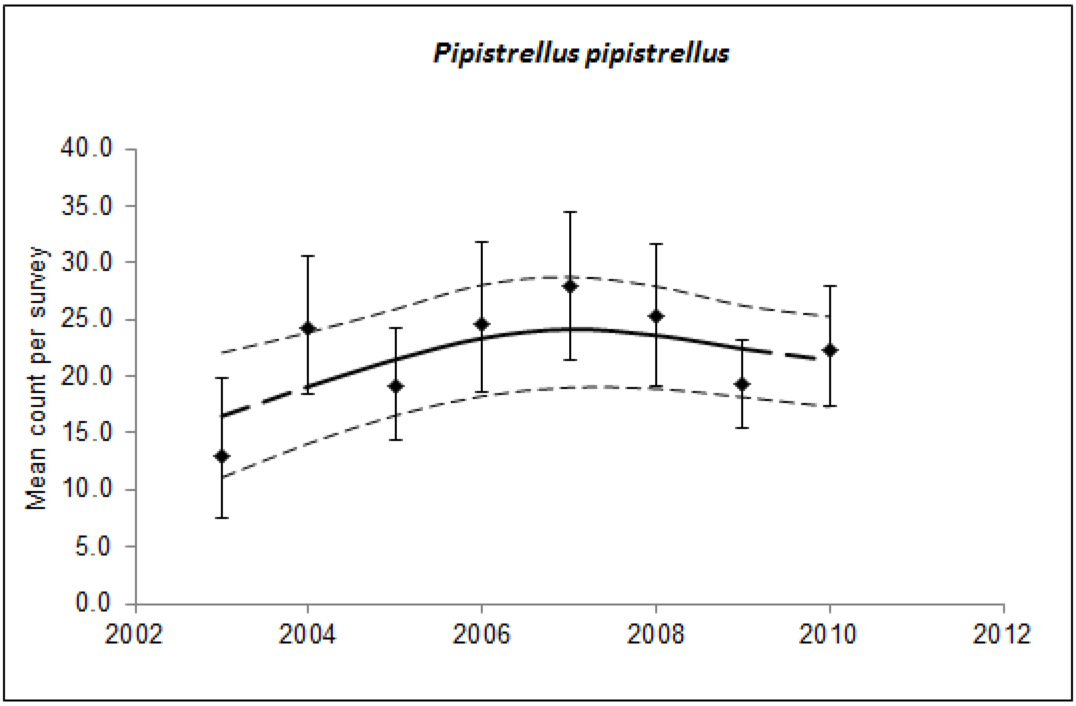

Figure 3.4: Results of the GAM/GLM model for common pipistrelle passes per survey. Points are estimated annual means derived from the Generalised Linear Model and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model curve with 95% confidence limits shown by the lighter dotted lines. All estimates are adjusted to 1,125 0.32s snapshots. Start and end of the smoothed trend are shown with a broken line to illustrate uncertainty at the start of the survey and, for 2009-2010, the possibility that the slope will change with coming years' data.

Table 3.4: GAM results for common pipistrelles with 95% confidence limits (using first 15 transects only 2003-2008). Values in the data section are ordinary means, whereas other figures are modelled estimates adjusted to 1,125 snapshots per survey.

Data					Smoothed GAM model				Unsmoothed GLM	
							95% conf limits			
year	**surveys**	**sites**	**mean**	**s.e.**	**estimate**	**s.e.**	**lower**	**upper**	**fitted**	**s.e.**
2003	9	7	16.4	3.6	16.5	2.8	11.1	22.1	12.9	3.0
2004	27	17	25.6	2.9	19.1	2.4	14.1	23.9	24.3	3.1
2005	31	17	21.3	2.3	21.5	2.4	16.6	25.9	19.1	2.5
2006	44	25	24.3	2.7	23.3	2.5	18.2	28.0	24.7	3.4
2007	43	25	27.0	2.8	24.1	2.5	19.0	28.7	28.0	3.3
2008	41	23	24.2	2.9	23.6	2.3	18.9	27.9	25.3	3.2
2009	52	28	18.0	1.6	22.4	2.1	18.2	26.2	19.4	2.0
2010	53	27	20.9	2.1	21.4	2.0	17.3	25.3	22.3	2.6

3.2.2.3 Factors Influencing Common Pipistrelles

A REML model of common pipistrelle passes (logged) with average monthly temperatures for July and August, with rainfall held constant, did not show a significant relationship between the two (Estimate 0.00072, S.E. 0.01617, Wald p-value 0.965). Likewise no significant relationship was found between logged bat passes per minute and monthly rainfall totals (Estimate -0.0002336, S.E. 0.0002836, Wald p-value 0.41), with temperature held constant. It is of interest, however, that the relationship between common pipistrelle passes and mean monthly temperature is positive while the relationship between common pipistrelle passes and total monthly rainfall is negative, albeit nowhere near significant.

When temperature data collected by surveyors on the start of each survey was used in a similar model the relationship was closer to but still not significant (Estimate -0.012417, S.E. 0.007422, Wald p-value 0.095), although this relationship is counter-intuitively negative so may be a chance effect.

3.2.3 *Soprano pipistrelles,* **Pipistrellus pygmaeus**

3.2.3.1 2010 Results

The overall average number of soprano pipistrelle encounters per hour was 8.55 during Survey 1 in 2010 and 11.52 during Survey 2; see Tables A1.1 and A1.2 (Appendix). Consequently, the overall average number of soprano pipistrelle encounters per hour for both survey periods was 10.1. This figure is lower than the 2009, 2008 and 2007 averages of 10.7, 11.78 and 10.2, respectively.

Soprano pipistrelles are usually the second most frequently encountered species during the monitoring scheme but the years 2010 and 2006 were exceptions when Leisler's bat encounter rates exceeded those of soprano pipistrelles. Figure 3.5 illustrates low, medium and high encounter rate squares for soprano pipistrelles in 2010. As in previous years the pattern of activity levels across the island are more difficult to distinguish than for common pipistrelles. Soprano pipistrelles were recorded in all survey squares in 2010.

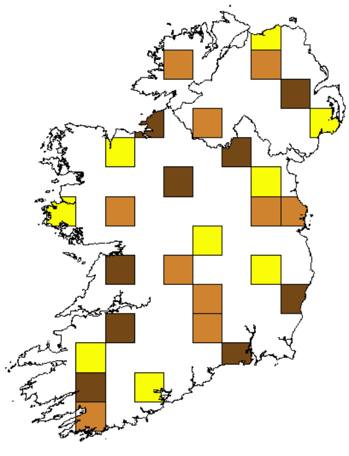

Figure 3.5: Survey squares colour coded according to soprano pipistrelle encounter rates (per hour) in 2010. The overall average rate of soprano pipistrelle encounters for all squares in 2010 was 10.1hr^{-1}.

Absent.
Encounter rate >0≤6hr^{-1}
Encounter rate >6≤12hr^{-1}
Encounter rate >12hr^{-1}

3.2.3.2 Trends

Figure 3.6 shows the results of Generalised Linear Model applied to car-based bat monitoring data for the soprano pipistrelle, along with Generalised Additive Model smoothed curves. The soprano pipistrelle appears to show a consistent, slightly increasing, linear trend even though 2010 is the second successive year of overall falling activity levels this has not been reflected in a downward turn in the GAM curve but rather a slight widening of the confidence interval bands. This may change following the coming years' surveys.

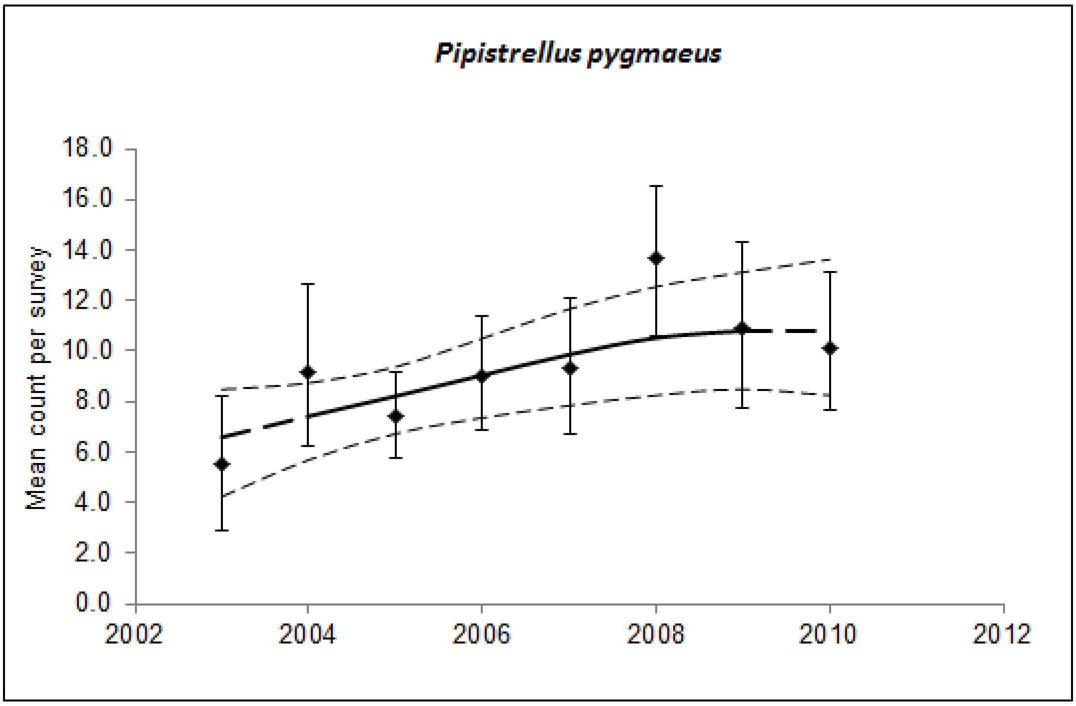

Figure 3.6: Results of the GAM/GLM model for soprano pipistrelle passes per survey. Points are estimated annual means derived from the Generalised Linear Model and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model curve with 95% confidence limits shown by the lighter dotted lines. All estimates are adjusted to 1,125 0.32s snapshots. Start and end of the smoothed trend are shown with a broken line to illustrate uncertainty at the start of the survey and for 2009-2010 the possibility that the slope will change with coming years' data.

Table 3.5: GAM results for soprano pipistrelles with 95% confidence limits (using first 15 transects only 2003-2008). Values in the data section are ordinary means, whereas other figures are modelled estimates adjusted to 1,125 snapshots per survey.

	Data				Smoothed GAM model				Unsmoothed GLM	
							95% conf limits			
year	surveys	sites	Mean	s.e.	estimate	s.e.	lower	upper	fitted	s.e.
2003	9	7	6.78	1.68	6.59	1.07	4.23	8.48	5.53	1.34
2004	27	17	10.30	1.77	7.42	0.79	5.68	8.73	9.15	1.64
2005	31	17	7.58	0.80	8.21	0.68	6.72	9.37	7.38	0.86
2006	44	25	9.84	1.19	9.04	0.82	7.35	10.50	8.99	1.18
2007	43	25	8.81	1.01	9.86	0.99	7.84	11.66	9.34	1.36
2008	41	23	12.07	1.45	10.52	1.11	8.24	12.55	13.64	1.53
2009	52	28	10.75	1.47	10.80	1.20	8.49	13.12	10.91	1.70
2010	53	27	10.09	1.25	10.81	1.38	8.24	13.63	10.13	1.40

3.2.3.2 Factors Influencing Soprano Pipistrelles

A REML model of soprano pipistrelle passes (logged) with average monthly temperatures for July and August showed a non-significant positive relationship between the two (Estimate 0.01801, S.E. 0.01437, Wald p-value 0.210). No significant relationship was found between logged soprano pipistrelle bat passes per minute and monthly rainfall totals (Estimate -0.0002774, S.E. 0.0002536, Wald p-value 0.274). It is of interest that, like common pipistrelles, the relationship between soprano pipistrelle passes and temperature is positive while the relationship between soprano pipistrelles and rainfall is negative.

When temperature data collected by surveyors at the start of each survey was used in a REML model the relationship was also non-significant (Estimate 0.005161, S.E. 0.006564, Wald p-value 0.432).

3.2.4 *Leisler's bat,* Nyctalus leisleri

3.2.4.1 2010 Results

The overall average number of Leisler's bat encounters per hour was 9.6 during Survey 1 in 2010 and 14.8 during Survey 2, see Tables A1.1 and A1.2 (Appendix) bringing the overall average number of Leisler's bat encounters per hour for both surveys to 12.26. This is higher than the average number of encounters from previous survey years: 7.58 in 2009, 11.2 in 2008 and 9.6 in 2007.

Leisler's bat was the third most frequently encountered species during the monitoring scheme in most years with the exception of 2010 and 2006 when numbers of encounters with this species exceeded those of soprano pipistrelles. Figure 3.7 illustrates low, medium and high encounter rate squares for Leisler's bat in 2010. In previous years, high encounter rate squares have been typically most frequent in the south and east of the country, a trend which has been largely followed in 2010, excepting M87. Low encounter rate squares are widely distributed, in particular in a band across the centre of the island. No Leisler's bats were recorded from square L64, Connemara in 2010, although this species was detected there in 2006 and 2007.

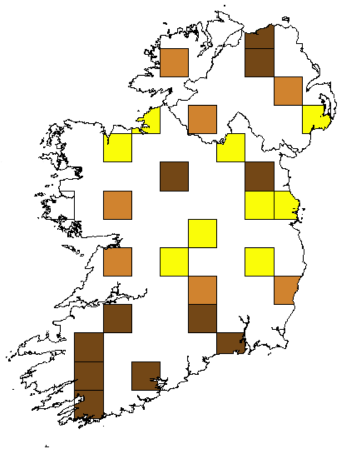

Figure 3.7: Survey squares colour coded according to Leisler's bat encounter rates (per hour) in 2010. The overall average rate of Leisler's encounters for all squares in 2010 was 12.26hr^{-1}.

Absent.

Encounter rate >0≤6hr^{-1}

Encounter rate >6≤12hr^{-1}

Encounter rate >12hr^{-1}

3.2.4.2 Trends

Figure 3.8 shows the results of the Generalised Linear Model applied to car-based bat monitoring data for the Leisler's bat, along with Generalised Additive Model smoothed curves. The decline in Leisler's bat annual means in 2008 and 2009 was offset by an increase in 2010. More year-on-year variation about the trend is apparent with Leisler's bat, compared with the common pipistrelle. Overall, however, the species appears to be relatively stable or slightly increasing.

