Irish Bat Monitoring Schemes

Annual Report for 2015

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1.0 Executive Summary

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

- Car-Based Bat Monitoring (All Ireland)
- All Ireland Daubenton's Bat Waterway Monitoring
- Brown long-eared Bat Roost Monitoring
- Lesser horseshoe bat monitoring

Weather conditions in 2015 were cooler than 2014. The early summer was particularly wet in the west. July was reasonably dry in most parts but wet weather, with some stormy conditions, prevailed again in August, hampering some Daubenton's and car-based surveys.

For the Car-Based Bat Monitoring Scheme 62 individuals participated in surveys of 28 squares around the island. Training courses were provided in 2015 for nine teams who used Android smart phones instead of minidiscs. Data from 54 surveys, most of which had >12 completed transects, were available to contribute to bat species trend modelling. Over 3,400 bats were recorded, 45% of which were common pipistrelles. The soprano pipistrelle was second most frequently recorded bat species and Leisler's the third most common.

The common pipistrelle continued on its significantly upward trend, and both the soprano pipistrelle and the Leisler's bat also show significant increases year on year. Nathusius' pipistrelle trends are still unclear but seem to show signs of stability, whilst the brown long-eared roadside trend dropped considerably in 2015, in contrast to the trend observed using roost monitoring counts (see below). For both species, numbers of observations are extremely low, leading to wide error bars.

Training courses were held at 15 locations across the island as part of the All Ireland Daubenton's Bat Waterway Monitoring Scheme. Two hundred and fifty waterway sites were surveyed in 2015, and this number of completed surveys is a slight decrease compared to 2014 (n=255) but the second highest in the ten years of the operation of the scheme. Of these 250 sites waterway sites, 213 were surveyed twice in the month of August. Over 20,000 'Sure' Daubenton's bat passes were recorded on 225 waterway sites (90%). All-Island Daubenton's bat numbers showed evidence for a decline from 2006 to 2008 but in 2009-2011 numbers recovered a little. Further slight decreases were noted again from 2012 to 2014. 2015 saw a moderate recovery. Overall the trend line appears to be fairly steady from year to year with error bars consistently encompassing the baseline.

For Brown Long-eared Roost Monitoring, 48 volunteers participated in 2015, which included four roost owners. Volunteers provided count data for 25 roost sites. In total, 107 monitoring surveys were carried out at 46 roosts, two of which were newly assessed in 2015 and deemed suitable for monitoring. Using the highest results for each roost monitored in 2015, the total number of brown long-eared bats counted was 1,657 individuals. Results from a GAM model indicates that there was an increase from 2008 followed by stable results for the last couple of years. The index is currently significantly above the baseline value for 2008. However caution is required when interpreting the trend as this scheme is only running since 2007.

NPWS regional staff and the VWT forwarded count data from 94 lesser horseshoe bat sites in summer 2015 and 85 sites in winter 2016. Trends for this species show a particularly steep increase in winter counts since 2012. Summer trends have begun to mirror this, albeit less steeply. Analysis of trends in VWT summer sites since 2006 show that the numbers at these sites have been increasing slightly, although the remainder of the dataset without VWT sites, shows a similar pattern.

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 of 'bat passes' of this bat species for four minutes at each of the 10 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 ran for a 3-year monitoring period (Aughney *et al*., 2011). Funding lapsed in 2011 but it has since been resumed with funding till 2017. 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 Aughney *et al.,* 2011.

BCIreland took over management of the lesser horseshoe bat monitoring dataset in November 2013. Surveys for this scheme are mainly carried out by staff of the NPWS and VWT, along with a small number of volunteers and ecological consultants. Each year counts are carried out at specific lesser horseshoe sites. Surveys take place in summer at dusk and are usually carried out using bat detectors, although video cameras and/or internal counts are also sometimes carried out depending on the site characteristics. The dates for surveying in summer are May 23rd to July 7th. Winter surveys are carried out in January and February each year using internal counts, sometimes aided by still photography.

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. The lesser horseshoe bat is confined to the Republic of Ireland. Regular monitoring under BCIreland management is, therefore, in process for six bat species for the Republic of Ireland, one of which is the only resident Annex II species on the island, and for four bat 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 2015

The survey season kicked off in January with counts at lesser horseshoe hibernacula. Weather was variable that month with rainfall of up to 150% of the long term average in many parts of the bat's range. Temperatures were generally at, or slightly below, the 30 year average. January was also very windy.

February was a cooler month, with less wind, and it was for the most part drier than January. Mayo was the exception; it recorded very high rainfall levels.

Summer surveying began in May with brown long-eared and lesser horseshoe counts. Rainfall totals in this month were almost all above the long term average (LTA). Parts of the North-west, midlands and southern Atlantic coasts experienced up to 200% LTA for the month. Eastern parts of the country experienced drier weather in the second half of the month. May temperatures were low.

Weather in June continued in the same vein, although rainfall eased off in the west somewhat. Temperatures remained low and many parts of the east experienced a 'dry spell' (i.e. 15+ days without rain).

Temperatures in July were again below normal with some stations even recording ground frosts (Cloosh, -2.7C on the 25th) while rainfall was up – most stations recorded levels above the LTA. Some high winds were also recorded in July.

August did not see much improvement in the weather with temperatures continuing below average. Rainfall was variable but generally above average and gale force winds were recorded in the west early in the month.

September saw some of the sunniest weather of the survey season and a consistent dry spell, although night time temperatures continued very cool.

All-in-all 2015 was a very mixed bag for bat survey work, generally cooler than average with high rainfall at times, particularly in the west.

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) HTC smart phone with memory card, pre-stamped envelopes to return the data, instruction manuals, recording sheets, batteries, flashing beacon, thermometer and a first aid kit. In addition, a Baton detector and additional recording system (smart phone or Edirol digital recorder) was provided to two teams in 2015 to compare how well it worked with the Tranquility detector.

In 2013 three training videos were also uploaded to YouTube and to the Car monitoring Facebook page in 2015 to provide further back-up information on how to use the smart phones and apps for the survey.

- http://www.youtube.com/watch?v=0vt_KhB9IWA
- http://www.youtube.com/watch?v=BKiK8ApwXPo
- http://www.youtube.com/watch?v=IRzcjf2Kmnk

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) to the smart phone. Surveyors using smart phones use a purpose built Android App – "Audio and Location Recorder" that was developed in 2011 and further upgraded in 2013.

The AudioAndLocationRecorder App records .wav files at 44,100Hz while simultaneously recording .csv files with locational data (latitude, longitude, altitude, error and speed).

An additional App – Spectral Pro-Analyszer was installed on each phone for surveyors. This app creates a visible display of the sound being recorded by the phones in real time. It was kindly provided to Bat Conservation Ireland free of charge by its developers RadonSoft. This app is used at the beginning of each survey so that volunteers can visually check that the sound coming into the phone is correct. It cannot be used simultaneously with the AudioAndLocationRecorder, however.

On completion of surveys, data is forwarded to BCIreland for analysis. In 2015 teams were strongly advised to make a backup copy prior to posting the SD card or to upload the data to a Dropbox folder which was provided to them for the survey. In this way, we hoped to prevent loss of survey data due to SD cards becoming corrupted or lost in the post.

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 or Natterer's (*Myotis daubentonii, M. mystacinus* or *M. nattereri*). Occasional social calls of brown long-eared bats are also recorded.

Purpose built adaptor leads were purchased from NHBS (www.nhbs.com), to connect the 3.5mm TRS jack lead from the detector into the phone's 3.5mm TRRS jack socket.

Smart phone sound recordings were downloaded directly using a smart phone connected to PC. For those surveys where GPS data was successfully recorded using the Audio and Location Recorder App, a .csv file corresponding to each .wav file (transect) was also available. Csv files were also downloaded to computer.

For quality control purposes .wav files from three randomly selected surveys are forwarded each year to Dr Jon Russ for comparative analysis.

All data was analysed using Bat Sound. Information for each survey was inputted to a tailor made MySQL database. Once analysis was complete, smart phone .csv files with date and time stamps, latitude and longitude were linked to the MySQL database bat records. Links were created based on the duration of the transect and the time that each bat was recorded at. It was possible to geo-reference each bat recorded on a smart phone survey transect that had a corresponding .csv GPS file although this year we also took into account the fact that GPS data and bats were not always recorded simultaneously so the programme also calculated the time difference between GPS location point and the time a bat was recorded.

For the purposes of providing volunteer feedback, spreadsheets listing bat species, date, time, location and accuracy were uploaded to Google Maps using Fusion Tables (see http://www.google.com/drive/start/apps.html#fusiontables) and bat locations were pinned to a map for each route, with icons of differing colour and shape denoting a particular bat species.

In 2015 a new Facebook page (IrishCarBats) was set up to communicate ongoing progress with Facebook users and surveyors. Training videos were also uploaded to this Facebook page.

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 and brown long-eared bats, trend models were constructed based on a binomial distribution. This is because both species sometimes occur in the same transect on multiple occasions but there are, much more often, transects with no occurrences 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-present 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.

3.2 Results

A number of training courses were provided to new surveyors and surveyors who were taking on smart phone equipment for the first or second time. Training was carried out in Belfast, Cork, Killarney, Limerick, Downpatrick, Bailieborough, Castlebar and Kilkenny.

Smart phones were provided to 22 teams in 2015. Apps and equipment were provided to five additional teams that used their own smart phones.

Survey work in 2015 was carried out from mid to end July and a repeat survey was carried out in early to mid-August. The median date of the first survey in 2015 was 23rd July. The median date of the second survey was 18th August.

All 28 survey squares were surveyed in July 2015 and 26 squares were surveyed in August (see Figure 3.1). In total 1264km of monitoring transects were surveyed and approximately 300hrs of survey time was spent on the scheme by 62 volunteers. A full or almost complete dataset (≥12 transects) was available from 27 survey routes during July and 26 survey routes in August.

Overall, the quality of data collected in 2015 was very good. In 2015, one SD card became corrupted in the post but backup data was available from the relevant team, underlining the need for back up or cloud sharing of data. Many teams availed of the option to upload their data to Dropbox.

Each year different issues tend to arise while checking equipment prior to the survey, some of which can be very time consuming. Issues include software compatibilities and versions of Android. On the whole, however, the smart phones, leads and apps worked well in 2015.

Squares that were surveyed in 2015 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 (see Figure 3.1).

In total, 3406 bat encounters were recorded during the July and August 2015 surveys, from 786 monitoring transects. Overall encounter rates with the various bat species (raw data), dropped slightly in 2015 compared with 2014 but are still higher than most years prior to 2014.

The proportions of species encountered (Figure 3.2) show a similar picture to previous years with common pipistrelles the most abundant species accounting for just under half (45%) of all bat encounters. Leisler's bats and soprano pipistrelles account for 20% and 24% of the total bat encounters, respectively, in 2015. Nine 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, but in very low numbers.

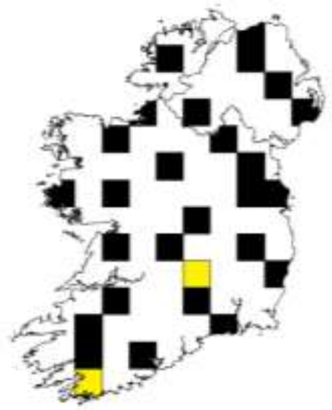

Figure 3.1: Location of 30km Survey Squares. Black squares were surveyed twice in 2015, Yellow squares were surveyed once.

Table 3.1: Mean bat encounter data, per 1.609km/1 mile transect, not corrected to encounters per km or per hour, Car-Based Bat Monitoring Scheme 2003-2015. Average number of bats reflects the average number of bat encounters observed during each 1.609km/1 mile transect travelled*.

Year	No. Transects	Common pipistrelle	Soprano pipistrelle	Pipistrelle unid.	Nath. Pip.	Leisler's bat	Myotis spp.	Brown long-eared	Total Bats
2003	190	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
2011	763	1.560	0.800	0.360	0.022	0.790	0.038	0.020	3.602
2012	663.5	1.399	0.799	0.353	0.048	0.754	0.027	0.026	3.415
2013	704	1.550	0.847	0.324	0.021	0.807	0.011	0.028	3.592
2014	754	1.985	1.085	0.424	0.044	1.001	0.025	0.017	4.594
2015	786	1.944	1.033	0.403	0.014	0.877	0.047	0.009	4.333
Mean Per Transect (S. E.)		**1.599** (±0.071)	**0.750** (±0.047)	**0.321** (±0.021)	**0.023** (±0.006)	**0.703** (±0.055)	**0.032** (±0.003)	**0.017** (±0.002)	**3.430** (±0.179)

* 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).

** Number of transects = 597 for Leisler's bats in 2004. More data was available for Leisler's than other species in this year due to a detector problem in one survey square which caused sounds at frequencies above 30kHz to be non-analysable.