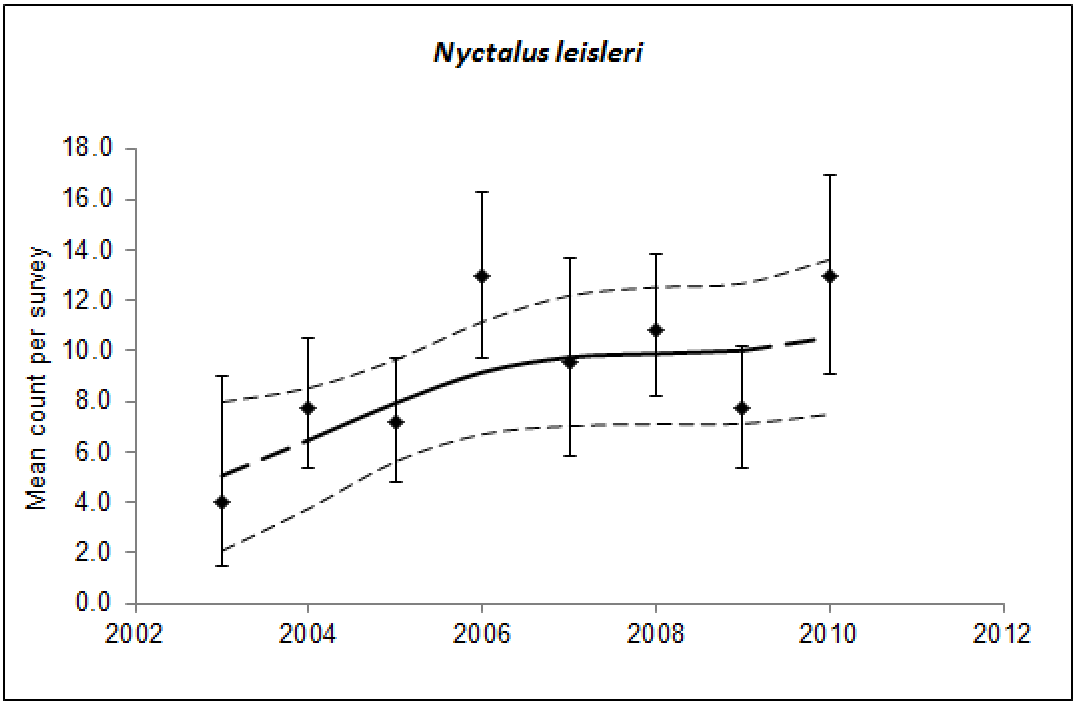

Figure 3.8: Results of the GAM/GLM model for Leisler's bat passes per survey. Points are estimated annual means derived from the Generalised Linear Model and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model curve with 95% confidence limits shown by the lighter dotted lines. All estimates are adjusted to 1,125 0.32s snapshots. Start and end of the smoothed trend are shown with a broken line to illustrate uncertainty at the start of the survey and for 2009-2010 the possibility that the slope will change with coming years' data.

Table 3.6: GAM results for Leisler's bat with 95% confidence limits (using first 15 transects only 2003-2008). Values in the data section are ordinary means, whereas other figures are modelled estimates adjusted to 1,125 snapshots per survey.

		Data			Smoothed GAM model				Unsmoothed GLM	
							95% conf limits			
year	surveys	sites	Mean	s.e.	estimate	s.e.	lower	upper	fitted	s.e.
2003	9	7	5.11	1.65	5.06	1.50	2.08	7.98	3.97	1.91
2004	28	17	7.71	1.18	6.47	1.21	3.75	8.53	7.71	1.35
2005	31	17	7.68	1.46	7.94	1.02	5.62	9.65	7.16	1.27
2006	44	25	13.59	1.58	9.16	1.14	6.70	11.16	12.94	1.66
2007	43	25	9.47	1.68	9.75	1.34	7.02	12.19	9.53	2.01
2008	41	23	10.07	1.34	9.89	1.40	7.11	12.53	10.83	1.43
2009	52	28	7.35	1.03	10.02	1.45	7.12	12.68	7.71	1.24
2010	53	27	12.23	1.67	10.53	1.57	7.49	13.61	12.98	2.05

3.2.4.2 Factors Influencing Leisler's Bats

A REML model of Leisler's bat passes (logged) with average monthly temperatures for July and August, and rainfall held constant, showed a significant relationship between the two (Estimate 0.03389, S.E. 0.01327, Wald p-value 0.011), see Figure 3.9. A significant relationship was also found between Leisler's bat passes per minute and monthly rainfall totals (Estimate -0.0006818, S.E. 0.0002401, Wald p-value 0.005), with temperature held constant. It is of interest that, like common and soprano pipistrelles, the relationship between Leisler's passes and temperature is positive while the relationship between Leisler's passes and rainfall is negative. Analysis of Leisler's passes in 2009, however, failed to show any significant relationships with monthly temperature or rainfall data so these significant results in 2010, with considerable random variation around the line, should be treated with caution.

When temperature data collected by surveyors at the start of each survey was used in a similar model the relationship was also found, to be significant (Estimate 0.016281, S.E. 0.005835, Wald p-value 0.006), a similar result to that found in 2009 (see Figure 3.9, although note that these graphs show a simplified version of the relationship with one point per survey rather than per transect since the graph showing points per transect would be too confusing).

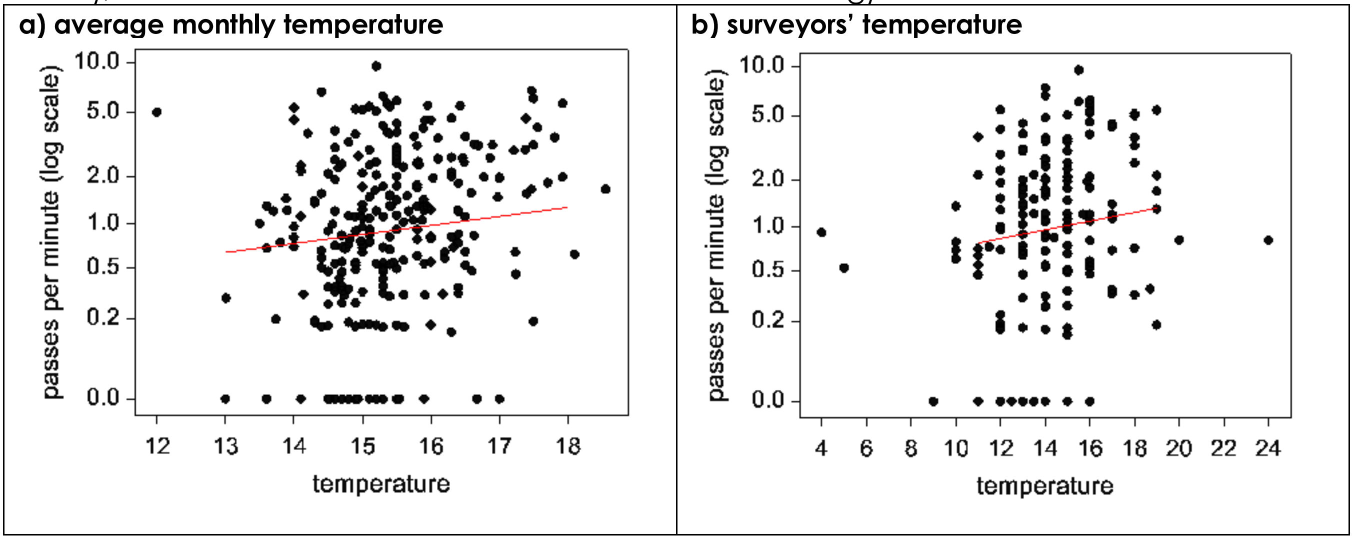

Figure 3.9: relationship between Leisler's bat passes per minute and temperature. Each point represents one car survey and the fitted line is linear on the log scale.

3.2.5 *Nathusius' pipistrelle,* Pipistrellus nathusii

3.2.5.1 2010 Results

The overall average number of Nathusius' pipistrelle encounters per hour was low, 0.148 during Survey 1 in 2010 and 2.01 during Survey 2, see Tables A1.1 and A1.2 (Appendix). The higher average for Survey 2 was heavily skewed by high numbers encountered along one transect. The overall average number of Nathusius' pipistrelle encounters per hour for both survey periods was 1.098, see Table 3.2. This is a much higher figure when compared with 0.1 in 2008 and 0.22 in 2007 but the 2010 mean was boosted by a large number of encounters from one transect during one survey in J06.

Figure 3.10 illustrates squares where the species was present in 2010. As in previous years this species was not recorded, during the car-based bat monitoring survey, from squares in the mid-west, e.g. M24, L64, R28 and G20.

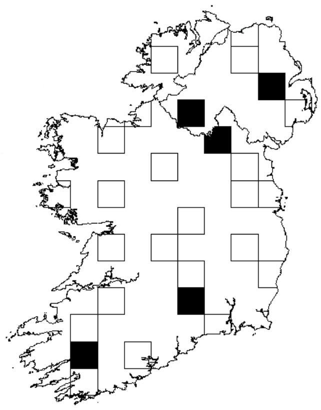

Figure 3.10: Survey squares indicating presence (black) or absence (white) of Nathusius' pipistrelle records from the 2010 car-based bat monitoring scheme.

3.2.5.2 Trends

Nathusius' pipistrelle has clearly increased from the zero values recorded in the first two years of the monitoring scheme. Figure 3.11 shows the results of fitting a GLM/GAM model for the proportion of one mile transects with Nathusius' pipistrelle passes. The smoothed curve suggests that, after an initial increase, the proportion has remained similar since 2006. Note that the fitted value for 2010 is rather lower than that for 2009, in contrast to the means in Table 1 where the 2010 value was inflated by the high count from J06 on 20/8/10.

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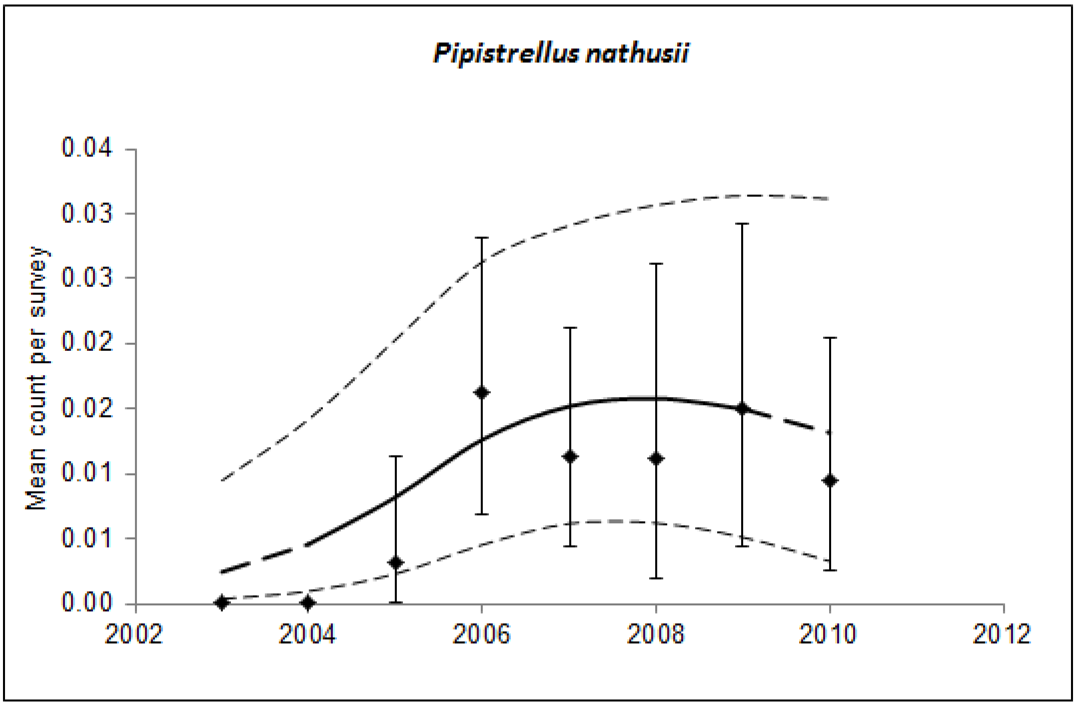

Figure 3.11: Results of the Generalised Linear Model for Nathusius' pipistrelle passes per survey. Points are estimated annual means derived from the GLM and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model curve with 95% confidence limits shown by the lighter dotted lines. All estimates are adjusted to 1,125 0.32s snapshots. Start and end of the smoothed trend are shown with a broken line to illustrate uncertainty at the start of the survey and for 2009-2010 the possibility that the slope will change with coming years' data.

Table 3.7: Binomial GAM results with 95% confidence limits for Nathusius' pipistrelle (using first 15 transects only 2003-2008).

Data					Smoothed GAM model				Unsmoothed GLM	
			Proportion transects				95% conf limits			
year	surveys	sites	Mean	s.e.	estimate	s.e.	lower	upper	fitted	s.e.
2003	9	7	0.000	0.000	0.002	0.003	0.000	0.009	0.000	0.001
2004	28	17	0.000	0.000	0.005	0.004	0.001	0.014	0.000	0.000
2005	31	17	0.002	0.002	0.008	0.005	0.002	0.020	0.003	0.003
2006	45	25	0.023	0.006	0.013	0.006	0.005	0.026	0.016	0.005
2007	46	26	0.015	0.005	0.015	0.006	0.006	0.029	0.011	0.004
2008	44	25	0.008	0.004	0.016	0.007	0.006	0.031	0.011	0.006
2009	53	28	0.014	0.004	0.015	0.007	0.005	0.031	0.015	0.007
2010	54	28	0.009	0.003	0.013	0.008	0.003	0.031	0.009	0.005

3.2.6 *Myotis* spp.

3.2.6.1 2010 Results

The overall average number of *Myotis* species encounters per hour was very low, 0.34 during Survey 1 in 2010 and 0.32 during Survey 2, see Tables A1.1 and A1.2 (Appendix). The overall average number of *Myotis* species encounters per hour for both months was 0.33 in 2010, see Table 3.2. This average figure is lower than previous years: 0.46 in 2009, 0.42 in 2008 and 0.56 in 2007.