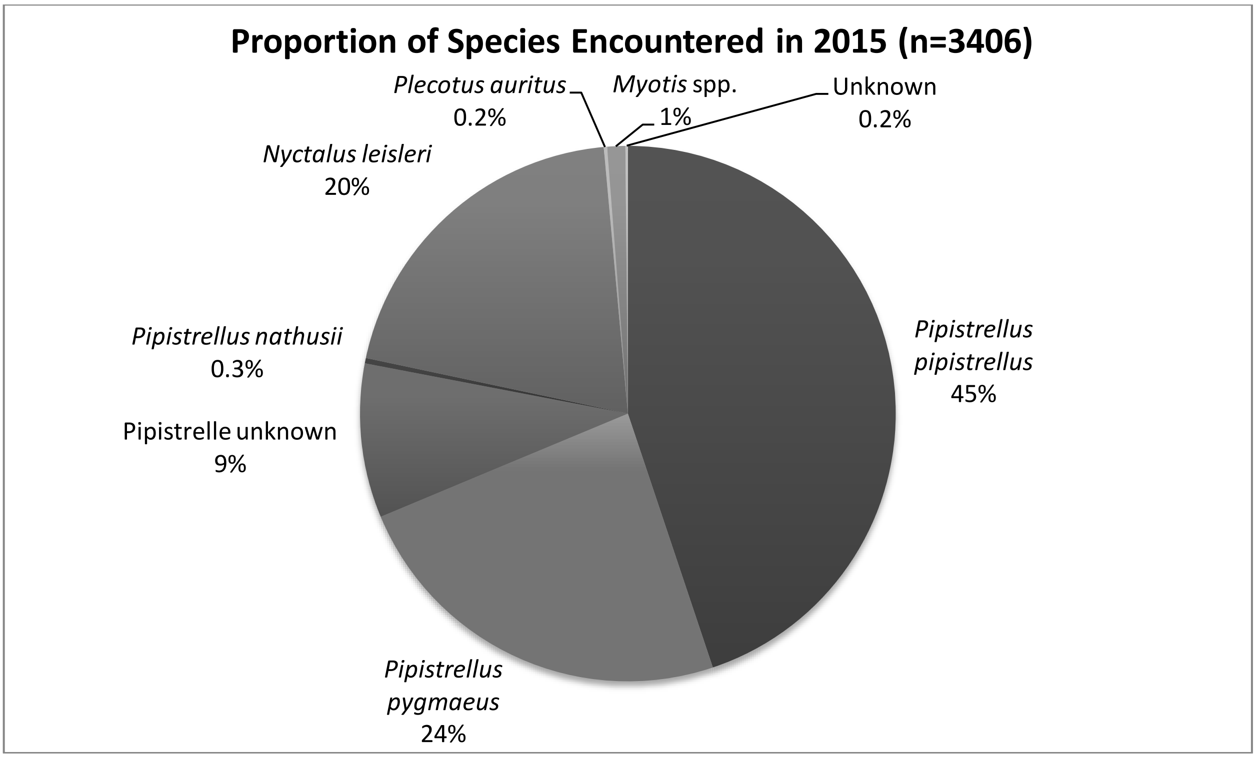

Figure 3.2: Proportion of bat species encountered during the survey in 2015. Total number of bat encounters, 3406. Excepting social calls of Leisler's bats and brown long-eared bats, which are unlikely to be mistaken for those of other species, bat social calls were noted during sonogram analysis but are not included in the above pie chart or in any statistical analyses.

Overall encounter rates varied between squares and between surveys. In general the squares with highest encounter rates were found in the east and south of the country. These included squares S78, V99, W56 and T05, where over 100 bat encounters each were recorded during at least one survey night. In 2015 high numbers of bats were also recorded in Longford (M87) and Cavan/Monaghan (H40). 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, 2015. Total = total number of encounters for all species per hour. Means derived from total number of encounters divided by total time spent sampling by the time expansion detector corrected to 1 hour.

All Surveys 2015	Common pipistrelle	Soprano pipistrelle	Pipistrelle unknown	Nathusius' pipistrelle	Leisler's bat	Myotis spp.	Brown long-eared	Total/hr
Overall Mean	25.94	13.44	5.35	0.20	11.34	0.58	0.12	57.05
Standard Deviation	±18.60	±8.92	±3.35	±0.66	±10.27	±1.08	±0.34	±30.39
Minimum	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2.23*
Maximum	*97.24*	*48.35*	*16.39*	*3.91*	*44.89*	*5.34*	*1.50*	*117.28*

3.2.2 Common pipistrelle, Pipistrellus pipistrellus

3.2.2.1 2015 Results

The overall average number of common pipistrelle encounters per hour was 24.2 during Survey 1 and 27.79 in Survey 2 in 2015. The overall average number of common pipistrelle encounters per hour for both survey periods was 25.95 (see Table 3.3). The square with the highest number of records for the species was N74 (Co. Meath), as has been the case for several years including 2012 and 2013.

Common pipistrelles were the most frequently encountered species during the monitoring scheme in 2015 and in all survey years to-date. Figure 3.3 illustrates low, medium and high encounter rate squares for common pipistrelles in 2015 for each of the surveyed 30km squares. As in previous years this map shows lower common pipistrelle encounter rates in the north and north-west while squares with the highest encounter rates are located in the south and east of the country. The trend over the past number of years has been for slightly higher encounter rates in the north and northwest compared with early years of the survey. For ten years no common pipistrelles were recorded from square L64 (Connemara) but they have now been picked up on surveys there for two years in a row, albeit in extremely low numbers.

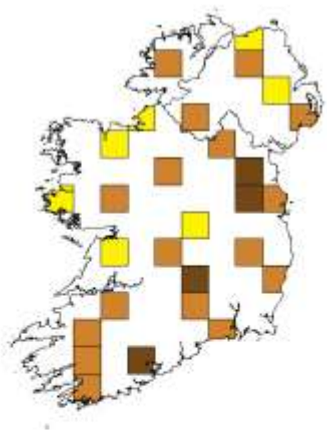

Figure 3.3: Survey squares colour coded according to common pipistrelle encounter rates (per hour) in 2015. The overall average rate of common pipistrelle encounters for all squares in 2015 was 25.94hr^{-1}.

- No available data
- 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 (GLM) applied to the Car-based Bat Monitoring data for the common pipistrelle, along with Generalised Additive Model (GAM) smoothed curves. Common pipistrelles showed a consistent increase in the early years and error bars around the trend have now significantly exceeded the baseline. This means that the common pipistrelle is increasing, albeit at a slower rate than the soprano pipistrelle or Leisler's bat. The yearly estimate for 2015 was lower than that of 2014 and, as a result, the lower confidence limit has levelled out a little.

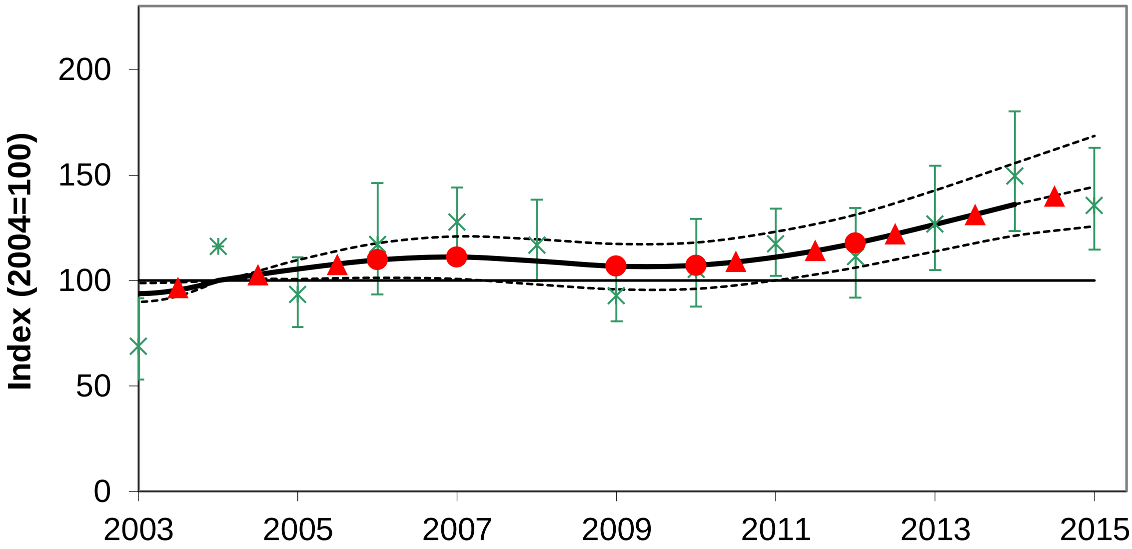

Figure 3.4: Results of the GAM/GLM model for common pipistrelle passes per survey, all-Ireland. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. All estimates are adjusted to 1,125 0.32s snapshots. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2014-2015 and the possibility that the slope will change with coming years' data. Red circles indicate significant (P<0.05) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant (P<0.05).

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 modeled estimates adjusted to 1,125 snapshots per survey.

			smoothed		95% limits		unsmoothed	
Year	***Counts***	***Sites***	***index***	***s.e.***	***lower***	***upper***	***fit***	***s.e.***
2003	7	9	93.77	2.32	89.89	98.78	52.67	9.96
2004	17	27	100.00	0.00	100.00	100.00	100.00	0.00
2005	17	31	105.44	2.34	100.69	109.70	77.32	8.54
2006	25	45	109.72	4.25	101.28	117.67	101.01	13.56
2007	26	46	111.15	5.29	100.72	120.89	111.53	8.04
2008	23	42	109.22	5.65	98.12	119.51	100.69	10.12
2009	28	52	106.76	5.64	95.81	117.34	76.77	7.00
2010	27	53	107.21	5.70	96.06	118.00	89.09	10.66
2011	28	53	111.09	5.92	100.06	123.14	101.16	8.36
2012	26	44	117.69	6.41	106.12	131.17	95.10	11.05
2013	25	46	126.59	7.31	113.81	142.75	110.65	12.23
2014	27	49	136.08	8.69	121.21	155.61	133.37	14.63
2015	28	53	144.44	10.86	125.73	168.53	119.54	12.37

3.2.3 *Soprano pipistrelle,* Pipistrellus pygmaeus

3.2.3.1 2015 Results

The overall average number of soprano pipistrelle encounters per hour was 11.33 during Survey 1 in 2015 and 15.71 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 13.44.

The highest number of discrete soprano pipistrelle passes was recorded from Survey 2 in H40 (Cavan-Monaghan).

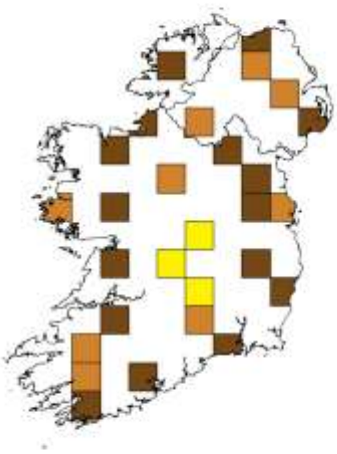

Figure 3.5: Survey squares colour coded according to soprano pipistrelle encounter rates (per hour) in 2015. The overall average rate of soprano pipistrelle encounters for all squares in 2015 was 13.44hr^{-1}.

In 2015, as for most years bar 2006 and 2010, the soprano pipistrelle was the second most frequently encountered species during the monitoring scheme. Figure 3.5 illustrates low, medium and high encounter rate squares for soprano pipistrelles in 2015. As in previous years the patterns of activity levels across the island are more difficult to distinguish than for common pipistrelles, in 2015 the lowest encounter rate squares were clustered in the southern midlands. Soprano pipistrelles were recorded on all survey routes in 2015.

3.2.3.2 Trends

Figure 3.6 shows the results of a Generalised Linear Model (GLM) applied to Car-based Bat Monitoring data for the soprano pipistrelle, along with Generalised Additive Model (GAM) smoothed curves. The soprano pipistrelle shows a consistent upward drift which remains significantly above the baseline.

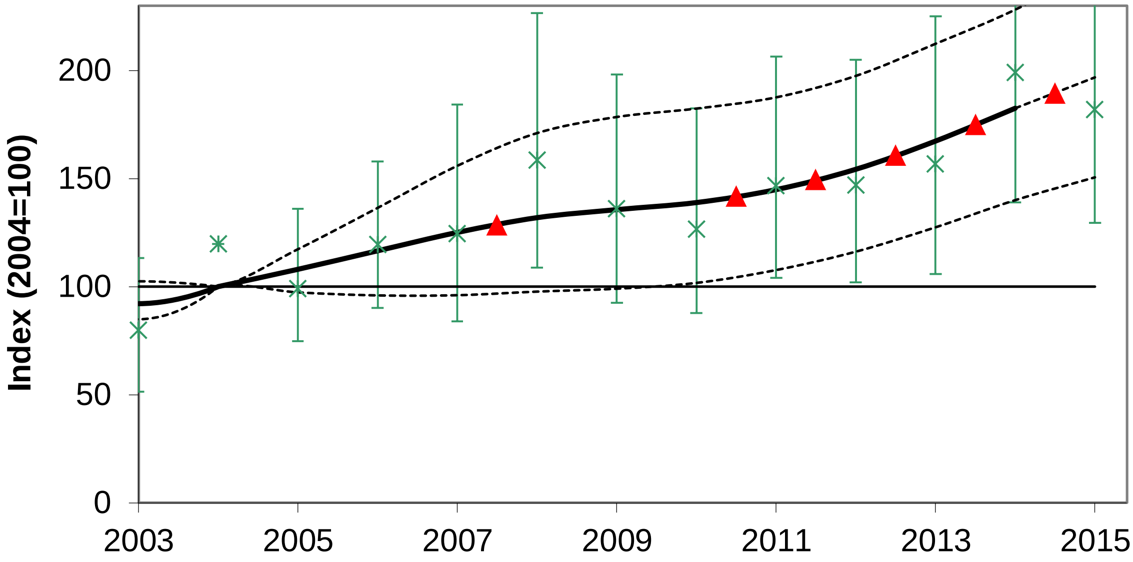

Figure 3.6: Results of the GAM/GLM model for soprano pipistrelle passes per survey. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by lighter black lines. All estimates are adjusted to 1,125 0.32s snapshots. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2014-2015 and the possibility that the slope will change with coming years' data. Red circles indicate significant (P<0.05) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant (P<0.05).

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 modeled estimates adjusted to 1,125 snapshots per survey.

			smoothed		95% limits		unsmoothed	
Year	***Counts***	***Sites***	***index***	***s.e.***	***lower***	***upper***	***fit***	***s.e.***
2003	7	9	92.12	4.48	84.90	102.46	60.05	15.58
2004	17	27	100.00	0.00	100.00	100.00	100.00	0.00
2005	17	31	108.01	5.11	97.33	117.30	79.39	15.34
2006	25	45	116.57	10.37	95.94	136.42	99.71	17.35
2007	26	46	125.06	15.17	96.02	155.87	104.99	25.73
2008	23	42	131.89	18.49	97.69	171.02	138.99	30.45
2009	28	52	135.61	19.86	99.03	178.46	116.33	26.97
2010	27	53	138.89	20.12	101.72	182.37	106.97	25.25
2011	28	53	144.87	20.26	107.66	187.56	127.05	25.83
2012	26	44	154.28	20.60	116.17	197.47	127.34	26.47
2013	25	46	167.33	21.25	127.43	212.34	137.05	31.24
2014	27	49	182.52	22.48	140.00	228.12	179.29	36.16
2015	28	53	196.80	25.02	150.55	247.82	162.18	32.47

3.2.4 *Leisler's bat,* Nyctalus leisleri

3.2.4.1 2015 Results

The overall average number of Leisler's bat encounters per hour was 11.58 during Survey 1 in 2015 and 11.08 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 11.34.

The survey with the highest number of Leisler's bat encounters was T05, south Wicklow, Survey 1.

Leisler's bat was the third most frequently encountered species during the monitoring scheme in most years including 2015. Exceptional years were 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 2015. 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 2015.

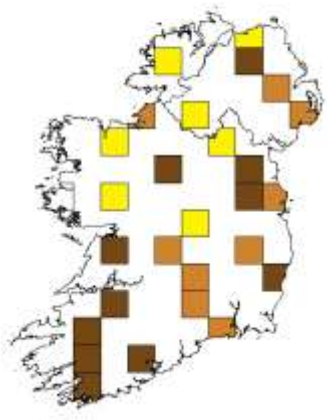

Figure 3.7: Survey squares colour coded according to Leisler's bat encounter rates (per hour) in 2015. The overall average rate of Leisler's encounters for all squares in 2015 was $11.34hr^{-1}$.

Encounter rate = $0hr^{-1}$ (L64, Connemara)
Encounter rate $>0\leq6hr^{-1}$
Encounter rate $>6\leq12hr^{-1}$
Encounter rate $>12hr^{-1}$

3.2.4.2 Trends

Figure 3.8 shows the results of the Generalised Linear Model (GLM) applied to Car-based Bat Monitoring data for Leisler's bat, along with Generalised Additive Model (GAM) smoothed curves. The estimate for Leisler's bat is significantly above the baseline. The smoothed trend continues upwards, despite the fact that the 2015 annual estimate was lower than 2014, although note that the lower confidence interval has a slightly downward trajectory.

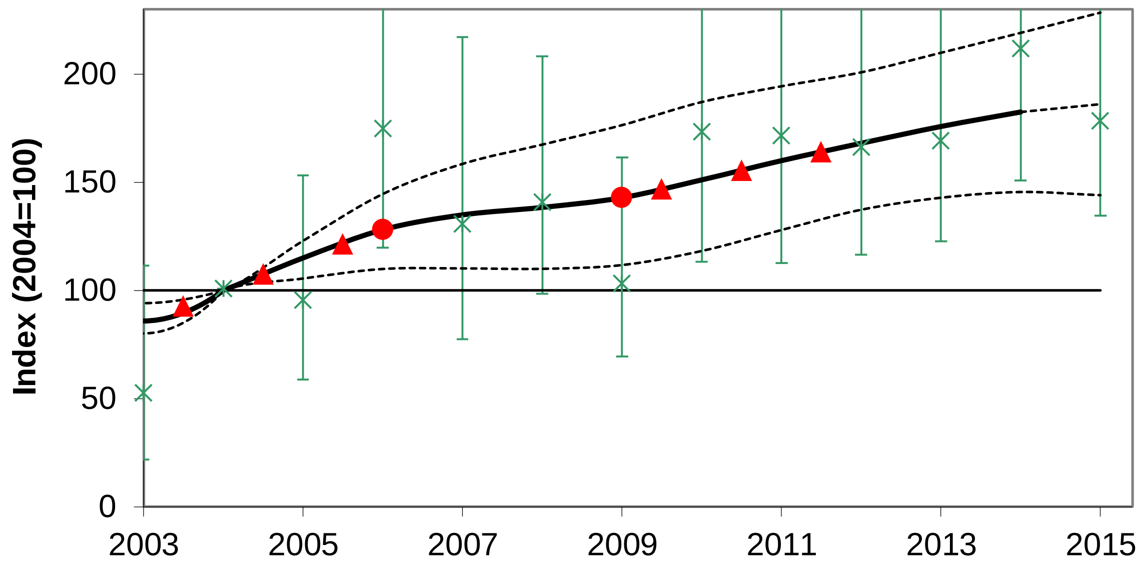

Figure 3.8: Results of the GAM/GLM model for Leisler's bat passes per survey. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. All estimates are adjusted to 1,125 0.32s snapshots. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2014-2015 and the possibility that the slope will change with coming years' data. Red circles indicate significant (P<0.05) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant (P<0.05).

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.

			smoothed		95% limits		unsmoothed	
Year	*Counts*	*Sites*	*index*	*s.e.*	*lower*	*upper*	*fit*	*s.e.*
2003	7	9	85.86	3.55	80.11	94.09	51.79	22.89
2004	17	27	100.00	0.00	100.00	100.00	100.00	0.00
2005	17	31	114.98	4.42	105.48	122.89	94.47	23.90
2006	25	45	128.02	8.86	109.89	144.53	173.83	34.49
2007	26	46	134.89	12.33	110.15	158.47	129.92	36.16
2008	23	42	138.34	14.70	109.96	167.37	139.84	27.58
2009	28	52	142.82	16.38	111.70	176.37	102.31	23.14
2010	27	53	151.07	17.36	118.21	187.05	172.39	37.63
2011	28	53	159.95	16.93	127.90	194.34	170.60	37.61
2012	26	44	168.00	16.38	137.27	200.78	165.38	32.27
2013	25	46	175.75	17.08	142.82	209.82	168.20	31.04
2014	27	49	182.44	18.75	145.46	219.03	210.90	41.74
2015	28	53	186.07	21.61	143.99	228.37	177.35	25.35

3.2.5 *Nathusius' pipistrelle*, Pipistrellus nathusii

3.2.5.1 2015 Results

The overall average number of Nathusius' pipistrelle encounters per hour was low, 0.21 during Survey 1 in 2015 and 0.19 during Survey 2, see Tables A1.1 and A1.2 (Appendix).

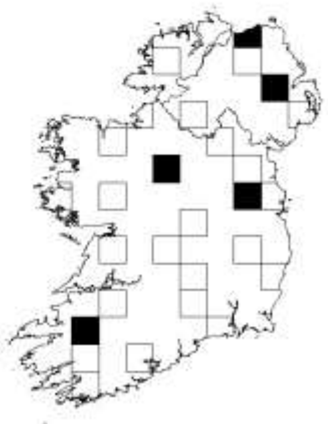

Figure 3.9: Survey squares indicating presence (black) or absence (white) of Nathusius' pipistrelle records from the 2015 car-based bat monitoring scheme.

Figure 3.9 illustrates squares where the species was present in 2015. Most Nathusius' pipistrelle passes were recorded from squares J06 (south Antrim) and V99 (Kerry). Nathusius' pipistrelles were also recorded from C72 in Northern Ireland and from N74 (Meath) and M87 (Longford). The overall average number of Nathusius' pipistrelle encounters per hour for both survey periods was 0.2, see Table 3.2.

3.2.5.2 Trends

Figure 3.10 shows the results of fitting a GLM/GAM model for the proportion of one mile transects with Nathusius' pipistrelle passes (binomial model). Nathusius' pipistrelle increased from zero values recorded in the first two years of the monitoring scheme, although in latter years of the scheme the activity levels have again dropped.

Thus far, the maximum yearly estimate was in 2006. The smoothed curve suggests that, after an initial increase, Nathusius' pipistrelle has now somewhat stabilized.

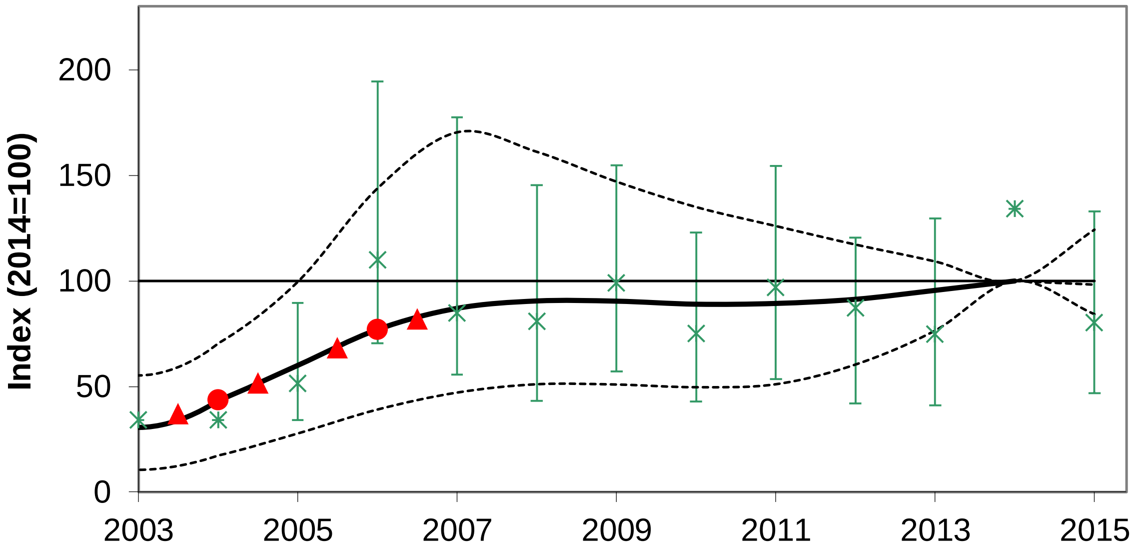

Figure 3.10: Results of a Binomial GLM modeling for proportion of transects with Nathusius' pipistrelle present, all-Ireland. The black line is the smoothed GAM curve, with 95% confidence limits shown by the lighter black lines. Points are estimated annual means and are shown to illustrate the variation about the fitted line. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2014-2015 and the possibility that the slope will change with coming years' data. Red circles indicate significant (P<0.05) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant (P<0.05).

3.2.6 *Myotis* spp.

3.2.6.1 2015 Results

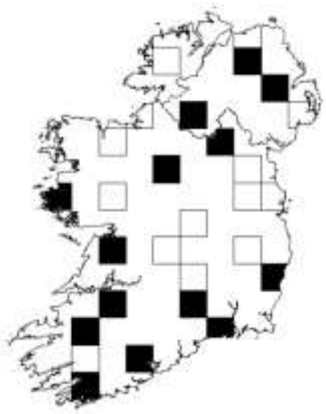

Figure 3.11: Survey squares indicating presence (black) or absence (white) of *Myotis* spp. records from the 2015 Car-based Bat Monitoring Scheme.

The overall average number of *Myotis* species encounters per hour was high in 2015 compared to other years, 0.66 during Survey 1 in 2015 and 0.5 during Survey 2, see Tables A1.1 and A1.2 (Appendix 1). The overall average number of *Myotis* species encounters per hour for both months was 0.58 in 2015, see Table 3.2. This represents a considerable increase in average encounter rates compared with previous years.

Figure 3.11 illustrates squares where this species group was recorded in 2015.

3.2.6.2 Trends

Myotis spp. numbers showed reasonably constant year-year levels until 2013 (see Figure 3.12) when they dropped considerably. Yearly estimates have increased since then and 2015 had the highest yearly estimate since 2004. As a result of this, the trend which had steadily decreased to almost significantly below the 2004 baseline, has now turned upwards.