Figure 3.12 illustrates squares where this species group was recorded in 2010.

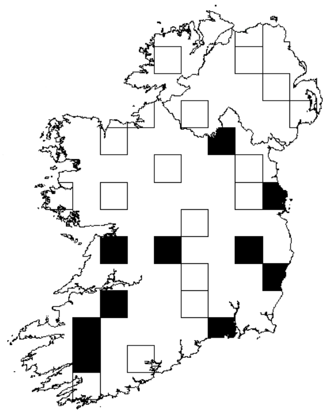

Figure 3.12: Survey squares indicating presence (black) or absence (white) of *Myotis* spp. records from the 2010 car-based bat monitoring scheme.

3.2.6.2 Trends

Myotis spp. numbers seem to show reasonably constant year-year levels (see Figure 3.13), although confidence limits are relatively wide due to the low encounter rate.

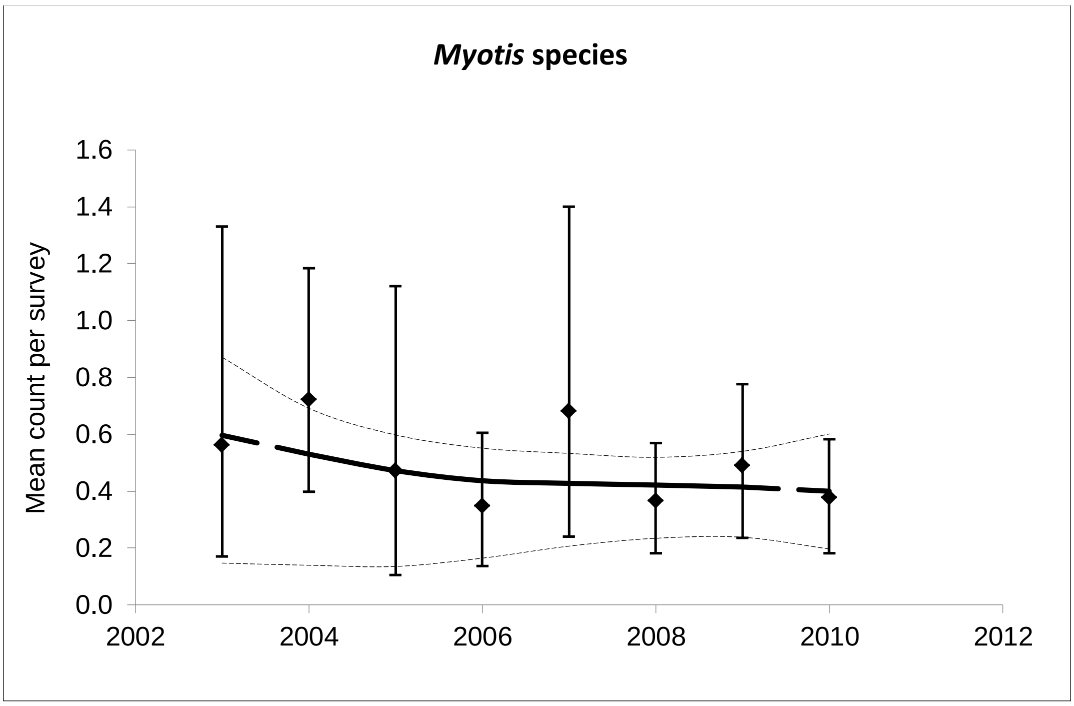

Figure 3.13: Results of the GAM/GLM model for *Myotis* spp. passes per survey. Points are estimated annual means derived from the Generalised Linear Model and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model curve with 95% confidence limits shown by the light dotted lines. All estimates are adjusted to 1,125 0.32s snapshots. Start and end of the smoothed trend are shown with a broken line to illustrate uncertainty at the start of the survey and for 2009-2010 the possibility that the slope will change with coming years' data.

Table 3.8: GAM results for *Myotis* species with 95% confidence limits (using first 15 transects only 2003-2008). Values in the data section are ordinary means, whereas other figures are modelled estimates adjusted to 1,125 snapshots per survey.

		Data			Smoothed GAM model				Unsmoothed GLM	
							95% conf limits			
year	**surveys**	**sites**	**Mean**	**s.e.**	**estimate**	**s.e.**	**lower**	**upper**	**fitted**	**s.e.**
2003	9	7	0.78	0.32	0.60	0.18	0.15	0.87	0.56	0.31
2004	27	17	0.78	0.21	0.53	0.14	0.14	0.69	0.72	0.20
2005	31	17	0.52	0.22	0.47	0.12	0.14	0.60	0.47	0.27
2006	44	25	0.39	0.11	0.44	0.10	0.16	0.55	0.35	0.12
2007	43	25	0.63	0.25	0.43	0.08	0.21	0.53	0.68	0.31
2008	41	23	0.32	0.10	0.42	0.07	0.23	0.52	0.37	0.10
2009	52	28	0.48	0.13	0.41	0.08	0.24	0.54	0.49	0.14
2010	53	27	0.36	0.10	0.40	0.10	0.20	0.60	0.38	0.10

3.2.7 Brown long-eared bat, Plecotus auritus

3.2.7.1 2010 Results

Since this species was encountered just 10 times during the survey in 2010, the overall average number of brown long-eared bat encounters per hour was very low, 0.19 during Survey 1 in 2010 and 0.19 during Survey 2, see Tables A1.1 and A1.2 (Appendix). The overall average number of brown long-eared encounters per hour for both months was 0.19 in 2010, see Table 3.2. This compares with 0.19 in 2009, 0.03 in 2008 and 0.29 in 2007.

Figure 3.14 illustrates squares where this species was recorded in 2010.

Of all the species encountered during the monitoring scheme, the brown long-eared bats is typically the least common.

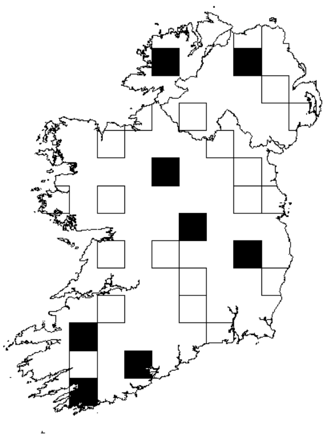

Figure 3.14: Survey squares indicating presence (black) or absence (white) of brown long-eared bat records from the 2010 car-based bat monitoring scheme.

3.2.7.2 Trends

This species is recorded in very low numbers by the car-based bat monitoring scheme. A dedicated brown long-eared bat monitoring programme, with counts from summer roosts, is now underway. Results from that scheme are the subject of a separate three year synthesis report in 2011.

3.2.8 Scientific publications

A paper on the use of car-based bat monitoring in Ireland was submitted to the peer-reviewed periodical Animal Conservation. This was provisionally accepted for publication in January 2011 pending revisions. Two tranches of revisions have been carried out and we are waiting on confirmation of acceptance.

Acoustic Leisler's bat recordings collected as part of the car-based bat monitoring programme were analysed in detail in 2010. This was carried out as part of a review into the possibility of the presence of Noctule (*Nyctalus noctula*) in Ireland. Ninety eight *Nyctalus* sp. Calls, recorded from five 30km squares (J06, N77, O04, S78 and T05) on the east coast (see Figure 3.15), during the car-based monitoring scheme were analysed (peak frequency & call duration). These were compared to 220 reference calls of *N. leisleri* from Dartry and Phoenix Parks, County Dublin, Ireland and published data on *N. leisleri* and *N. noctula* calls from Britain. All Irish calls recorded from Dartry Park, Phoenix Park and the car monitoring squares fell within the known parameters range of *N. leisleri* but also overlapped with the higher frequency and shortest duration calls of *N. noctula* (see Figure 3.16). For *N. noctula*, however, no Irish calls overlapped with the lower frequency range and longest call duration of *N. noctula*, indicating that this latter species was probably not recorded in the Irish dataset. See: Buckley D.J., Puechmaille S.J., Roche N. and Teeling E.C. (2010). A critical assessment of the presence of *Barbastella barbastellus* and *Nyctalus noctula* in Ireland with a description of *N. leisleri* calls from Ireland. Hystrix Italian Journal of Mammalogy. In press.

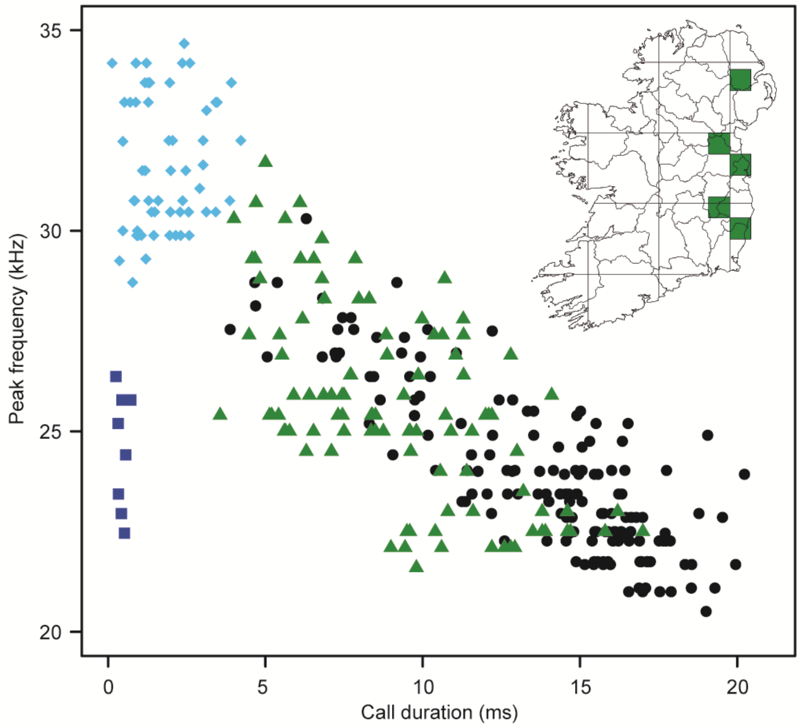

Figure 3.15: Echolocation peak frequency versus call duration for search phase and approach phase calls (●), feeding buzz I (♦) and feeding buzz II (■) for *N. leisleri* recorded in Ireland. Green triangles (▲) represent echolocation calls recorded during the car transects from eastern Ireland (green squares on the map of Ireland) (From Puechmaille *et al*., In Press).

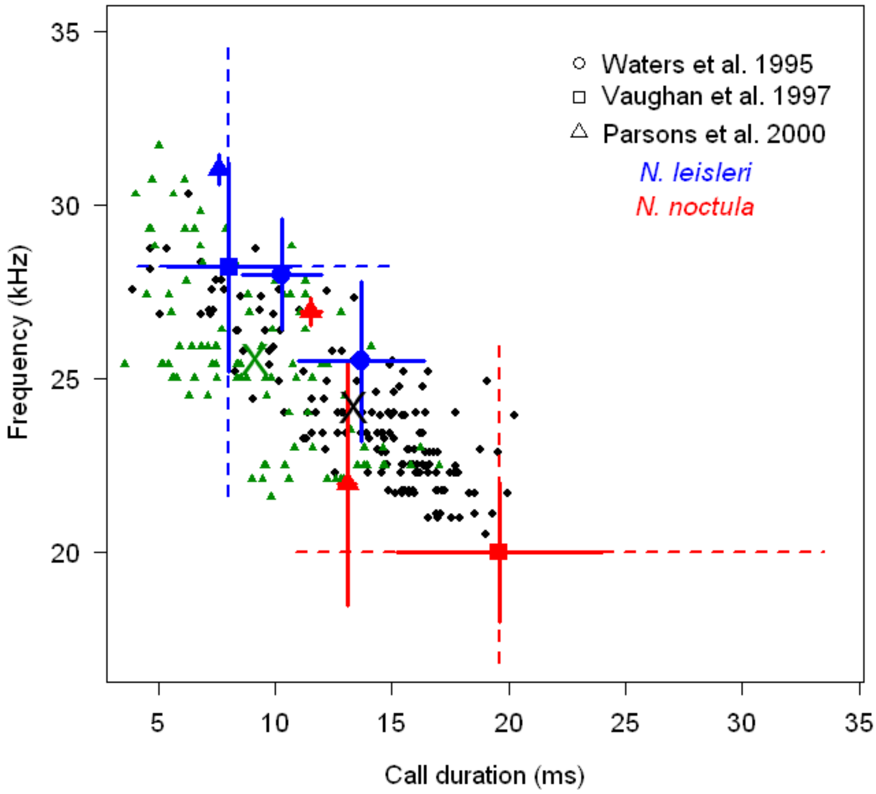

Figure 3.16: Echolocation peak frequency versus call duration for *N. leisleri* recorded from stationary position (**+**) and car transect data (▲). The average values for the two data sets are presented by large "X" symbols. Published averages (larger solid symbols), one standard deviation (solid line) and range (dashed line) of published *N. noctula* (red) and *N. leisleri* (blue) calls from England and Wales are also presented. For published data, different types of calls were presented whenever available in the original publication (e.g. type 1 & type 2 calls; Parsons & Jones 2000). (From Puechmaille *et al*., In Press)

3.2.8 Other Vertebrates

As in previous years, surveyors were asked to record living and dead vertebrates, that they encountered during the surveys during and between transects. This resulted in the collection of 285 records of living vertebrates (apart from bats) and 24 records of dead vertebrates in 2010. Figure 3.17 is a pie chart illustrating proportions of living vertebrate observations attributed to species or species groups. As in previous years records are dominated by cats, which in 2010 accounted for 57% of all records collected. Rabbits were the second most frequently encountered species with 27 records collected. Dogs were the third most common (25 records, although the same rounded percentage, 9%, as rabbits), followed by foxes. Just one mink was recorded in 2010, along with two barn owls.

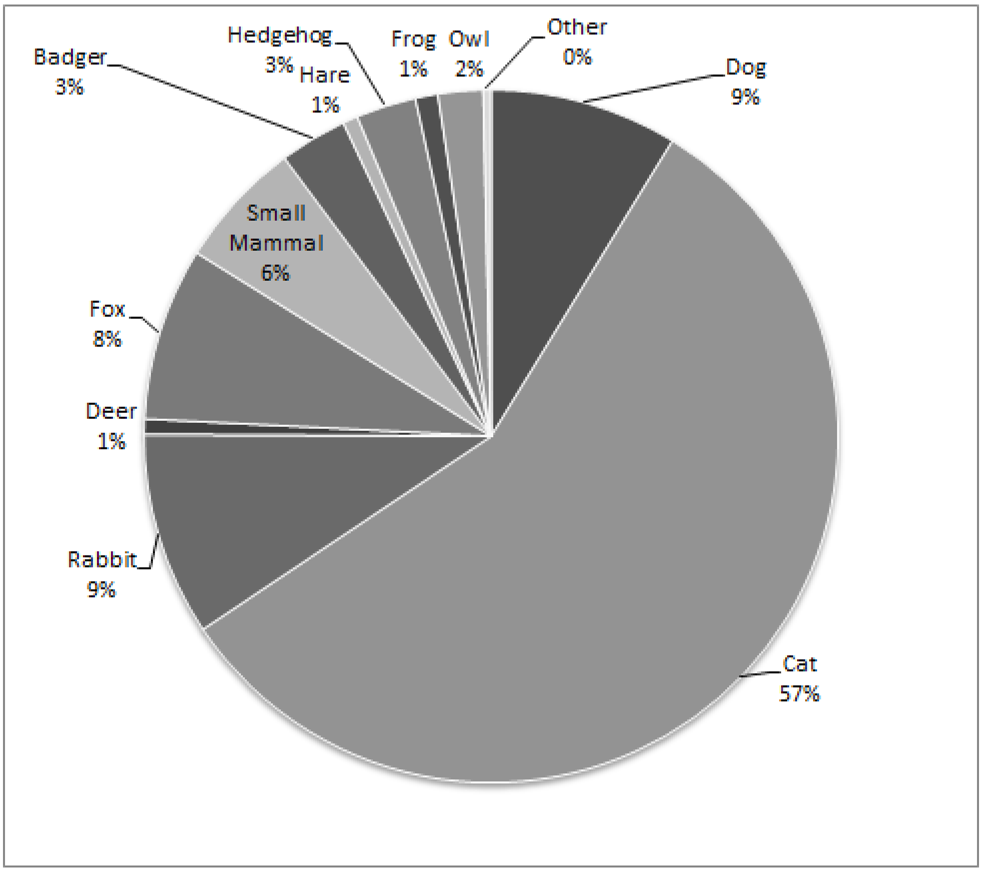

Figure 3.17: Living vertebrates, other than bats, observed during 2010, n=285. The category 'Small mammals' includes mice, rats, shrews and unidentified small mammals. The category 'Owls' includes two Barn Owl and four Long-eared Owl records. The 'Others' category includes one mink record for Survey Square R28.

3.2.8.1 Cats

Cats are the other vertebrate species most frequently encountered during the survey. From 2006 until 2008 this species showed a steady increase. In 2009, there was a decline in the number of cats observed per hour of surveying but 2010 saw an increase again.

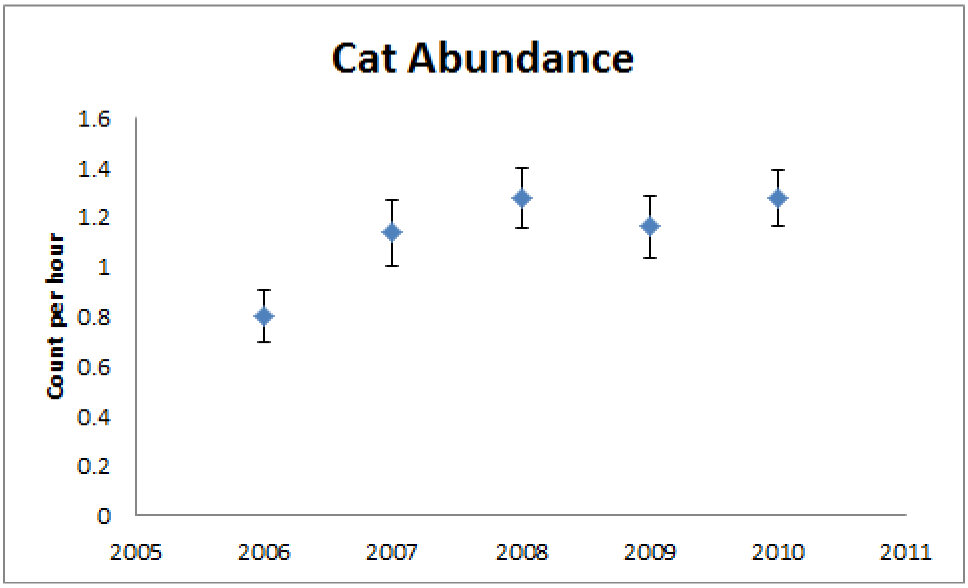

Figure 3.18: Average number of cats observed per hour of surveying with 95% standard error bars.

3.2.8.2 Foxes and Rabbits

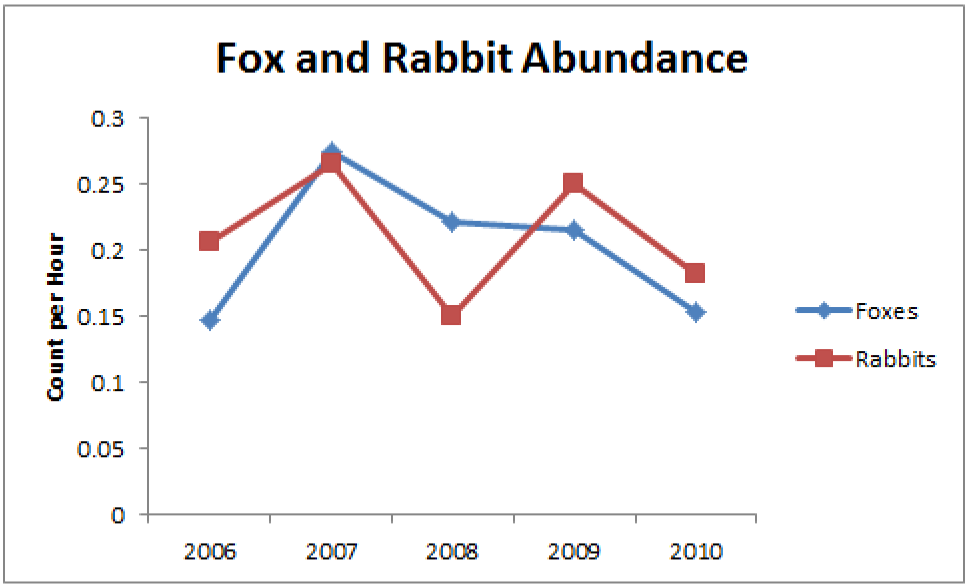

Figure 3.19: Average number of foxes and rabbits per hour of surveying.

Roadside counts of fox and rabbit numbers, rabbits in particular, show considerable yearly variability.

3.2.8.3 Dead vertebrates

The number of dead specimens recorded from roadsides totalled 24 in 2010. Rabbits, foxes, cats, badgers and hedgehogs were recorded. As in previous years, species proportions differ from living fauna, with greater representation of small mammals, hedgehogs and badgers among dead, compared with living roadside specimens.

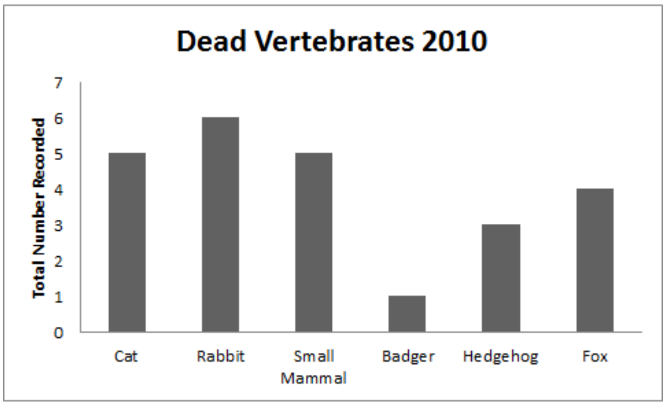

Figure 3.20: Dead vertebrates, other than bats, observed during 2010, n=24. The category 'Small mammals' includes mice and unidentified small mammals.

3.3 Discussion

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. A study of roadside bird survey data from New Brunswick in Canada highlighted this problem. There, the rate of change in mature forest cover along roadsides was found to be much lower than the actual rate of decline in the wider countryside for at least some of the three decades of the survey. This, therefore, potentially affected population trend estimates derived from roadside surveys for, in this instance, woodland bird species, such as the blackburnian warbler (*Dendroica fusca*), for which no decline had been recorded in one of the decades of the survey when the rate of roadside forest cover change was far lower than that of the wider landscape (Betts *et al.*, 2007).

3.3.1 Volunteer uptake

Sixty three individuals, a relatively large number of volunteers, undertook the survey in 2010. Volunteer teams' level of experience has increased due to yearly participation. As a consequence in 2010 there were no training courses required.

3.3.2 Survey Coverage in 2010

A similarly high number of completed surveys were achieved in 2010 compared with 2009. In 2010, 55 surveys were undertaken, out of a possible maximum of 56. However, data from all surveys was usable in 2010, compared with 2009 when faults with detectors meant that recordings from three surveys of could not be used. So, in 2010, 27 surveys were successfully completed in July and 28 in August. A combination of back up survey teams for the North, and reduced survey time, may have contributed to this positive outcome. In the two years since the shorter survey regime was introduced there has been a higher rate of survey completion which may be directly attributable to the greater ease in carrying out the survey. In 2009 a number of volunteers mentioned that the reduced survey time had made the survey considerably easier to complete.

3.3.3 Dataset

The 2010 dataset consisted of 2,672 bat encounters. The common pipistrelle was the most frequently encountered species, as in all previous years, but it constituted just 44% of the bat observations compared with roughly 50% in most previous years. Leisler's bat showed an increase in 2010 and accounted for 25% of total bat encounters.

3.3.4 Smart Phone Recordings

Consultation with Jon Russ of iBATs has been carried out on lower encounter rates between the HTC smart phone and the digital recordings during the trial in R88 and he has suggested that a resistor and capacitor need to be added to the lead between the detector and phone. Jon Russ also indicated that trials by iBATS using both iPhones and other HTC phones in Britain in 2010 have shown promising results. Further trials will be completed with this in Ireland in 2011.

3.3.5 Species Abundance and Yearly Trends

3.3.5.1 Common pipistrelles

The activity distribution of this species followed its usual pattern with higher encounter rate squares located in the southern half of the country, although fewer squares showed very high abundance compared with previous years. In 2010, the species was absent from square L64 in Connemara, as in all previous survey years. This species was not recorded from the L64 area during the 2008-2009 BATLAS survey but it was found in two 10km squares immediately to the south of the survey route (Carden *et al.*, 2010). In general, the BATLAS results showed that the species was present in some parts of the extreme west of Ireland but was not abundant or frequent there.

According to the trend model this species increased in the first few years of the survey reaching a peak in 2007. The peak was then followed by a decline from 2008 to 2009 but a further increase in 2010. Last year the trend model appeared to show a quadratic pattern with an increase followed by a more recent decline, but with 2010's data included in the model the trend now appears more stable.

No significant relationship was found between common pipistrelle passes and weather variables. The relationship between common pipistrelles and temperature, although not significant, is positive. Common pipistrelles showed a weak, non-significant negative relationship with monthly rainfall totals.

3.3.5.2 Soprano pipistrelles

The pattern of activity distribution for the soprano pipistrelle has never been as clear as for common pipistrelles although this species does show some western bias. In 2010, however, some eastern squares, along with those in the west, recorded medium and high soprano pipistrelle abundance.

The trend for this species showed a decline in 2010 compared with 2009, but the species still appears relatively stable or even slightly increasing, despite year-on-year oscillation.

Results of REML analysis, however, showed that the nature of the relationship between soprano pipistrelles and monthly temperature was positive and between rainfall and soprano passes was negative, the same as for Leisler's bat.

3.3.5.3 Leisler's Bat

As is fairly typical when examining yearly activity distribution of Leisler's bat, it is difficult to discern any particular patterns, although overall the species usually shows an eastern and southern bias (see Roche *et al.* 2009).

Overall average encounter rates for 2010 showed an increase in Leisler's activity from 2009 levels. Despite some yearly oscillation, the trend model indicates that this species may be increasing.

REML analysis showed that the species has a significant positive relationship with mean monthly temperature and a significant negative relationship with monthly total rainfall. There was also a highly significant positive relationship between temperature data collected by surveyors and Leisler's bat activity.

3.3.5.4 Nathusius' Pipistrelle

Nathusius' pipistrelle has increased from zero values in the first two years of the monitoring scheme. However, it should be noted, that squares in Northern Ireland where this species has a stronghold, were not surveyed for the first few years of the survey. Due to multiple passes in a single transect in Northern Ireland this year it was decided to carry out trend analysis for this species using presence absence rather than count data. As a result the error bars are reduced, along with yearly variation.

While error bars are still very wide, the species has increased from the early years of the survey but further years of survey are required to determine whether it will continue to increase or stabilise.

The car-based bat monitoring survey continues to add records for the species where it has not previously been encountered.

3.3.5.5 Myotis spp.

Myotis spp. numbers seem to show reasonably constant year-year levels, although confidence limits are very wide due to the low encounter rate. This trend should not be viewed as a true representation of *Myotis* species' trends since it combines observations from three, or possibly four, species and this, along with wide error bars, means that downward trends in any of the individual *Myotis* spp. could be easily masked.

3.3.5.6 Brown Long-eared Bat

This species is the least frequently observed species from the car-based bat monitoring scheme. Results from the roost count-based monitoring scheme are described in a separate report in 2011.

3.3.6 Other Vertebrates

Other vertebrates were recorded in 2010 as in previous years, and again cats were the most commonly observed animal. This species showed an increase from 2006 to 2008 and, in 2009, a slight decline. 2010 saw another increase in the number of cats counted along roadsides per hour.

A similar plot of mean rabbit and fox numbers shows considerable year-year oscillation in roadside observations of these species.