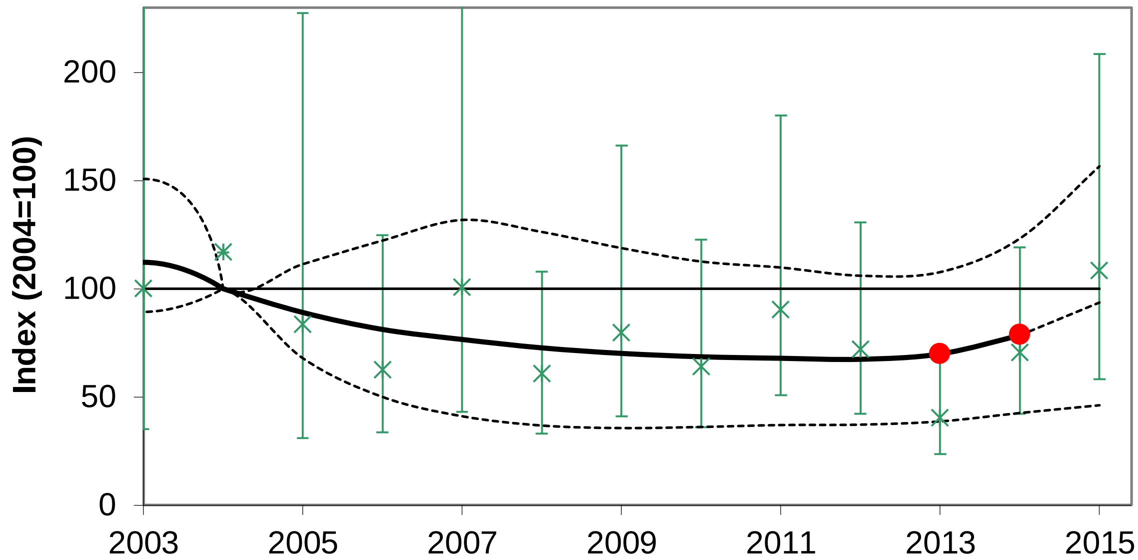

Figure 3.12: Results of the GAM/GLM model for *Myotis* spp. passes per survey. Points are estimated annual means derived from the Generalised Linear Model and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model curve with 95% confidence limits shown by the lighter black lines. All estimates are adjusted to 1,125 0.32s snapshots. End of the smoothed trend is shown with a broken line to illustrate uncertainty for 2014-2015 and the possibility that the slope will change with coming years' data. Red circles indicate significant ($P<0.05$) change points, where the slope of the smoothed trend line changes.

3.2.7 Brown long-eared bat, **Plecotus auritus**

3.2.7.1 2015 Results

The overall average number of brown long-eared bat encounters per hour was 0.12 during Survey 1 in 2015 and 0.11 during Survey 2, see Tables A1.1 and A1.2 (Appendix 1). The overall average number of brown long-eared encounters per hour for both months was 0.12 in 2015, see Table 3.2.

Figure 3.13 illustrates squares where this species was recorded in 2015.

Of all the species encountered during the monitoring scheme, the brown long-eared bats is typically the least common. The methodology of this monitoring scheme means that encounter rate for this species is expected to be low and therefore it is not a target species. Nonetheless, the rate of encounters with this species was particularly low in 2015.

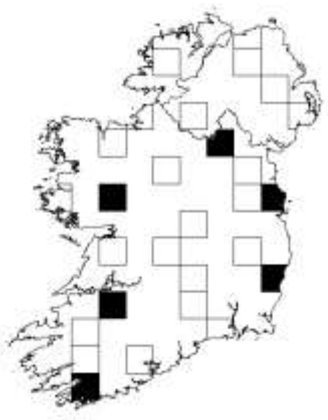

Figure 3.13: Survey squares indicating presence (black) or absence (white) of brown long-eared bat records from the 2015 Car-based Bat Monitoring Scheme.

3.2.7.2 Trends

This species is recorded in very low numbers by the Car-based Bat Monitoring Scheme. The annual trend has been analysed using a binomial model, the results are shown in Section 5 alongside trends derived from the dedicated brown long-eared bat monitoring programme.

3.2.8 Baton Trial

Two units of Baton (Stag Electronics) combined frequency division/full spectrum detectors were trialled in 2015 in tandem with the traditional Tranquility Transect detectors. The two detectors were used on three different survey squares R88, N74 and N77. Data from both detectors were collected from 75 transects in total. Data from the Baton were analysed in the same manner as for Tranquility detectors, using Bat Sound. The Baton detector picked up all species well but there were some differences that mean the datasets are not directly comparable.

In total, per survey night, the Baton recorded more common pipistrelles, pipistrelle bats (*Pipistrellus* species) and soprano pipistrelles (see Figures 3.14-3.16 which show the totals from each survey per detector), although the difference is less apparent at the transect level.

Wilcoxon signed rank tests (because the datasets deviated from normal) were carried out on the number of bat passes (per species) per transect to see if they differed significantly between the Baton and Tranquility Transect.

For common pipistrelles the number of passes per transect were found to differ significantly ($Z=-3.3077$, $p<0.05$, $n=56$), with greater numbers per transect recorded by the Baton. Similarly for soprano pipistrelles, more passes were recorded on transects by the Baton ($Z=-4.7587$, $p<0.05$, $n=39$). In contrast, for Leisler's the number of passes tended to be greater for Tranquility Transects than for Baton. This difference was not significant using a Wilcoxon signed rank test ($Z=-1.5968$, $p=0.11$, $n=23$), but this non-significant result may have arisen due to the high number of zeroes in the dataset.

Figure 3.17 shows scatterplots of bat passes per transect (common pipistrelles, soprano pipistrelles and Leisler's bats). A line of best fit has been drawn for each species.

For common pipistrelles the intersect with the y axis is >0 while the slope of the line is <1. There are fewer datapoints for the soprano pipistrelle, nonetheless for this species there is a similar relationship between encounter rates picked up by the Baton and the Tranquility. For Leisler's bat the line of best fit intersects Y close to zero but the slope of the line is 0.45, indicating that for every two Leisler's bat passes recorded by the Tranquility, less than one is recorded by the Baton. This is likely to be due to the fact that the Baton records continuously, so that Leisler's bat passes are not broken into sections and treated as separate bat encounters as for the Tranquility detector. This issue is likely to arise with any full spectrum detector and may need to be addressed in order to prevent a loss of power in the data with an equipment changeover.

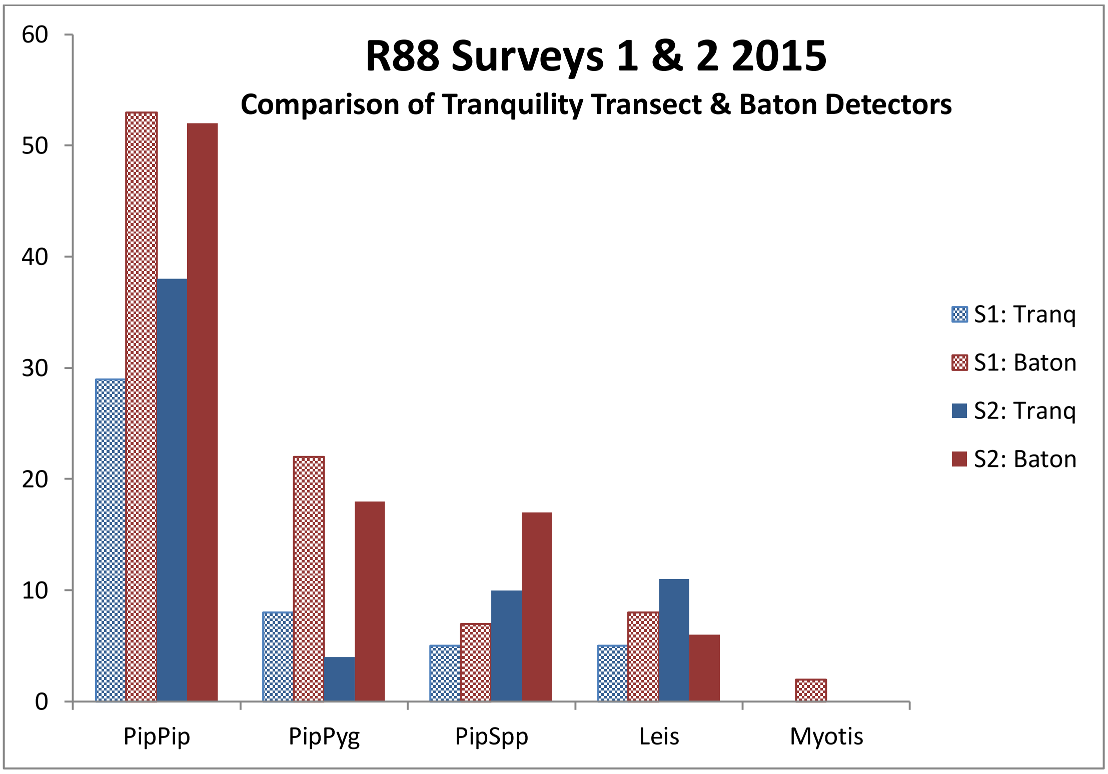

Figure 3.14: Baton and Tranquility detector trials. Total bat passes per survey in square R88. PipPip = common pipistrelle, PipPyg = soprano pipistrelle, PipSpp = pipistrelle unidentified, Leis = Leisler's bat, Myotis = *Myotis* spp.

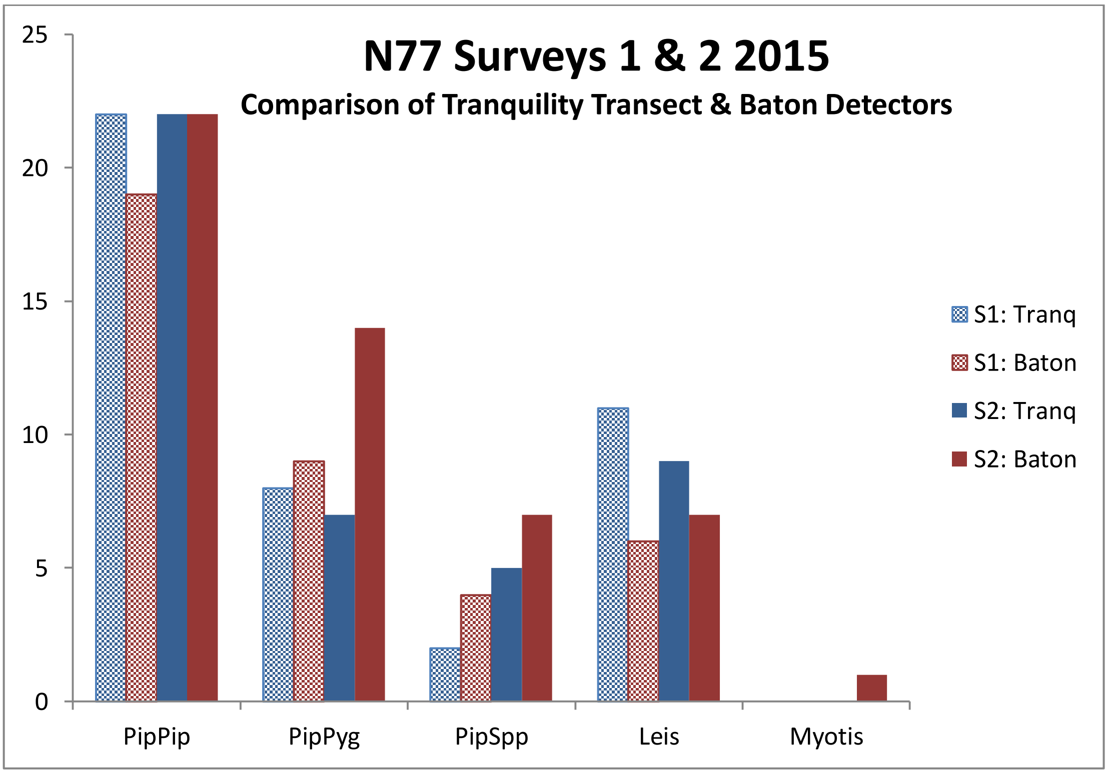

Figure 3.15: Baton and Tranquility detector trials. Total bat passes per survey in square N74. PipPip = common pipistrelle, PipPyg = soprano pipistrelle, PipSpp = pipistrelle unidentified, Leis = Leisler's bat, Myotis = *Myotis* spp.