4.0 ALL-IRELAND DAUBENTON'S BAT WATERWAY MONITORING SCHEME

4.1 Methods

The All-Ireland Daubenton's Bat Waterway Monitoring Survey methodology is based on that currently used in BCT's UK National Bat Monitoring Programme NBMP) (Anon, 2004).

Prior to the allocation of sites, all surveyors are contacted by email to determine their participation in the coming year's surveys. All newly recruited surveyors are invited to attend an evening training course organised for the months of June and July. This training course consists of a one hour PowerPoint presentation followed by a discussion of potential survey areas. An outdoor practical session on a local river or canal to demonstrate the survey methodology is then completed. An information pack consisting of a detailed description of the methodology, maps, survey forms and online training details are provided for each survey team. Heterodyne bat detectors are also available on loan for the duration of the summer months.

Newly recruited surveyors are assigned a choice of 2-3 starting points located within 10km of their home address or preferred survey area. Seasoned surveyors are reassigned starting points surveyed in previous years. Starting points are selected from the EPA's National Rivers Monitoring Programme in the Republic of Ireland and the Water Quality Management Unit dataset under the NIEA, Northern Ireland.

Surveyors undertake a daytime survey of their allocated sites to determine its safety and suitability for surveying. At the chosen site, ten points (i.e. survey spots) approximately 100m apart are marked out along a 1km stretch of waterway. The surveyors then revisit the site on two evenings in August and start surveying 40 minutes after sunset. At each of the ten survey spots, the surveyor records Daubenton's bat activity as bat passes for four minutes using a heterodyne bat detector and torchlight (Walsh *et al.*, 2001).

Bat passes are either identified as 'Sure' Daubenton's bat passes or 'Unsure' Daubenton's bat passes. A 'Sure' Daubenton's bat pass is where the surveyor, using a heterodyne detector, has heard the typical rapid clicking echolocation calls of a *Myotis* species and has also clearly seen the bat skimming the water surface. Bat passes that are heard and sound like *Myotis* species but are not seen skimming the water surface may be another *Myotis* species. Therefore, these bat passes are identified as 'Unsure'. The number of times a bat passes the surveyor is counted for the duration of the four minutes. Therefore, counting bat passes is a measure of activity and results are quoted as the number of bat passes per survey period (No. of bat passes/40 minutes).

Surveyors are also requested to record a number of parameters including air temperature, weather data and waterway characteristics, such as width and smoothness.

Surveyors are asked to undertake the survey on two dates, one between the dates of 1st to 15th August (Survey 1, S1) and the repeat survey between the dates of 16th to 30th August (Survey 2, S2). On completion of surveys, survey forms are returned to BCIreland for analysis and reporting.

4.1.1 Statistical Analysis

In previous years bat pass counts were used in a REML model (log-transformed) to investigate the potential relationships with collected variables. For 2010, the dataset

(2006-2010) was entered into a model looking at the impact of the various covariates on the probability of observing bats at a spot i.e. a binomial model. Covariates used in previous years were also applied to the model in 2010. The REML model was also calculated to compare to the binomial model but the results are not reported here.

Analyses were based on data collated on survey dates between day numbers 205-250 (i.e. 24th July and 7th September, if not a leap year) which is designed to give approximately one week either side of the official survey period to maximise the amount of data available.

For analysis based on bat passes, both counts excluding and including 'Sure' and 'Unsure' Daubenton's bat passes were used. For binomial analyses, the presence of both 'Sure' and 'Unsure' Daubenton's bat passes at each spot were used.

In addition, data from met stations from Met Eireann in the Republic of Ireland were compared to data collated by surveyors. This met data was added to the binomial model. The data from climatological stations were used. For each survey site the distance to each met station was calculated and rain, wind or temperature estimates formed as weighted means, with the weights being the inverse of the distances, so that the nearest stations make the greatest contribution. The median distances between sites and their nearest met station is 32km for wind, 13.7km for rainfall and 15.7km for temperature.

To assess trends, a Generalised Linear Model (GLM) with a Poisson error distribution (see Glossary) is applied to the entire dataset (i.e. 2006-2010). Confidence intervals are generated by bootstrapping at waterway site level (Fewster *et al*., 2000, see Glossary). The maximum number of bat passes per survey spot used for analysis is 48 passes (both Sure and Unsure) (i.e. one pass per 5 seconds) because it is considered that volunteers differ greatly in how they record continuous activity and this truncation reduces the uncertainty associated with higher counts.

This year, additional trend analysis was carried out with data from 2006-2010 using Binomial (presence/absence) Models (dataset only includes waterway sites surveyed for 2 or more years as waterway sites surveyed in a single year do not contribute to information on trends). This essentially models the percentage of survey spots with bats present at each waterway site. Bootstrapping is used to find standard errors using logistic regression (a GLM with a logit link function). A smoothed GAM trend is also fitted (to highlight the change in trend) to the results both with and without co-variates. The co-variates were determined using the binomial GLMM model.

4.2 Results

4.2.1 Training and Volunteer Participation

In 2010, training courses were organised in counties Wexford, Kerry, Louth, Kildare, Offaly, Meath, Dublin, Tyrone, Galway, Armagh, Antrim (x2 courses) and Limerick. Over 200 people attended these courses.

A total of 211 waterway sites were surveyed by 181 survey teams in 2010; this included 38 new survey teams. Nineteen teams surveyed 2 or more waterway sites (n=49) while all remaining teams (n=162) surveyed one waterway site. The majority of waterway sites were surveyed by teams composed of members of the public (n=145) and the remainder were NPWS staff (n=22), NIEA staff (n=18) and BCIreland committee members/local bat group members (n=26).

A total of 16 different bat detector models were used by survey teams in 2010. The Bat Box III heterodyne bat detector was the most common model (n=40, 19%) followed by Magenta Mark IV heterodyne bat detector (n=30, 14.3%) and Bat Box Duet Frequency Division/Heterodyne Detector (n=27, 12.9%) (see Table A2.1, Appendix 2).

4.2.2 Waterway sites surveyed

A total of 211 waterway sites were surveyed in 2010, the highest number of waterway sites since the monitoring programme began in 2006. Forty-two waterways sites surveyed in 2010 were new waterway sites. Thirty-six waterways sites were located in Northern Ireland and 175 waterway sites in the Republic of Ireland. Fifty-three (25%) of the waterway sites surveyed in 2010 have been surveyed each year since 2006. Overall, 375 waterway sites across the island have been surveyed at least once over the 5 years of the monitoring scheme.

In 2010 a total of 10 canals (26 waterway sites), 2 channels and 118 rivers (183 waterway sites) were surveyed. The Royal Canal had 8 waterway sites surveyed along its length while the River Boyne and River Nore had 10 waterway sites each located along their length. Of the four provinces, the highest number of waterway sites were surveyed in Leinster (n=96) and County Meath, for the first time, had the highest number of waterway sites surveyed per county (n=17). The number of waterway sites surveyed in Ulster (n=47) in 2010 was the highest number of sites surveyed in the province over the five years of the scheme. Totals for the remaining three provinces were lower than other monitoring years.

4.2.3 Completed surveys

A total of 402 completed surveys from 211 waterway sites were returned to BCIreland in 2010. Two hundred and one surveys were completed in each survey period in 2010 (Survey 1: 1st – 15th August) (Survey 2: 16th – 30th August). Waterway sites with repeated surveys (i.e. surveys completed in both sampling periods S1 and S2) provide more robust data for monitoring. In 2010, a total of 193 repeated surveys (91.4% of waterway sites) were completed (see Figure 4.1). This was greater than the number of repeat surveys in 2009 (81%) and 2008 (74%), which was poor due to adverse weather conditions, but less than 2007, which had the highest rate of repeat surveys of all five years to-date (93%).

In 2010 ‘Sure’ Daubenton’s bat passes were recorded on 196 waterway sites (93%) (see Figure 4.2).

At each of the 10 survey spots of each completed survey volunteers recorded Daubenton’s bat activity for 4 minutes generating 40 minutes of data per completed survey. In total, 20,728 ‘Sure’ Daubenton’s bat passes and 3,734 ‘Unsure’ Daubenton’s bat passes were recorded during 268 hours of surveying. The mean number of ‘Sure’ Daubenton’s bats passes per survey was 51.5 passes, which is the highest mean for the five years of monitoring. In addition, bats were recorded on 61.5% of survey spots. Connaught, for the fifth year running, had the highest mean (Mean no. = 68.9 ‘Sure’ bat passes) and in 2010 the highest proportion of survey spots with bats (63.8% of survey spots with bats). All provinces, except for Connaught, recorded higher mean numbers of passes than in 2009.

For a full break down of descriptive results for 2010 see Table A2.2, Appendix 2.

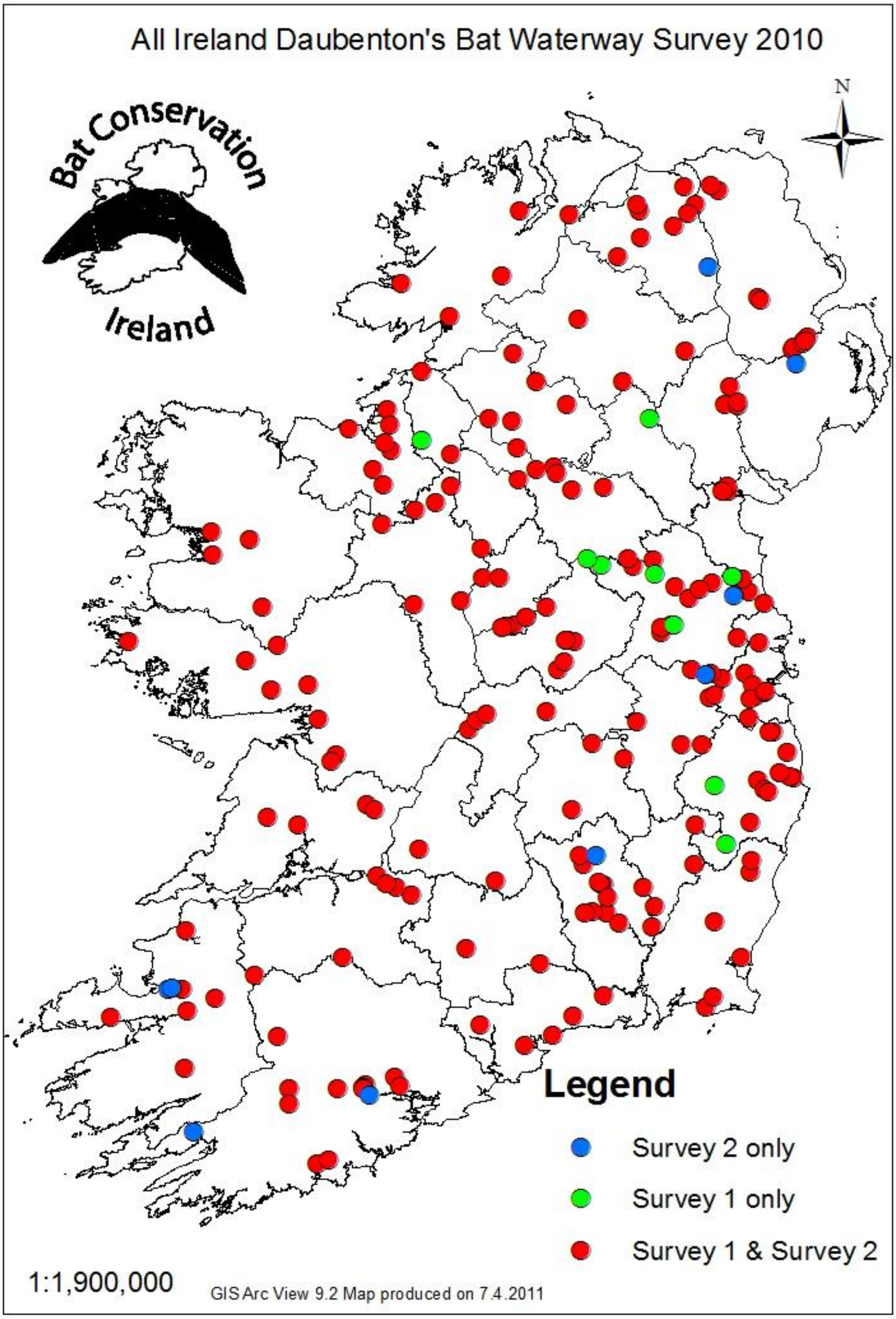

Figure 4.1: Location of all waterway sites surveyed once (Survey 1 or Survey 2 only) or twice (Survey 1 & Survey 2) in 2010.

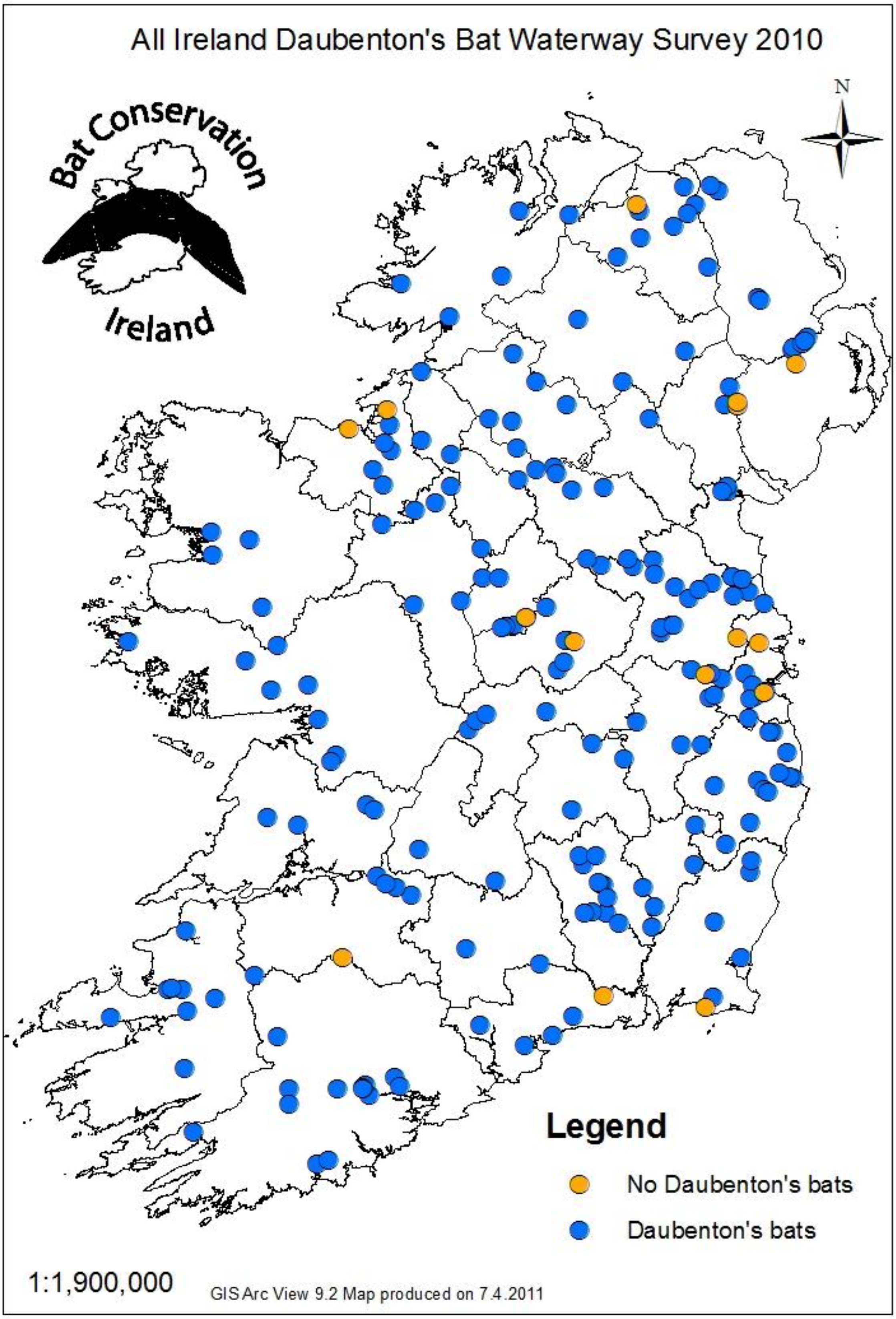

Figure 4.2: Location of all waterway sites surveyed in 2010 with records for 'Sure' Daubenton's bat passes only.

4.2.4 Relationships with other variables

To investigate the impact of the various covariates on the probability of observing bats at a spot, a binomial model was applied to the data. F-tests rather than χ^2 tests were used, since they accommodate for the structure of the data better. To complete this task, all of the results collated from 2006 to 2010 were included. This dataset is comprised of 1723 completed surveys (See Table A2.2, Appendix 2 for further information on the entire dataset used). However, the number of completed surveys used in the analyses for each variable differs depending on the amount of data noted by volunteers (i.e. missing values) (See Table A2.3, Appendix 2 for details).

An array of variables was tested and a total of 6 variables tested were significant and these results are presented below while detailed results of these variables are shown in Table A2.3, Appendix 2. Significant terms in the binomial model were similar to those from the REML model. Where possible, the terms were fitted as linear or quadratic relationships but for ease of presentation, the tables present the continuous variables in categories.

Waterway width values, as estimated by surveyors, were categorised into five groups (from <2m to >20m) and the analysis uses data from 1465 completed surveys (85%). The majority of waterway sites were in the 5m-10m group (n=609). This parameter was found to be highly significant with an upward trend (F = 10.67 with 1 and 529 d.f., P<0.001, for quadratic term). As in previous years, width is highly significant, with a higher proportion of survey spots with bats in wider waterways but this effect lessens on very wide rivers (i.e. >20m).

Volunteers are also requested to estimate the percentage of smooth water along the length of their survey transect. There are three categories available to volunteers to tick. A total of 1466 completed surveys (85%) were used in analyses. In previous years, smooth water did not have a significant influence on the number of bat passes recorded at survey spots. However, the percentage of smooth water has a very strong relationship with the proportion of survey spots with bats (F = 6.06 with 3 and 435 d.f., P<0.001). The proportion of survey spots with bats was greater for the 'greater than 50%' smooth water category.

Air temperature was recorded by surveyors at the start of the survey night. The values recorded were grouped into five categories (e.g. <12°C; 12.1-14.0°C, etc). A total of 1368 completed surveys (79%) were used for analyses. Temperature is significant, as in previous years (F = 6.288 with 1 and 907 d.f., P<0.0109). A higher proportion of survey spots with bats were highest for the temperature category of 'over 18°C'.

Volunteers are requested to start surveying 40 minutes after sundown. While the majority of surveyors do follow the survey protocol, some surveys may be completed at an earlier or later time after sunset. A total of 1321 completed surveys (77%) were used in analyses. Statistical analysis has shown that when surveyors start surveying (i.e. the number of minutes after sundown) is highly significant when fitted as a linear term (F = 9.49 with 1 and 950 d.f., P<0.002) using adjusted means; i.e. an increase in the proportion of survey spots with bats with later start times. When unadjusted means are examined, the number of bat passes recorded either by starting too early (e.g. before 30 minutes after sundown) yielded a lower mean number of the proportion of survey spots with bats. This fits with the observation that there tend to be fewer Daubenton's bats, on average, at the first couple of survey spots.

Surveyors are requested to note the time they start the survey and the time they complete the survey. While volunteers record bat activity for 40 minutes, the total length of time the survey takes is dependent on how long it takes to travel between survey spots. Consequently, factors such as ease of travel between survey spots affects the overall duration of the survey. Waterway sites that are located along canals can be completed faster than transects located along rivers edged by agricultural fields because the canal sites are facilitated by towpaths. A total of 1295 completed surveys (75%) was used in analyses. Time taken to complete surveys, as in previous years, was a significant influence on the number of bat passes recorded. This is also true for the proportion of survey spots with bats (F = 7.55 with 2 and 1041 d.f., P=0.006). Significantly fewer survey spots with bats were recorded for 'fast' surveys (completed in less than 60 minutes) compared to surveys completed 'slow' surveys (>60 minutes).

4.2.6 Met Eireann Weather Data

The relationships between the weather variables recorded by the surveyors and the data derived from the met stations collated by Met Eireann in the Republic of Ireland were investigated. A total of 1386 completed surveys (80%) were used in analyses. There are two significant Met Eireann variables. However, the temperature data collated by surveyors fits better than the temperature data from met stations. The reverse is true for Met Eireann rain data with this data being highly significant with a lower proportion of survey spots with bats on rainy days (F = 10.55 with 1 and 674 d.f., P=0.001).

4.2.7 Trends – GLM

To assess trends, a Poisson Generalised Linear Model was applied to the data. Daubenton's bat activity per annum was modelled using four different measures ('Sure' passes only, 'Unsure' and 'Sure' passes combined, a maximum of 48 passes per survey, a maximum of 48 passes with covariates included in the model). The pattern is essentially the same for the four models. The difference between the 2006 and 2007 values is much less in the second graph due to the exclusion of 'Unsure' Daubenton's bat passes in the analysis (Figure 4.3). This reflects the fact that surveyors tend to record more 'Unsure' Daubenton's bat passes in their first year. As the observer gains experience, there is greater confidence in correctly recording 'Sure' Daubenton's bat passes. Therefore, lower counts of 'Sure' passes can be expected for the first and perhaps second years of the survey but this does not necessarily represent the true values.

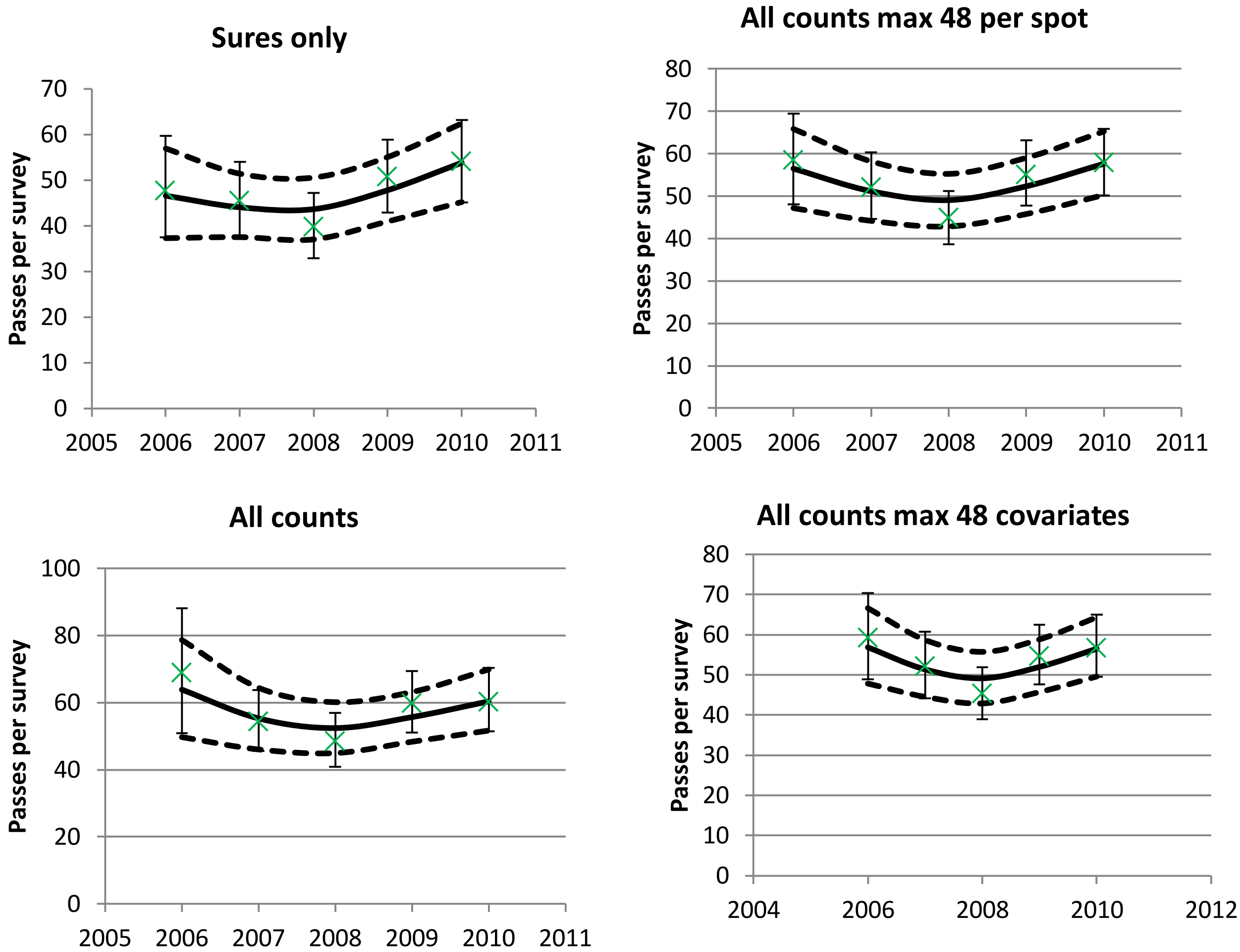

Figure 4.3: Results of the GLM for total number of Daubenton's bat passes (All counts = 'Sure' Daubenton's bat passes and 'Unsure' Daubenton's bat passes) and for total number of 'Sure' Daubenton's bat passes only. Lower numbers of 'Sure' passes can be expected in the early years of the survey, graph on right, when more inexperienced surveyors are involved. Bars are 95% bootstrapped confidence intervals.

4.2.8 Trends – Binomial GAM

For the first time in 2009, modelling using the percentage of survey spots with bats present was undertaken (e.g. response variable in the analysis is, for example, 0.7 if Daubenton's bat passes (both 'Sures' and 'Unsures' bat passes combined) were observed at seven of the ten survey spots. This type of analysis was also completed in 2010 and separately using covariates, which were determined using binomial GLMM. However the co-variates were not considered to be useful in helping to reduce the standard error of estimates so have not been included in the report.

Bootstrapping is used to find the standard errors using logistic regression (a GLM with a logit link function). A smoothed GAM trend was also applied to the results. At this stage (i.e. with only 5 years of data) results suggest a decline to 2008 with numbers stabilising in 2009 and 2010 (Figure 4.4) but changes are quite small relative to the width of the confidence limits and must, therefore, be treated with caution. This type of trend analysis will become much more useful once more years of data are available. See Table A2.5, Appendix 2 for information on additional analysis.

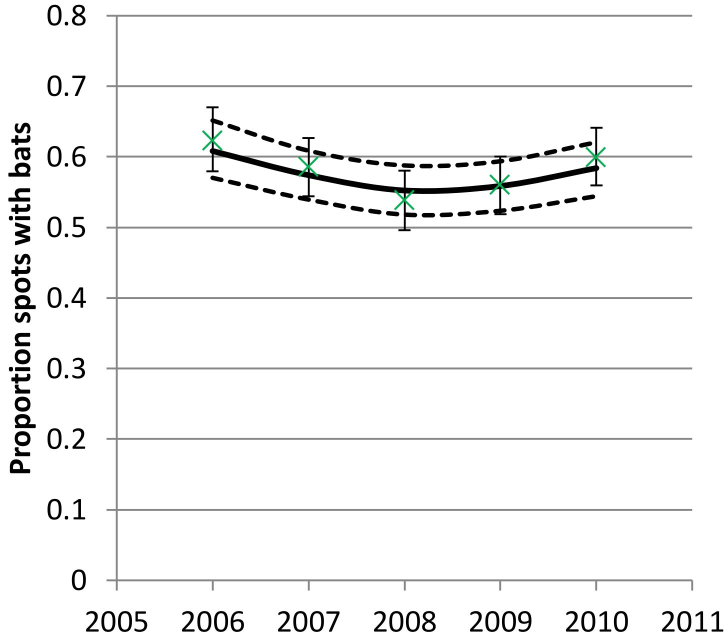

Figure 4.4: Results of the Daubenton's bat Binomial GAM/GLM without covariates. Green points are estimated annual proportions derived from the Generalised Linear Model and the bars are bootstrapped 95% confidence limits. The black dashed line is the fitted Generalised Additive Model curve with 2 d.f. The GAM curve is shown with a broken line since there are too few years of data available to determine trends with any certainty.

4.3 Discussion

4.3.1 Volunteer uptake

One hundred and eighty one survey teams (minimum two individuals per team), a relatively large number of volunteers, undertook the survey in 2010. As a result of well-attended training courses the number of new volunteer teams participating increased in 2010.