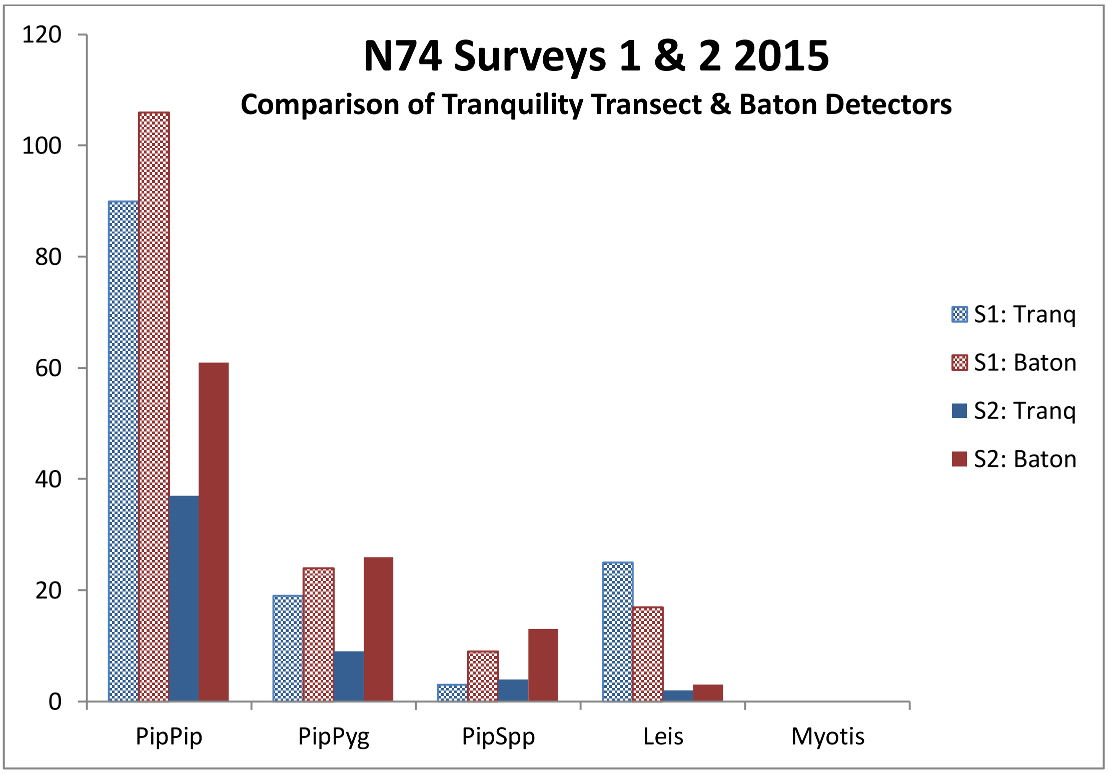

Figure 3.16: Baton and Tranquility detector trials. Total bat passes per survey in square N77. PipPip = common pipistrelle, PipPyg = soprano pipistrelle, PipSpp = pipistrelle unidentified, Leis = Leisler's bat, Myotis = *Myotis* spp.

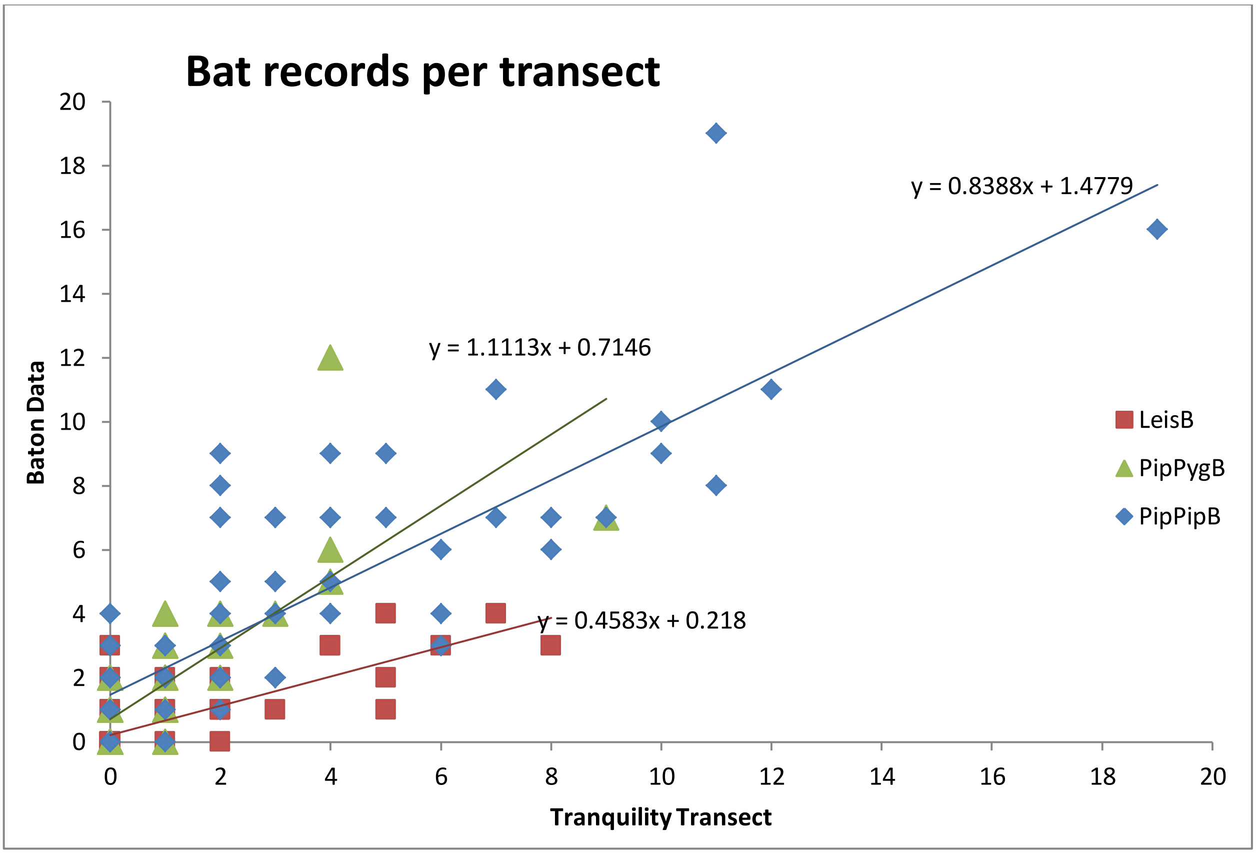

Figure 3.17: Baton and Tranquility detector trials. Total bat passes per transect, per detector. Includes data from all 75 transects in 2015. PipPipB = common pipistrelle, PipPygB = soprano pipistrelle, LeisB = Leisler's bat.

3.2.9 Other Vertebrates

As in previous years, surveyors were asked to record living and dead vertebrates that they encountered while surveying, during and between transects. This resulted in the collection of 373 records of living vertebrates (apart from bats) and 22 records of dead vertebrates in 2015. Figure 3.18 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 2015 accounted for 57% of all records collected. Rabbits were the second most common (47 records). Dogs accounted for the third highest number of records (31 records). Owl records were the highest of any year to date with the exception of 2009. This year, 10 owls were observed. One was a barn owl, three long-eared owls and the remainder were species unspecified.

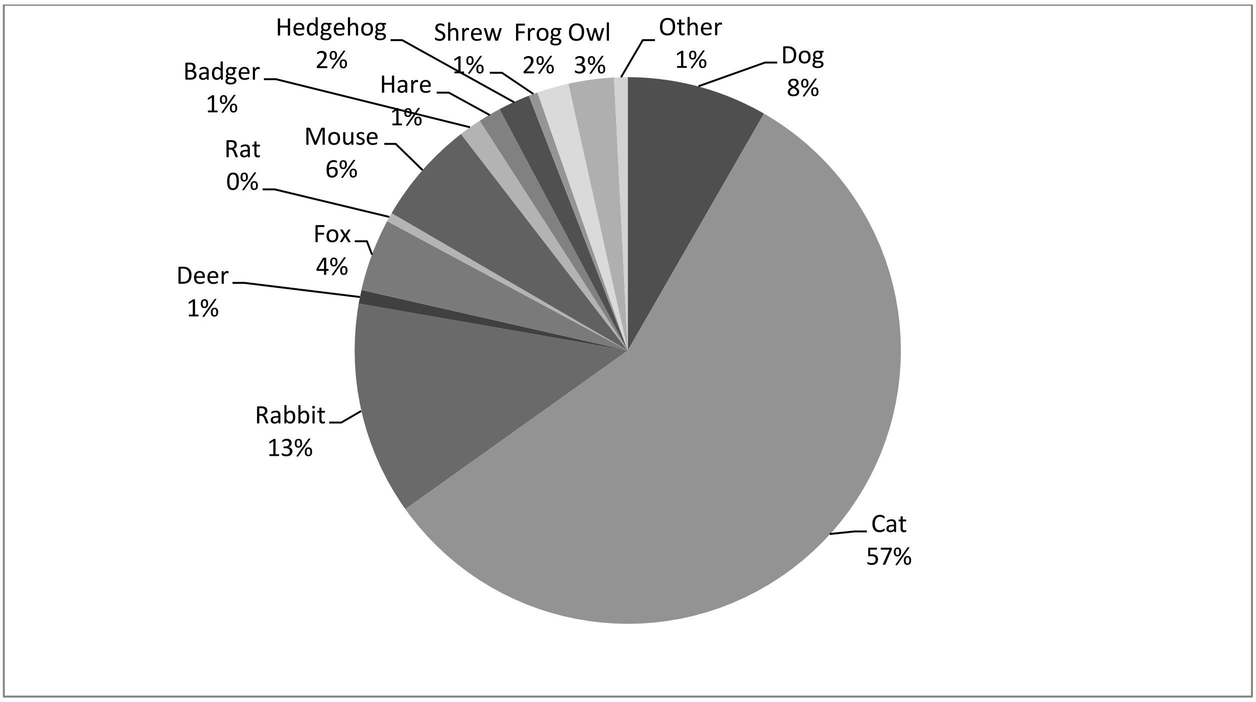

Figure 3.18: Living vertebrates, other than bats, observed during 2015, n=373. The category 'Other' includes two bank vole and an unidentified mustelid. The category 'Owls' includes one barn owl, three long-eared and six unspecified owl records.

3.2.9.3 Dead vertebrates

The number of dead specimens recorded from roadsides totalled 22 in 2015. Rabbits, foxes, cats, badgers, rats and a mouse were recorded. As in previous years, species proportions differ from living fauna, with a lower representation of cats, among dead, compared with living roadside specimens.

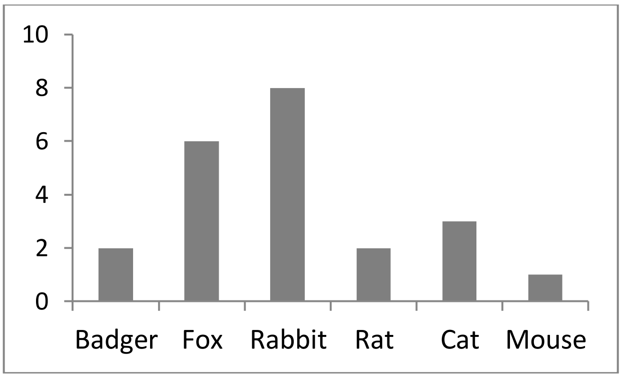

Figure 3.19: Dead vertebrates, other than bats, observed during 2015, n=22.

3.3 Discussion

3.3.1 Volunteer uptake

Sixty two individuals undertook the survey in 2015. Volunteer teams' level of experience has increased due to yearly participation. Refresher and new team training courses were held around the country to train in surveyors in the use of the method/smart phone system.

3.3.2 Survey Coverage in 2015

A higher number of completed surveys were achieved in 2015 compared with 2014. Just two surveys out of the maximum 56 were not completed in 2015, both during Survey 2.

The main problem reported by teams across the island in 2015 was difficulty locking on to GPS satellites. This may have arisen due to weather conditions or software issues, but appears to be a particular problem to which the smart phones are susceptible. Some issues with leads did arise but most were dealt with in situ and did not cause loss of data quality.

3.3.3 Dataset

The 2015 dataset consisted of 3406 bat encounters. The common pipistrelle was the most frequently encountered species, as in all previous years, but it constituted just 45% of the bat observations compared with roughly 50% in some years. Leisler's bat accounted for 20% of total bat encounters.

3.3.4 Species Abundance and Yearly Trends

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).

3.3.4.1 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. In 2015, for the second year running, common pipistrelles were detected in square L64, Connemara.

According to the trend model this species has increased slowly but significantly since the baseline in 2004. Overall, the trend has been for a significant, slight year on year increase of 3.4%, thus representing a total change of +44% since the base year in 2004.

3.3.4.2 Soprano pipistrelles

The pattern of activity distribution for the soprano pipistrelle has never been as clear as for common pipistrelles although this species shows some western bias in some years. In 2015 lowest abundance squares were located in the midlands.

The trend for this species showed a significant increase for the first time in 2011. The highest yearly estimate for the species was recorded in 2014 and there has been an overall significant year on year increase of 6.3%, representing a total increase of +96.8% since the base year in 2004.

3.3.4.3 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 tends to show an eastern and southern bias (see Roche *et al.* 2009).

The average encounter rate for 2015 was slightly lower than the previous year, although the trend model indicates that this species is still significantly increasing. The per annum increase is estimated to be 5.8% representing a total increase since the base year, 2004, of 86%.

3.3.4.4 Nathusius' Pipistrelle

Nathusius' pipistrelle 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. Trend analysis for this species was carried out using presence absence rather than count data. As a result, the error bars are somewhat reduced, along with yearly variation.

Results indicate that following an initial increase in the early years of the survey that the trend is now more stable. Despite the binomial model, error bars around the trend are still very wide, however.

The Car-based Bat Monitoring survey continues to add records for the species where it has not previously been encountered.

3.3.4.5 Myotis spp.

Myotis spp. numbers until 2013 seemed to show reasonably constant year-year levels, although confidence limits are very wide due to the low encounter rate. In 2013 there was a significant dip in numbers, but this was followed by increases in 2014 and 2015. There is no evidence that the smartphone system has caused a decrease in detections of this species.

3.3.4.6 Brown Long-eared Bat

This species is the least frequently observed species from the Car-based Bat Monitoring Scheme. Results from the Brown Long-eared Bat Roost Monitoring Scheme are described in Section 5.

3.3.5 Other Vertebrates

Other vertebrates were recorded in 2015 as in previous years, and again cats were the most commonly observed animal. In decreasing order rabbits, dogs and foxes were the next most common roadside species. A number of owls were also observed in 2015 although many of these were not identified to species level.

3.3.6 Baton Detector Trials & Future Equipment Changes

The Baton detector worked well alongside the Tranquility Transect detector. It picked up greater numbers of pipistrelle bats, thus ensuring that power to detect trends in this species could be maintained in the event of a changeover to this equipment type. The number of Leisler's bats recorded by this system is lower, however, than the Tranquility Transect. This is probably due to the fact that the Tranquility breaks down individual Leisler's passes into multiple snapshots, as a result of its defined 320ms trigger time.

Also, in view of the fact that underlying problems with leads would be retained if we were to proceed with a changeover of this type, it does not currently seem like a satisfactory system.

This trial was very useful in pointing out the kind of sample sizes we will need in the event of a change of equipment type. It has been suggested that as well as trials to see how the equipment works, we need to carry out the real surveys with dual equipment systems for preferably two survey seasons so that we can be sure of the impacts the new equipment has on bat encounter rates.

The NPWS has provided five units of Elekon Batlogger detectors for the car monitoring scheme. This system is currently used for car-based bat monitoring in the Netherlands and combines full spectrum ultrasonic recording with an inbuilt SD card and GPS recorder. Therefore, all of the essential information is available on one unit with no connecting leads required.

We aim to conduct trials with the new Batlogger detectors in April and May 2016 to see how they work and determine best settings to use. We will then deploy the system among five teams in 2016 along with the originaly Tranquility detector and smart phone combination.

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 willingness to participate 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 facilities 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 1km transects surveyed in previous years.

Surveyors undertake a daytime survey of their allocated site 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

For statistical analysis, a log-transformation is carried out on data at the ten individual points within each survey; this effectively calculates the mean of passes for the survey and helps to reduce the influence of the very high counts sometimes recorded due to one or two bats repeatedly passing the observation point.

In previous years bat pass counts were used in a REML model (log-transformed) to investigate the potential relationships with collected variables. Since 2010, the dataset (2006-2014) has been entered into a model looking at the impact of the various covariates on the probability of observing bats at a given spot i.e. a binomial model (Binomial GLMM/GAM model).

Analyses are based on data collated from 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. As a consequence, the majority of submitted surveys are included in the model as only a few surveys from the second week in September are excluded.

For analysis based on bat passes, both counts excluding and including 'Unsure' Daubenton's bat passes were used. For binomial analyses, the presence of both 'Sure' and 'Unsure' Daubenton's bat passes at each survey spot were used. Surveys where no bat passes were recorded are also included in the analysis.

To assess trends, two different methods are used. One is a Generalised Linear Model (GLM) with a Poisson error distribution which is applied to the entire dataset (i.e. 2006-2014) and the other is a GLM with a binomial distribution. The first is undertaken in order to compare the trends with the BCT waterways survey (e.g. Barlow *et al.*, 2015) while the latter is also reported since presence/absence models such as this are considered to more effectively deal with the issue of multiple encounters with the same individual bats, a problem common to static detector surveys.

The trend datasets only include waterway sites surveyed for two or more years as waterway sites surveyed in a single year do not contribute to information on trends.

For the GLM with Poisson distribution Daubenton's bat activity per annum was modeled 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 model with the maximum number of bat passes per survey spot is set to 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 approach is similar to the approach used for assessing Daubenton's trend in Britain in the National Bat Monitoring Programme (NBMP) undertaken by the BCT and also for trends in bird populations.

The binomial (presence/absence) model uses the proportion of survey spots with bats present at each waterway site (e.g. 0.7 if Daubenton's bats were observed at seven of the ten survey spots). Bootstrapping is used to find standard errors using logistic regression (a GLM with a logit link function) (Fewster *et al.*, 2000). A smoothed GAM trend is also fitted (to highlight the change in trend) to the results without co-variates to give a general indication of the trend.

4.2 Results

4.2.1 Training and Volunteer Participation

In 2015, 13 training courses were organised in counties Dublin, Antrim, Belfast, Tyrone, Clare, Cork, Tipperary, Offaly, Mayo, Louth, Kerry, Westmeath and Roscommon. Over 180 people attended these courses. These training courses were completed in June and July 2015. A total of 41 new teams that signed up during training courses and received survey packs prior to August completed surveys in 2015. A total of 330 survey packs were posted out to volunteers prior to August 2015.

A total of 250 waterway sites were surveyed by 192 survey teams in 2015; this included 41 new survey teams who surveyed 25 new waterway sites and 16 previously surveyed waterway sites. Twenty seven teams surveyed two or more waterway sites (n=85) while all remaining teams (n=165) surveyed one waterway site. The majority of waterway sites were surveyed by teams composed of members of the public (n=150) and the remainder were NPWS staff (n=17), NI government staff (n=4) and BCIreland committee members/local bat group members (n=21).

A total of 13 different bat detector models were used by survey teams in 2015. The Bat Magenta Mark IV heterodyne bat detector was the most common model (n=88, 35.2%) followed by Bat Box III heterodyne bat detector (n=35, 14.3%) and Pettersson D200 heterodyne bat detector (n=34, 13.9%) (see Table A2.1 & A2.2, Appendix 2).

4.2.2 Waterway sites surveyed

A total of 250 waterway sites were surveyed in 2015, the second highest number of waterway sites since the monitoring programme began in 2006 (highest in 2014, n=255 waterways sites). Twenty-five waterways sites surveyed in 2015 were new waterway sites.

Thirty-six waterways sites were located in Northern Ireland and 214 waterway sites in the Republic of Ireland.

Twenty-three (4.1%) of the waterway sites surveyed in 2015 have been surveyed each year since 2006 while 54 (9.7%) of the waterway sites surveyed in 2015 have been surveyed for at least nine of the ten years of the scheme (Figure 4.1).

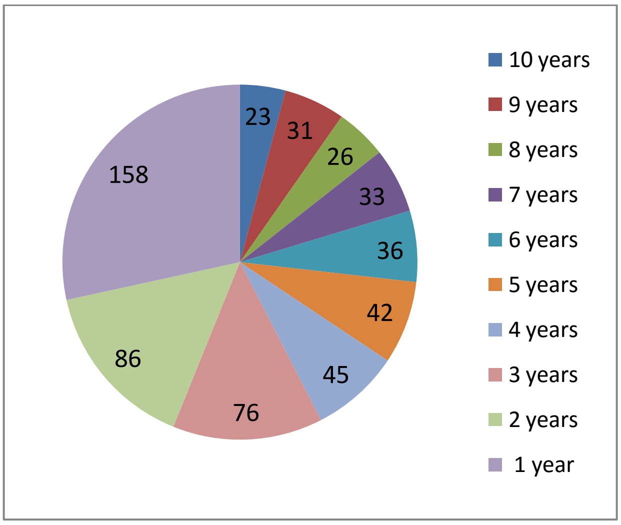

Figure 4.1: Number of years each waterway sites across the island were surveyed during 2006-2015 as part of the All Ireland Daubenton's Bat Monitoring Scheme.

Overall, 556 waterway sites across the island have been surveyed at least once over the ten years of the monitoring scheme (Figure 4.2).

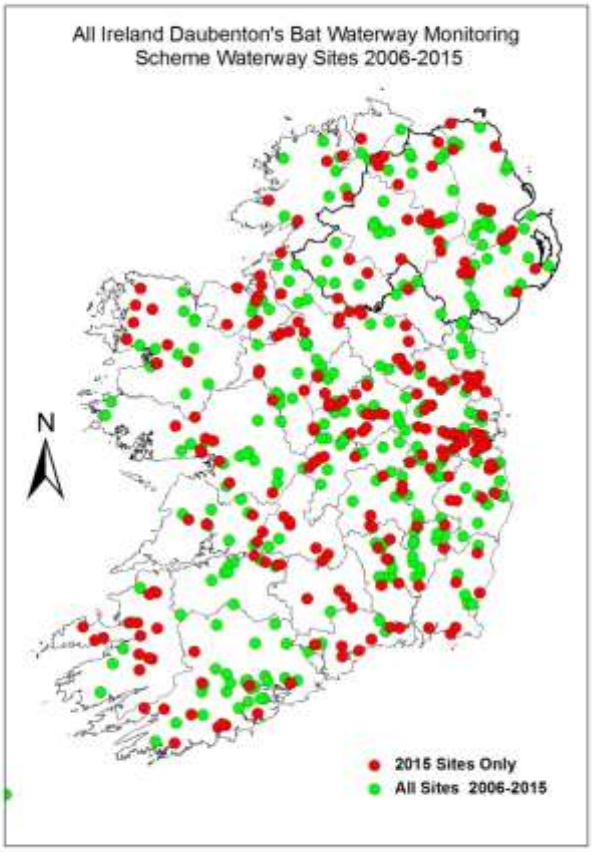

Figure 4.2: Location of all waterway sites surveyed across the island from 2006-2015 as part of the All Ireland Daubenton's Bat Monitoring Scheme. Red circles: 2015 waterway sites only, Green circles: all other waterway sites.

In 2015 a total of 15 canals (45 waterway sites), two channels and 129 rivers (203 waterway sites) were surveyed. The Royal Canal had 14 waterway sites surveyed along its length while the River Boyne had nine waterway sites located along its length (Figure 4.3).

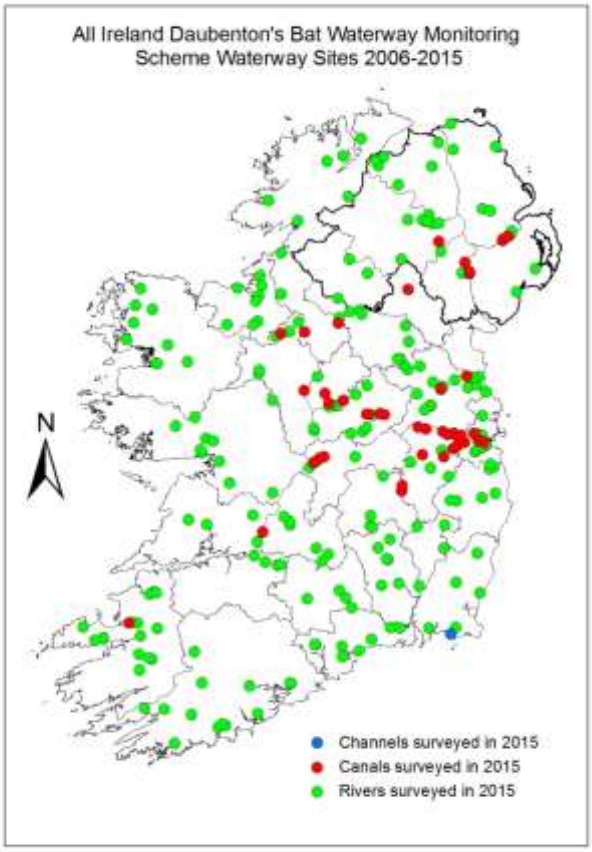

Figure 4.3: Different type of waterways surveyed in 2015 as part of the All Ireland Daubenton's Bat Monitoring Scheme. Red circles = Canals surveyed; Green circles= Rivers surveyed; Blue circles = Channels surveyed.

Of the four provinces, the highest number of waterway sites were surveyed in Leinster (n=103, Figure 4.4) and County Dublin had the highest number of waterway sites surveyed per county (n=18).

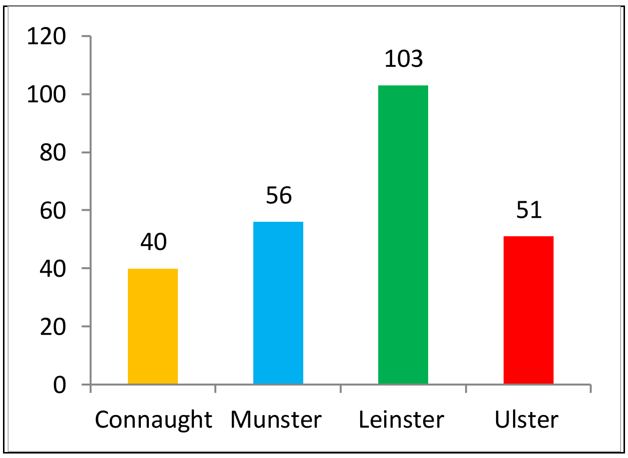

Figure 4.4: Number of waterway sites surveyed in each province in 2015 as part of the All Ireland Daubenton's Bat Monitoring Scheme.

4.2.3 Completed surveys

A total of 463 completed surveys from 250 waterway sites surveyed in 2015 were returned to BCIreland.