While a core group of survey teams have participated in the programme for each of the five years, there is still need for a recruitment drive each year since a certain percentage of volunteers are lost to the survey every year. The recruitment drive involves approximately 14 training courses per year. A considerable amount of work is involved in organising and running courses. However, when these are run in conjunction with local heritage or biodiversity officers in individual counties, the effort required on the part of BCIreland staff is greatly reduced and the benefit of running the event as part of the county heritage forum greatly increases their value for positive promotion of bats and wildlife conservation.

4.3.2 Survey Coverage in 2010

The highest number of completed surveys was achieved in 2010 compared with all previous years of the survey. Two hundred and eleven waterways sites were surveyed and a total of 402 surveys were completed. The waterway sites were located in all thirty two counties of the island with the largest coverage for a single county in County Meath.

4.3.3 Dataset & Distribution

The 2010 dataset consisted of 24,462 bat passes, the majority of which were 'Sure' Daubenton's bat passes (n=20,728 bat passes). The Daubenton's bat was recorded on the majority of the waterway sites surveyed in 2010, thus re-confirming this species' wide distribution on linear waterways across the island. Daubenton's bats were recorded in every county on the island from the most northern waterway sites in Antrim to waterway sites in south west Kerry and also at sites on the western seaboard in Mayo. A similarly widespread distribution of this species was reported by the BCT NBMP where Daubenton's bats were recorded from northern Scotland to southern England (www.bats.org.uk). This monitoring scheme is, therefore, making a considerable contribution to our knowledge of the distribution range of the Daubenton's bat.

The large dataset currently held by BCIreland about this species provides a potentially useful way of mapping Daubenton's bat activity on a county, river catchment and river level. Such representation may prove useful for future county planning and conservation work in relation to waterways. BCIreland plans to continue exploring this avenue of data representation as well as further analysis in relation to water quality once further data sets are received from the EPA.

In addition, since these data are mapped on GIS it will be possible to carry out further exploration of the influence of riparian habitat (woodland in particular) and water quality once these GIS datasets become available.

Another factor that can be considered for further exploration or inclusion in habitat/water quality mixed models could be the impact of river drainage works on Daubenton's bat activity. For some rivers, such as the Boyne in County Meath, considerable lengths of the river have been subjected to drainage and straightening works. These works have been implicated in lower numbers of some protected species along the drained corridors, e.g. River and Brook Lamprey (O'Connor, 2006). The impact of such works on Daubenton's bat is unknown but there may be potential for combining information on this in a general mixed model to further explore Daubenton's bat requirements.

4.3.4 Variables affecting activity

Results from binomial analysis for the five years of data suggest that several of the variables tested have a significant impact on the proportion of survey spots with bats. These include the width of waterways surveyed, air temperature recorded by volunteers at the start of the surveys, start time in relation to minutes after sundown, time taken to complete surveys and the duration of the programme, and smoothness of the water surface.

Width of waterway was a highly significant influence on the number of bat passes recorded and under the new model continues to have a significant influence on the number of survey spots with bats. The results suggest that a higher proportion of survey spots with bats are recorded on wider Irish waterways. This parameter has also been found to be an important influence on the number of bat passes recorded by surveyors in previous years and corresponds to similar results in the BCT Daubenton's bat Waterway Survey.

Air temperature was also found to be significant with a greater proportion of survey spots with bats recorded on warmer nights. On nights with a temperature lower than 12° Celsius, significantly lower proportion of survey spots were recorded with bats. Therefore, we should continue to emphasise the importance of surveying on mild nights to ensure that chances of detecting Daubenton's bats are optimised. It is also apparent that surveyors should be encouraged to record temperature so that this variable can be allowed for when assessing trends.

Identification skills of volunteers did not have a significant influence on the proportion of survey spots with bats. However, in general volunteers with a greater level of skill record fewer 'Unsure' Daubenton's bat passes. With continuous recruitment being undertaken each year, there will always be a group of volunteers that will categorise their identification skills as poor or okay. However, with continued participation in the programme these volunteers will increase their skill level. This is demonstrated by the fact that the significance of this parameter has lessened over the four years of the survey.

The time at which bats emerge to feed is generally related to sunset times with additional influences including weather conditions and surrounding habitats. Daubenton's bats have been recorded only emerging from their roosts when it is fully dark (Walsh *et al*, 2001) which can range from 30-120 minutes after sunset (Swift and Racey, 1983; Altringham, 2003). This species has also been reported commuting along the most sheltered route available from roosting sites to feeding grounds (Limpens and Kapteyn, 1991). The Daubenton's Waterway Surveys start 40 minutes after sunset and results show that if surveys start earlier, there are fewer survey spots with bats compared to starting on time or a little later than 40 minutes after sunset. This result is not surprising given the species' known emergence characteristics.

Another important influence on the number of bat passes recorded is the duration of time the survey takes to complete. This time can vary from as little as 60 minutes up to 120 minutes plus. Surveys completed in 60 minutes record fewer bat passes compared to surveys completed in 76-90m minutes. While the survey protocol emphasises that individual spots should be surveyed for exactly 4 minutes, there is a possibility that surveyors may not be strict in the application of this. However, there is also the possibility that surveys completed in 60 minutes are those waterway sites located along tow paths, such as canals, or structured walkways while other waterway sites that take longer to survey require more 'negotiating time' by surveyors. There is also the possibility that along transects with no or few bats, surveyors will complete the survey quicker.

4.3.5 Met Eireann Weather Data

The relationship between the weather variables recorded by the surveyors and the data derived from the met stations collated by Met Eireann in the Republic of Ireland were investigated. For rain, there is a clear, negative relationship with a greater proportion of survey spots with bats on dry days. This is not a surprising result.

There is also a significant correlation with temperatures collated by both surveyors and met stations with a stronger correlation with the maximum temperature than the minimum. This may be due to the possibility that the surveyors' measurements at the start of the survey relate more closely to the maximum recorded in the day, rather than to the minimum temperature in the night.

Temperature recorded by the surveyors' assessment is statistically significant while temperature recorded by the met station variables is not significant. Thus the surveyor's assessment appears better here.

4.3.6 Yearly Trends

REML analysis in 2008 showed evidence of a downward trend in Daubenton's bat activity over the course of the survey from 2006-2008. Poor weather conditions in 2007 and 2008 may have been a factor influencing this decline. Poor weather conditions continued in August 2009 but Daubenton's bat activity showed a slight recovery. This recovery continued in 2010 which, overall, had better weather conditions compared to previous years. However, additional years of data are required before making any conclusions about trends, and other factors should also be considered such as water quality and potential loss of insect diversity, which has been well documented for certain insect groups across Europe (Conrad *et al.,* 2006).

In 2009 for the first time, we examined trends using a binomial method. This is considered to be a more effective way to establish trends since the impact of bat detector model on observed passes is diminished and other effects such as surveyor skill are likely to have less of an impact on overall trends (MacKenzie *et al*, 2006). As a result, the binomial model was again used in 2010. Also, power analyses on field survey data of other species have suggested that the binomial analysis is more likely to identify trends of conservation importance. This is because using presence/absence data minimises the distortion of trends caused by multiple bat passes by the same individuals. We propose to continue to use this binomial method as the main tool for tracking Daubenton's bat trends as the monitoring scheme progresses.

5.0 References and Sources of Information

Altringham, J. D. (2003). British Bats. Harper Collins Publishers.

Anon (2004). *The National Monitoring Programmes, Annual Report 2004*. Bat Conservation Trusts, UK.

Aughney, T., Carden, R. and Roche, N. (2009) Irish Bat Monitoring and Recording Schemes: Annual Report 2008. Bat Conservation Ireland. www.batconsevationireland.org.

Aughney, T. and Roche, N. (2006) Proposals and Recommendations for a Pilot Daubenton's Bat Waterways Survey: Irish Bat Monitoring Programme. Bat Conservation Ireland. www.batconservationireland.org.

Aughney, T. et al (2007) All Ireland Daubenton's Bat Waterway Monitoring Scheme 2006: Irish Bat Monitoring programme. Bat Conservation Ireland www.batconservationireland.org.

Aughney, T., Langton, S. and Roche, N. (2009) All Ireland Daubenton's Bat Waterway Monitoring Scheme: Synthesis Report for 2006-2008. *Irish Wildlife Manuals* No. 42. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government.

Aughney, T., Langton, S. and Roche, N. (In Prep). Brown Long-eared Bat Roost Monitoring for the Republic of Ireland: Synthesis Report 2007-2010. Irish Wildlife Manuals. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government.

Battersby, J. (comp.) (2010). Guidelines for Surveillance and Monitoring of European Bats. EUROBATS Publication Series No. 5. UNEP / EUROBATS Secretariat, Bonn, Germany, 95 pp.

Betts, M. G., Mitchell, D., Diamond, A. W. and Bêty, J. (2007). Uneven Rates of Landscape Change as a Source of Bias in Roadside Wildlife Surveys. *Journal of Wildlife Management*. 71: 2266-2273.

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.

Buckley D.J., Puechmaille S.J., Roche N. and Teeling E.C. (2010). A critical assessment of the presence of *Barbastella barbastellus* and *Nyctalus noctula* in Ireland with a description of *N. leisleri* calls from Ireland. *Hystrix Italian Journal of Mammalogy*. In press.

Carden, R., Aughney, T., Kelleher, C. and Roche, N. (2010). Irish Bat Monitoring Schemes: BATLAS Republic of Ireland Report for 2008-2009. Bat Conservation Ireland.

Catto, C., Russ, J. and Langton, S. (2004). Development of a Car Survey Monitoring Protocol for the Republic of Ireland. The Heritage Council, Kilkenny, Ireland.

Conrad, K.F., Warren, M. S., Fox, R., Parson, M. S., Woiwood, I. P. (2006). Rapid declines of common, widespread British moths provide evidence of an insect biodiversity crisis. *Biological Conservation*, 132: 179-291.

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.

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

Mac Kenzie, D. I., Nichols, J. D., Royle, J. A., Pollock, K. H., Bailey, L. L. And Hines, J. E. (2006) Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence. Elsevier Inc., USA.

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.

Marnell, F., Kingston, N. and Looney, D. (2009). Ireland Red List No. 3: Terrestrial Mammals. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin.

Mitchell-Jones, A.J., Amori, G., Bogdanowicz, W., Krystufek, B., Reijnders, P.J.H., Spitzenberger, F., Stubbe, M., Thissen, J.B.M., Vohralik, V. and Zima, J. (1999). The Atlas of European Mammals. Poyser Natural History.

O'Connor W. (2006). A survey of juvenile lamprey populations in the Boyne Catchment. *Irish Wildlife Manuals*, No. 24 National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Roche, N., Langton, S. and Aughney, T. (2009) The Car Based Bat Monitoring Scheme for Ireland: Synthesis Report 2003-2008. *Irish Wildlife Manuals*, No. 39. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Swift, S.M. and Racey, P.A. (1983.) Resource partitioning in two species of vespertilionid bats (Chiroptera) occupying the same roost. *Journal of Zoology (London),* 200: 249-259.

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

Walsh, A., Catto, C., Hutson, T., Racey, P., Richardson, P. and Langton, S. (2001). The UK's National Bat Monitoring Programme, Final Report 2001. Bat Conservation Trust UK.

Whilde, T. (1993). Threatened mammals, birds, amphibians and fish in Ireland. Irish Red Data Book 2: Vertebrates. HMSO, Belfast.

6.0 Glossary

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.

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NIEA Northern Ireland Environment Agency www.ni-environment.gov.uk

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

APPENDIX 1

Car-Based Bat Monitoring

Table A1.1: Average number of bat encounters per hour for each survey square, Survey 1, 2010 (number of 1 mile transects (n) = 15 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., BLE=Brown long-eared bat, 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.

Square	Ppip	Ppyg	Pipun	Myotis	Nl	Pnath	BLE	Total
C72 n=12	5.219	7.828	2.609	0.000	45.665	0.000	0.000	61.321
G20	3.716	2.787	0.000	0.000	4.645	0.000	0.000	12.077
G53	5.535	14.391	5.535	0.000	3.321	0.000	0.000	28.783
G89	5.572	7.800	3.343	0.000	6.686	0.000	0.000	23.401
H13	16.186	5.395	3.237	0.000	4.316	1.079	0.000	30.213
H40	16.735	10.569	2.642	2.642	3.523	0.881	0.000	36.992
H79	6.522	4.659	4.659	0.000	7.454	0.000	0.932	24.226
J06								
J33	18.616	5.475	2.190	0.000	1.095	0.000	0.000	27.377
L64	0.000	4.504	0.000	0.000	0.000	0.000	0.000	4.504
M24	17.439	7.181	6.155	0.000	9.232	0.000	0.000	40.007
M87	21.348	9.149	4.066	0.000	26.430	0.000	1.017	62.010
N11	51.974	4.331	3.248	0.000	0.000	0.000	1.083	60.636
N74	26.013	5.003	0.000	0.000	2.001	0.000	0.000	35.018
N77	8.801	5.501	2.200	0.000	14.302	0.000	0.000	30.803
O04	22.768	3.415	1.138	0.000	3.415	0.000	0.000	30.737
R22	52.978	36.815	13.469	1.796	10.775	0.000	0.000	115.833
R28	18.455	16.777	2.517	1.678	1.678	0.000	0.000	41.943
R88	27.469	12.590	2.289	1.145	2.289	0.000	0.000	45.781
S12	11.419	5.710	1.142	0.000	1.418	1.142	0.000	2.624
S15 n=14	42.328	3.386	1.693	0.000	8.466	0.000	0.000	55.873
S78	19.627	2.944	0.981	0.000	2.944	0.000	0.981	27.478
T05	30.352	16.188	6.070	0.000	12.141	0.000	0.000	64.751
V93	18.406	9.203	5.752	0.000	16.105	0.000	0.000	50.616
V96	16.959	8.033	4.463	1.785	21.422	0.893	0.000	53.555
V99	57.624	6.403	2.134	0.000	16.007	0.000	0.000	82.168
W56	18.404	2.454	1.227	0.000	12.269	0.000	1.227	36.808
X49	43.849	12.392	4.766	0.000	21.924	0.000	0.000	82.931
Average	**21.641**	**8.551**	**3.242**	**0.335**	**9.612**	**0.148**	**0.194**	**43.277**
Stdev	*±15.764*	*±6.951*	*±2.750*	*±0.746*	*±10.227*	*±0.364*	*±0.417*	*±25.083*

Table A1.2: Average number of bat encounters per hour for each survey square, Survey 2, 2010 (number of 1 mile transects (n) = 15 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., BLE=Brown long-eared bat, 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.