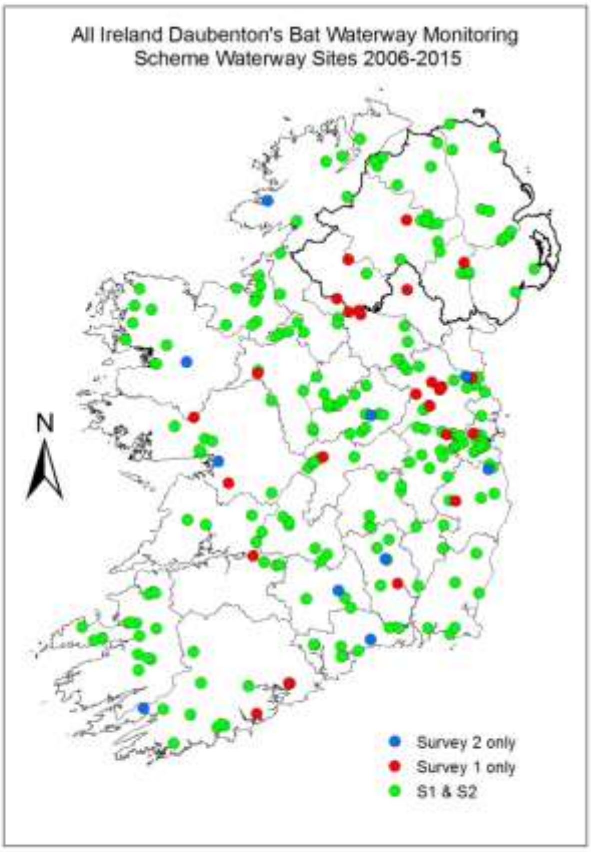

Figure 4.5: Waterways surveyed either twice (Survey 1 & Survey 2) or only once (Survey 1 only or Survey 2 only) in 2015 as part of the All Ireland Daubenton's Bat Monitoring Scheme. Green circles = Survey 1 & Survey 2; Red circles = Survey 1 only; Blue Circles = Survey 2 only.

Two hundred and forty surveys were completed in first survey period in 2015 (Survey 1: 1st – 15th August) while 223 surveys were completed in the second survey period (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 2015, a total of 213 repeated surveys (85.2% of waterway sites) were completed while 37 single surveys were completed (see Figure 4.4). This was greater than the number of repeat surveys in 2011 (78%), 2009 (81%), 2014 (87%) and 2008 (74%), but less than the total in 2007 and 2010 , which had the highest rates of repeat surveys of all ten years to-date (95% and 93% respectively).

In 2015 'Sure' Daubenton's bat passes were recorded on 225 waterway sites (90%) (see Figure 4.5).

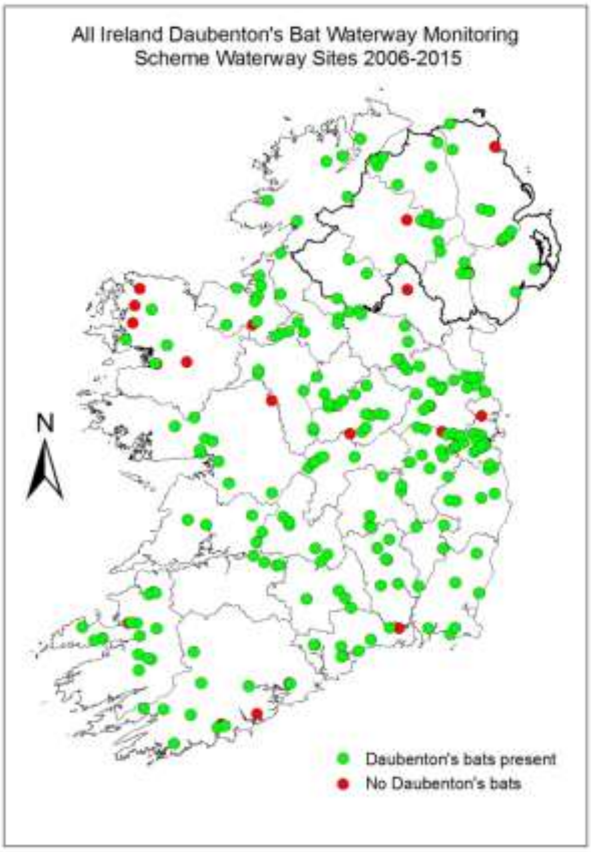

Figure 4.6: Location of waterways sites with Daubenton's bat recorded in 2015 as part of the All Ireland Daubenton's Bat Monitoring Scheme. Blue circles: Daubenton's bat not recorded; Red circles: Daubenton's bats recorded.

At each of the 10 survey spots of each completed survey volunteers recorded Daubenton's bat activity for four minutes generating 40 minutes of data per completed survey. In total, 20,635 'Sure' Daubenton's bat passes and 3,826 'Unsure' Daubenton's bat passes were recorded during 308 hours 40 minutes of surveying.

Taking the surveys that were returned in time for statistical analysis and were completed between Day 205 to 250 (n=445 surveys, See Table A2.3 in the Appendices) the mean number of 'Sure'

Daubenton's bats passes per survey was 44.7 passes, which is the fifth highest mean for the ten years of monitoring. In addition, bats were recorded on 63.1% of survey spots in 2015.

Ulster, for the first time in the ten years of monitoring, had the highest mean (Mean no. = 50.8 'Sure' bat passes). For a full break down of descriptive results for 2006-2015 see Table A2.3, Appendix 2.

4.2.4 Trends – Poisson GLM

To assess trends, a Poisson Generalised Linear Model (GLM) was applied to the data with the results expressed as an index and 2007 used as the base year. Just one of the models is reported here, the model that includes both sure and unsure and with the maximum number of passes set to 48 with covariates. This particular model is chosen to facilitate comparison with British data from the BCT. A total of 394 waterway sites that were surveyed for two years or more are included in this analysis. Waterway sites only surveyed for one year do not contribute to information on trends and are therefore omitted from the analysis.

Counts were relatively low in 2012, 2013 and 2014, with the result that the curves are no longer heading upwards, as they were in 2011. However, a greater number of passes were recorded in 2015 and as a result there is a levelling of the trend with a slight increase.

Overall the smoothed index is currently 2.82% above the 2007 base year value which is equivalent to an average 0.35% annual increase.

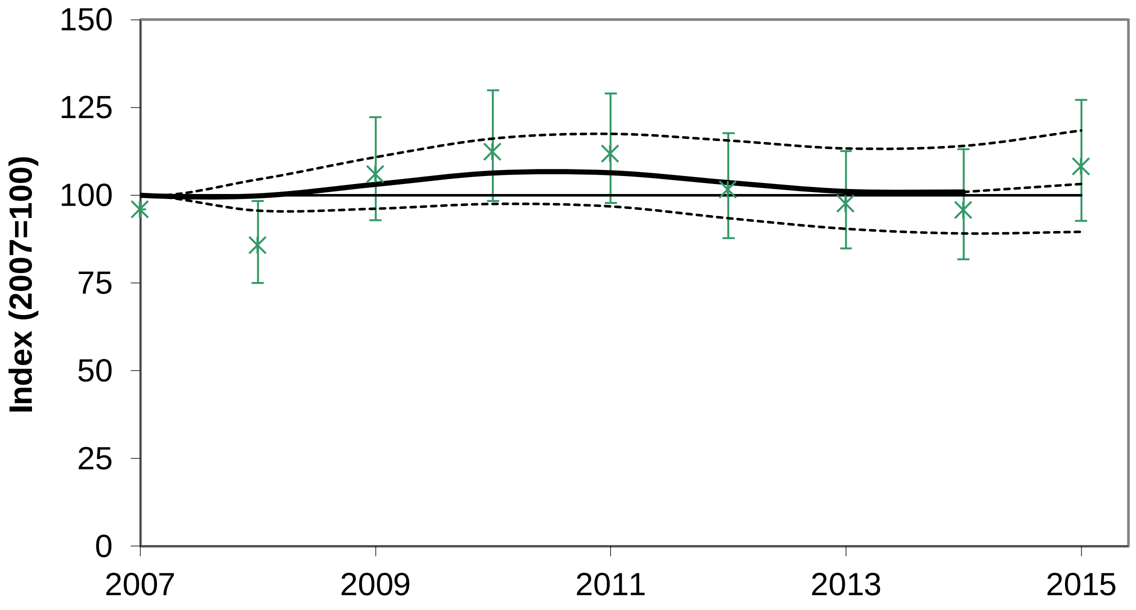

Figure 4.7: All Ireland results of the GAM/GLM model for total number of All bat passes (both 'Sure' and 'Unsure') with a maximum of 48 passes per spot. Green points are estimated annual means and are shown to illustrate the variation about the fitted line. '48 max' refers to counts capped at a maximum of 48 at each spot. The covariates used in the final graph are smooth water and rain.

4.2.5 Yearly Trends – Binomial GAM

Modelling using the percentage of survey spots with bats present was undertaken. The 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.

A similar modeling approach to that for the counts was followed, with bootstrapping used to find standard errors, but this time logistic regression (a GLM with a logit link function) rather than a Poisson GLM was used. As the covariates don't seem to help in terms of reducing the standard error of estimates, the results without covariates are presented (Figure 4.8). The pattern of results is similar to the Poisson model although, as seems to be common with these models, the amplitude of variation is less with a binomial model.

A smoothed GAM trend was also applied to the results. At this stage (i.e. with only 7 years of data) results suggest a decline to 2008 with numbers stabilising in 2009, 2010 and 2011 and declining again in 2012, 2013 and 2014 (Figure 4.8) but changes are quite small relative to the width of the confidence limits and must, therefore, be treated with caution. There was a slight upward trend in 2015. This type of trend analysis will become much more useful once more years of data are available.

Overall the smoothed index is currently 0.82% above the 2007 base year value which is equivalent to an average 0.1% annual increase.

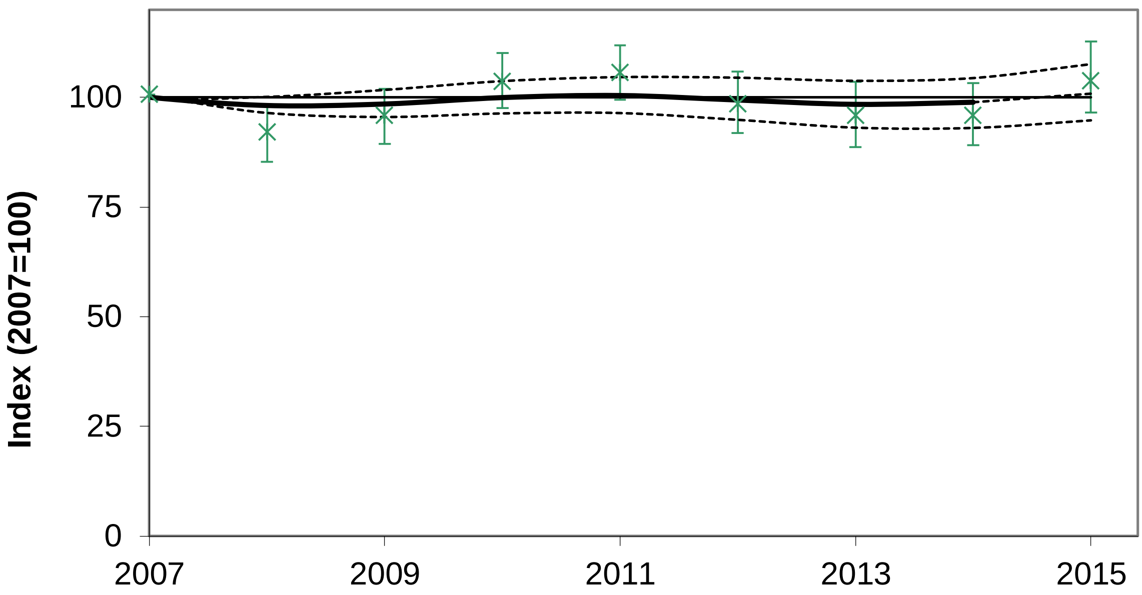

Figure 4.8: Results of Daubenton's bat Binomial GAM/GLM trend without covariates, for All-Ireland data. Green points are estimated annual proportions derived from the Generalised Linear Model (GLM) and the bars are bootstrapped 95% confidence limits. The black line is the fitted GAM curve with 95% confidence limits shown by the dotted lines.

4.2.6 Ten Years in Action

The All Ireland Daubenton's Bat Waterways Survey has been running for ten years. This provides us with an opportunity to take stock of how successful the scheme is in relation to the following factors:

1. Core Sites
2. Volunteer Participation
3. County Coverage

and to determine where the scheme can be improved, especially in relation to volunteer participation and support.

4.2.6.1 Core Sites

As stated above, twenty-three of the waterway sites surveyed in 2015 have been surveyed every year since the introduction of the scheme across the island and under the management of BCIreland. These Core Sites are distributed across the island, one waterway site in Northern Ireland and the remaining in the Republic of Ireland (See Figure 4.9). These sites are distributed across 14 counties (Table 4.1).

Table 4.1: Number of CORE waterway sites surveyed according to the county in 2006-2015 as part of the All Ireland Daubenton's Bat Monitoring Scheme.

County	No.	County	No.
Armagh	1	Kerry	1
Carlow	1	Kildare	2
Cavan	2	Kilkenny	1
Clare	1	Leitrim	2
Cork	1	Meath	2
Dublin	4	Waterford	1
Galway	3	Wexford	1

Eighteen volunteer teams that signed up in 2006 have surveyed their original waterway site in all ten years of the scheme while the remaining five sites have new survey teams.