Square	Ppip	Ppyg	Pipun	Myotis	Nl	Pnath	BLE	Total
C72	9.698	3.233	2.155	0.000	6.466	0.000	0.000	21.552
G20 n=13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
G53	6.974	31.882	11.956	0.000	6.974	0.000	0.000	57.787
G89	6.549	8.732	3.275	0.000	4.366	0.000	1.092	24.014
H13	24.583	11.174	2.235	0.000	13.409	0.000	0.000	51.400
H40	13.863	16.834	0.990	1.980	5.941	0.000	0.000	39.610
H79	20.815	8.921	0.000	0.000	33.701	0.000	0.991	64.429
J06	20.611	36.884	10.848	0.000	10.848	56.410	0.000	135.602
J33	7.720	5.514	3.308	0.000	0.000	0.000	0.000	16.542
L64	0.000	3.371	1.124	0.000	0.000	0.000	0.000	4.494
M24	11.804	10.730	1.073	0.000	7.511	0.000	0.000	31.118
M87	21.630	18.540	3.090	0.000	32.959	0.000	1.030	77.249
N11	45.995	5.348	3.209	0.000	4.279	0.000	0.000	58.831
N74	38.590	10.430	2.086	0.000	5.215	0.000	0.000	57.363
N77	8.910	5.569	3.341	0.000	27.843	0.000	0.000	45.662
O04	33.344	9.680	4.302	1.076	7.529	0.000	0.000	55.932
R22	36.722	32.132	8.262	0.000	22.951	0.000	0.000	100.068
R28	18.176	21.811	7.270	0.909	14.541	0.000	0.000	62.707
R88	20.801	2.311	1.156	0.000	8.089	0.000	0.000	32.357
S12	33.144	6.857	0.000	0.000	41.145	0.000	0.000	82.289
S15	59.198	11.840	2.960	0.000	4.440	0.000	0.000	78.437
S78	19.061	4.013	5.016	1.003	3.010	0.000	0.000	32.103
T05 n=14	33.949	10.373	4.715	0.943	3.772	0.000	0.000	53.753
V93 n=14	21.194	5.887	9.419	0.000	15.306	0.000	1.177	52.984
V96	34.834	16.077	5.359	0.000	31.261	0.000	0.000	87.532
V99	68.439	4.277	8.555	2.139	58.815	0.000	1.069	143.295
W56	33.410	1.237	4.950	0.000	16.087	0.000	0.000	55.684
X49	14.208	18.944	4.736	0.947	28.417	0.000	0.000	67.252
Average	**23.722**	**11.522**	**4.121**	**0.321**	**14.817**	**2.015**	**0.191**	**56.787**
Stdev	*±16.601*	*±9.610*	*±3.276*	*±0.620*	*±14.565*	*±10.661*	*±0.419*	*±33.606*

APPENDIX 2

All-Ireland Daubenton's Bat Waterway Survey

Table A2.1: Bat detector models used by survey teams in different years (2006-2010).
The table shows numbers of sites, and percentages, excluding those outside the usual date range.

	Numbers of surveys					Percentage of surveys				
year	**2006**	**2007**	**2008**	**2009**	**2010**	**2006**	**2007**	**2008**	**2009**	**2010**
detector										
Magenta Mk II	5	7	2	1	4	3.7	3.5	1.1	0.5	1.9
Magenta Mk III	31	34	31	26	20	23.1	16.9	17.2	12.4	9.5
Bat Box III	47	61	47	48	40	35.1	30.3	26.1	23.0	19.0
Pettersson D100	10	18	21	23	22	7.5	9.0	11.7	11.0	10.5
Pettersson D200	10	17	9	10	15	7.5	8.5	5.0	4.8	7.1
Bat box Duet	6	16	24	24	27	4.5	8.0	13.3	11.5	12.9
Pettersson D230	3	4	3	1	1	2.2	2.0	1.7	0.5	0.5
Pettersson D240x	5	6	8	6	9	3.7	3.0	4.4	2.9	4.3
Sky SBR 2100	2	1	0	0	0	1.5	0.5	0.0	0.0	0.0
Mini-3	4	2	2	8	5	3.0	1.0	1.1	3.8	2.4
Magenta Bat 4	0	1	3	25	30	0.0	0.5	1.7	12.0	14.3
Not noted	11	17	6	10	4	8.2	8.5	3.3	4.8	1.9
U30 Bat Detector	0	1	0	0	0	0.0	0.5	0.0	0.0	0.0
Bat Box IIId	0	16	17	10	10	0.0	8.0	9.4	4.8	4.8
Magenta Bat 5	0	0	7	13	14	0.0	0.0	3.9	6.2	6.7
Ciel Electronics	0	0	0	3	8	0.0	0.0	0.0	1.4	3.8
Anabat	0	0	0	1	1	0.0	0.0	0.0	0.5	0.5
All types	134	201	180	209	210	100.0	100.0	100.0	100.0	100.0

Note: For 2007 dataset, the total number of waterway sites is 201, 2 sites greater than was reported in the 2007 annual report. This is due to late submission of 2 survey forms which have been included in the full dataset for this monitoring scheme subsequently.

Table A2.2: Basic descriptive statistics shown by year and province. The final column refers to surveys with either sure or unsure Daubenton's passes. All values are per completed survey of 10 spot counts. Excludes surveys outside days 205-250.

	Connaght						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats	% spots with bats
2006	51	66.1	21.6	87.7	77.1	92.2	55.7
2007	59	55.7	10.5	66.2	62.2	96.6	56.4
2008	47	45.3	6.4	51.7	46.9	95.7	53.6
2009	52	72.9	8.6	81.5	74.2	86.5	62.1
2010	55	68.9	5.8	74.7	71.7	92.7	63.8
All years	264	62.0	10.6	72.6	66.7	92.8	58.4
	Leinster						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats	% spots with bats
year							
2006	102	43.9	27.2	71.2	51.1	94.1	61.1
2007	194	37.5	6.7	44.2	43.4	89.7	55.5
2008	135	33.4	5.6	39.0	38.0	85.9	52.9
2009	168	37.7	7.8	45.4	44.4	90.9	55.2
2010	180	48.8	9.9	58.7	55.1	95.0	62.9
All years	779	40.3	10.2	50.5	46.4	91.1	57.4

Table 1 (cont)

	Munster						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats	% spots with bats
year							
2006	64	47.0	13.8	60.8	58.0	95.2	61.6
2007	80	48.4	7.3	55.7	52.1	90.0	50.7
2008	68	39.3	7.6	46.8	42.9	91.2	49.7
2009	78	42.3	6.5	48.8	43.8	89.2	45.8
2010	76	48.1	12.3	60.4	58.7	94.7	59.6
All years	366	45.1	9.4	54.5	51.1	92.0	53.3
	Ulster						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats	% spots with bats
year							
2006	35	32.1	16.9	49.0	48.4	88.6	53.7
2007	49	29.9	8.7	38.6	37.7	95.9	56.9
2008	61	39.8	9.9	49.7	48.7	96.7	56.9
2009	78	44.1	9.8	53.9	51.4	94.9	59.9
2010	91	49.4	7.6	57.0	53.6	90.1	58.8
All years	314	41.3	9.8	51.1	49.1	93.3	57.8
	All Ireland						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats	% spots with bats
year							
2006	252	47.6	21.3	68.8	57.8	93.2	59.1
2007	382	41.6	7.7	49.3	47.4	91.6	54.8
2008	311	37.7	7.0	44.7	42.5	90.7	53.1
2009	376	45.1	8.1	53.2	50.2	90.8	55.2
2010	402	51.5	9.3	60.8	57.7	93.5	61.5
All years	1723	44.9	10.0	54.9	51.0	92.0	56.8

Table A2.3: numbers of years of data from each site (excludes surveys outside the usual date range).

Number of years	Number of observers	% of total	Cumulative %
1	138	36.8	36.8
2	67	17.9	54.7
3	72	19.2	73.9
4	45	12.0	85.9
5	53	14.1	100.0

Table A2.4: matrix of sites surveyed in all possible pairs of years (e.g. 118 sites were surveyed in 2007 and 2009). Numbers on the diagonal (italics) are total sites surveyed in each year.

2006	*132*				
2007	100	*201*			
2008	87	120	*180*		
2009	79	118	135	*209*	
2010	77	112	115	140	*211*
	2006	**2007**	**2008**	**2009**	**2010**

Table A2.5: Effects of factors from the GLMM model.
Percentage of spots with bats are shown with standard errors, as well as predicted values on the logit scale, after adjusting for the effects of other factors in the model. The number of surveys is for the raw means; adjusted means are based on fewer surveys due to missing values amongst the covariates. The absolute value of the adjusted means is not informative due to the averaging over other terms, but the relative sizes indicate where the differences lie; standard errors are applicable to the logit values, but back-transformed values are easier to interpret.

(a) Width (F = 10.67 with 1 and 529 d.f., P=0.001 for quadratic term)

		Raw data		Adjusted for other variables		
Group	surveys	% with	s.e.	logit	s.e.	back-trans
2m or less	7	31.4	5.55	0.81	1.235	69.3
<=5m	379	46.5	0.81	0.15	0.170	53.9
<=10m	609	59.2	0.63	0.53	0.155	62.8
<=20m	268	63.3	0.93	0.57	0.183	63.9
>20m	202	70.6	1.01	0.84	0.225	70.0

(b) Smooth/calm water (F = 6.06 with 3 and 435 d.f., P<0.001)

		Raw data		Adjusted for other variables		
Group	surveys	% with	s.e.	logit	s.e.	back-trans
None	62	38.5	1.97	-0.46	0.273	38.6
up to 50%	407	50.5	0.78	0.20	0.174	55.1
greater that 50%	992	62.6	0.49	0.53	0.155	62.8
Not noted	5	60.0	6.93	1.10	0.994	75.1

(c) Minutes after sunset (F = 9.49 with 1 and 950 d.f., P=0.002, fitted as linear term)

		Raw data		Adjusted for other variables		
Group	surveys	% with	s.e.	logit	s.e.	back-trans
before 30 mins	76	60.8	1.78	0.59	0.207	64.3
30-40mins	384	56.2	0.80	0.61	0.162	64.7
40-50mins	604	57.0	0.64	0.53	0.155	62.8
50-70mins	201	60.3	1.09	0.78	0.170	68.6
70-90mins	56	69.9	1.93	0.84	0.224	69.8

Table 6 (cont)
(d) time taken for survey (F = 7.55 with 2 and 1041 d.f., P=0.006)

		Raw data		Adjusted for other variables		
Group	surveys	% with	s.e.	logit	s.e.	back-trans
<=60min	219	52.4	1.07	0.29	0.175	57.1
61-75min	478	58.6	0.71	0.53	0.155	62.8
76-90min	385	59.4	0.79	0.58	0.157	64.2
over 90min	213	64.2	1.04	0.70	0.169	66.7

(e) temperature recorded by surveyor (F = 6.88 with 1 and 907 d.f., P=0.009)

		Raw data		Adjusted for other variables		
Group	surveys	% with	s.e.	logit	s.e.	back-trans
<=10C	103	58.7	1.54	0.27	0.188	56.8
10.1-12C	242	53.9	1.01	0.40	0.162	59.8
12.1-14	396	58.0	0.78	0.53	0.155	62.8
14.1-16	384	58.1	0.80	0.41	0.156	60.1
16.1-18	190	60.1	1.13	0.58	0.172	64.2
over 18C	53	60.9	2.12	0.72	0.218	67.3

(f) rain in 24 period derived from met data (F = 10.55 with 1 and 674 d.f., P=0.001)

		Raw data		Adjusted for other variables		
Group	surveys	% with	s.e.	logit	s.e.	back-trans
no data*	82	62.3	1.69	0.72	0.314	67.2
<0.5mm	441	60.5	0.74	0.58	0.156	64.0
<2mm	488	57.7	0.71	0.53	0.155	62.8
<5mm	245	57.8	1.00	0.50	0.160	62.2
5mm+	212	53.0	1.09	0.27	0.166	56.7

*'No data' refers to sites more than 50km from the nearest met station with readings on the survey date.

Table A2.6: Binomial GAM results with 95% confidence limits. Note that the proportions of spots with bats are slightly different to those shown in Table 1 since these results exclude sites only surveyed in a single year, which contribute no information on trends.

a) No covariates

			Prop'n spots with bats		**Proportion estimated from model**					
					Smoothed trend		**95% conf limits**		**unsmoothed**	
year	**counts**	**sites**	**Mean**	**s.e.**	**estimate**	**s.e.**	**lower**	**upper**	**fitted**	**s.e.**
2006	222	115	0.599	0.010	0.608	0.021	0.570	0.651	0.623	0.024
2007	315	165	0.574	0.009	0.574	0.018	0.539	0.609	0.586	0.021
2008	290	165	0.534	0.009	0.552	0.018	0.518	0.588	0.538	0.021
2009	325	182	0.563	0.009	0.559	0.018	0.523	0.594	0.560	0.021
2010	323	168	0.628	0.008	0.584	0.019	0.544	0.621	0.599	0.020

Total sites: 237

b) with covariates for smooth water, temperature and rainfall

			Prop'n spots with bats		**Proportion estimated from model**					
					Smoothed trend		**95% conf limits**		**unsmoothed**	
year	**counts**	**sites**	**Mean**	**s.e.**	**estimate**	**s.e.**	**lower**	**upper**	**fitted**	**s.e.**
2006	222	115	0.599	0.010	0.620	0.022	0.574	0.661	0.634	0.024
2007	315	165	0.574	0.009	0.598	0.019	0.559	0.634	0.603	0.022
2008	290	165	0.534	0.009	0.586	0.019	0.548	0.624	0.581	0.023
2009	325	182	0.563	0.009	0.592	0.020	0.553	0.631	0.593	0.022
2010	323	168	0.628	0.008	0.612	0.022	0.570	0.652	0.626	0.022

Total sites: 237