It took two years of operation to ensure that there were trained survey teams in all 32 counties on the island. Therefore, to gain a more accurate picture of the success of the scheme, Core Site status will be assigned those sites surveyed for at least 9 years of the current ten years.

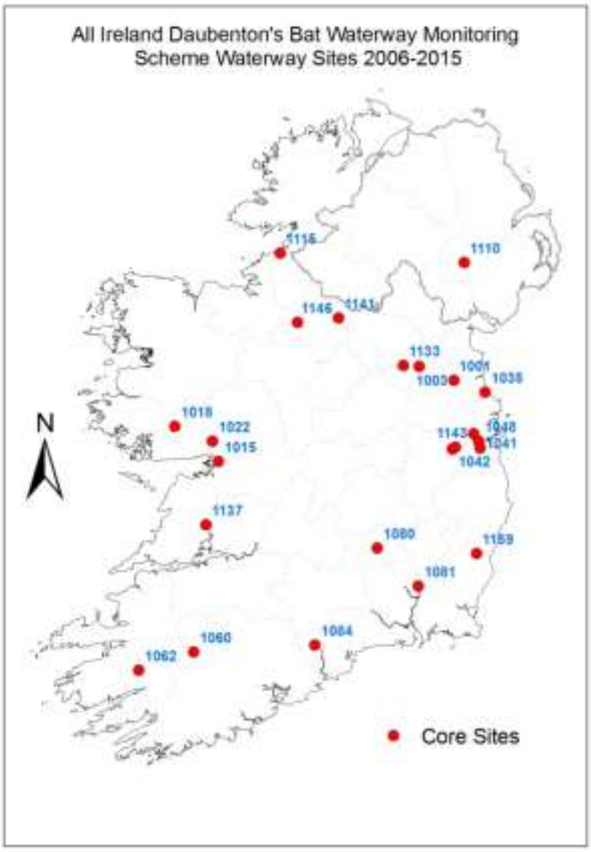

Figure 4.9: Location of CORE waterways sites surveyed for all ten years as part of the All Ireland Daubenton's Bat Monitoring Scheme. Red circles: Core Sites.

Fifty-four of the waterway sites were surveyed for at least 9 of the 10 years the schemes operation (Figure 4.10). These are distributed in 21 counties across the island (Table 4.2).

Table 4.2: Number of CORE waterway sites surveyed for at least 9 of the 10 years according to the county in 2006-2015 as part of the All Ireland Daubenton's Bat Monitoring Scheme.

County	No.	County	No.
Armagh	3	Leitrim	2
Carlow	3	Longford	4
Cavan	2	Mayo	1
Clare	2	Meath	5
Cork	2	Sligo	2
Donegal	1	Tipperary	3
Dublin	5	Waterford	2
Galway	5	Westmeath	3
Kerry	1	Wexford	2
Kildare	3	Wicklow	1
Kilkenny	2		

Thirty-seven volunteer teams that signed up in 2006/2007 have surveyed their original waterway site in all the years that they have participated in the scheme.

Overall, of the 556 waterways sites, 104 of them, once included in the survey scheme have been surveyed consistently since by the same volunteer survey team.

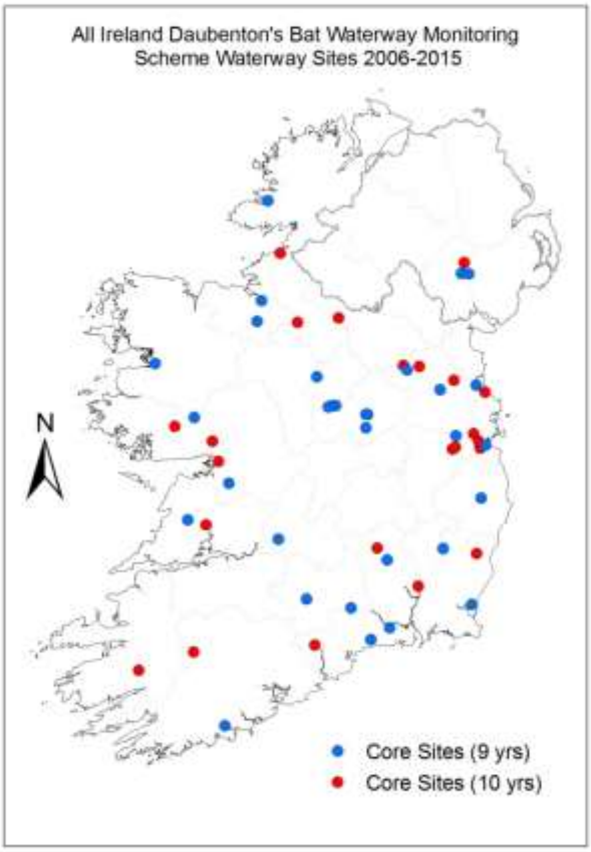

Figure 4.10: Location of CORE waterways sites surveyed for 9 and 10 years as part of the All Ireland Daubenton's Bat Monitoring Scheme. Red circles: 10 years. Blue circles: 9 years.

4.2.6.2 Volunteer Teams & Training

In total, 623 volunteer teams have participated in the monitoring scheme in the last 10 years. Fifty percent of these teams only participated for one year.

The number of volunteer teams increases for a county when there is a training course held in that year. However, in the following year, there is a noted drop in the volunteer participation with only a small number of teams signing up for a second year of participation. A training course is held annually in Dublin and Belfast and as a consequence, the number of waterway sites surveyed annually is consistent in County Dublin and County Antrim. In addition, counties with active bat groups are also consistently surveyed well e.g. County Kildare.

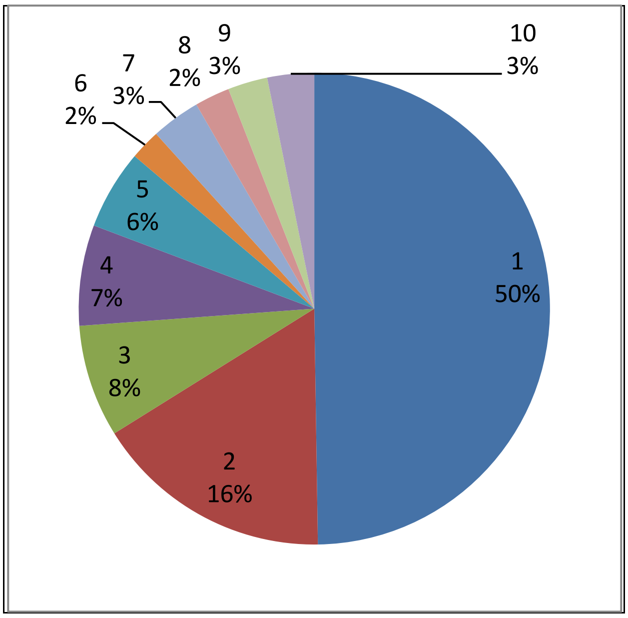

Figure 4.11: Number of volunteer teams and the number of years that they participated in the All Ireland Daubenton's Bat Monitoring Scheme.

4.2.6.3 County Coverage

One of the scheme's aims was to ensure that there was a minimum of five waterway sites per county. After ten years of the scheme and with a total of 556 waterways sites registered, this has been achieved. The least number of sites are located in County Armagh (n = 5 waterway sites) while the highest number of waterway sites is located in County Cork (n = 41 waterways sites, See Appendix 2 for full details).

However, a secondary aim was to survey a minimum of five waterway sites per county each year of the survey scheme. This was not achieved for all counties in any one survey year. County Monaghan has been one of the more erratically surveyed counties with no surveys completed in three of the ten years of the scheme (See Appendix 2 for full details).

4.3 Discussion

4.3.1 Volunteer uptake 2015

One hundred and ninety two survey teams (minimum two individuals per team), a relatively large number of volunteers, undertook the survey in 2015. As a result of well-attended training courses the number of new volunteer teams participating increased in 2015.

While a small core group of survey teams have participated in the programme for each of the ten 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 13-15 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 2015

The second highest number of completed surveys was achieved in 2015 compared with all previous years of the survey (the second highest number of waterway sites was surveyed in 2014). Two hundred and fifty waterways sites were surveyed in 2016 and a total of 463 completed surveys were used in analysis. The waterway sites were located in all thirty two counties of the island. The highest coverage for a single county was in County Dublin and this reflects a well attended training course hosted by Dublin City Council linked in with the Dodder Action Group. County Monaghan, had only one survey team. Another recruitment drive is required to target County Monaghan in 2016. In addition, a recruitment drive is required for Armagh, Down, Fermanagh, south Roscommon, south-east Limerick, east Laois and north-east Louth.

4.3.3 Dataset & Distribution

The 2015 dataset consisted of 20,635 Daubenton's bat passes. Daubenton's bat was recorded on the majority of waterway sites surveyed in 2015, thus re-confirming this species' wide distribution on linear waterways across the island. Daubenton's bats were recorded in every county surveyed 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.

4.3.4 Yearly Trends

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 2015 and can be compared with the Poisson model which has wider error bars and a slightly more fluctuating trend. However, the Poisson method is also reported as it is comparable with BCT reporting.

GLM/GAM analysis 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, in 2011 and 2012, the poor summer weather, especially in August continued to impact on the level of Daubenton's bat activity. In 2013, summer weather conditions were relatively better compared to previous years but the number of Daubenton's bat passes recorded in 2013 was lower compared to some previous years of the survey. The downward trend continued in 2014. Daubenton's bat showed a slight increase in 2015 and the current trend is therefore considered to be stable overall.

Overall the smoothed index (Possion Model) is currently 2.82% above the 2007 base year value which is equivalent to an average 0.35% annual increase. This is comparable to the trend data from the BCT National Bat Monitoring Scheme. The smoothed index reported by the BCT is currently 4.6% above the 1999 base year value, equivalent to an average annual increase of 0.3%. The trend has remained stable since monitoring began in 1999. There has been no significant change in the smoothed index since the base year.

In relation to the large number of waterway sites surveyed over the ten years of the monitoring scheme (n=556), only 395 of these sites have been surveyed for more than one year. The robustness of the scheme would be greatly improved if waterway sites only surveyed for one year were re-surveyed in subsequent years. In 2015, BCIreland further targeted some of these sites and allocated six waterway sites with only one year of surveying to new volunteer teams and reallocated a further 26 sites that were in need of new volunteer teams, thereby increasing the robustness of the data. BCIreland will continue to target such waterway sites in 2016 to improve the usefulness of data already collected in previous years of the scheme. There are currently 158 waterway sites that have been surveyed for one year only with counties such as Cork, Kildare, Wicklow, Galway, Carlow, Westmeath and Donegal with a high number of waterway sites in need of a second year of surveying. In addition Counties Monaghan, Armagh, Down, Limerick and Clare require more volunteer teams. BCIreland will endeavour to organise training courses in these counties in 2016.

4.3.5 Ten Years On

The Daubenton's monitoring scheme, in its ten years of operation, has provided training and/or an opportunity for 623 survey teams to participate in bat surveying. This means that over 1200 people have actively engaged in bat conservation, the majority of whom are members of the general public. As a consequence, this monitoring scheme has greatly increased the awareness of bat conservation across the island.

Unfortunately, 50% of the teams have only participated for one year which is an element that BCIreland needs to address. BCIreland needs to explore ways to encourage teams to continue to participate.

The number of waterways sites and island coverage is high and widespread, respectively. BCIreland shall continue to ensure that there is a large number of training courses available annually and that there is accessibility to such training for as many community groups as possible. BCIreland shall continue to liaise with Heritage Officers, Biodiversity Officers, NPWS, NIEA, wildlife groups and Tidy Town groups in relation to organising training courses and local advertisement of such.

5.0 BROWN LONG-EARED BAT ROOST MONITORING SCHEME

5.1 Methods

The Brown Long-eared Roost Monitoring Scheme methodology was designed by BCIreland. For a full description of the Preliminary Roost Assessment and Survey Methodology, see Aughney *et al.*, 2011.

5.1.1 Annual Roost Counts

Suitable roosts are monitored yearly by either Internal counts (2 counts) or External Emergence Dusk Counts (2-3 counts) during the specified survey periods (See Table A3.1, Appendix 3). In general, buildings with no access to the roof space are surveyed by Emergence Dusk Counts only. Buildings with exit points too high to clearly see emerging bats (i.e. greater than two floors high) are monitored using Internal Counts if the roof space is accessible. Not all individual brown long-eared bats leave the roost site every night, especially during poor weather conditions (Entwistle *et al.*, 1996) therefore internal validation is completed post emergence survey where possible. Buildings with both access to roof space and visible exit points are assessed by whichever method can be used with greatest ease and that results in reliable roost numbers.

Dates for survey periods are as follows: Survey 1: 16th May to 15th June; Survey 2: 16th June to 31st July & Survey Period 3: 1st August to 30th August. Volunteer survey teams are encouraged to adhere to these survey dates, where possible.

Internal counts are undertaken by a licensed surveyor and counts are completed during the day using a red-light torch. The entire internal space of the roost is examined and individual brown long-eared bats are counted. Emergence Dusk Surveys are completed using bat detectors with surveyors located at all known exit points from the roost. Surveys begin 20 minutes after sunset and continue until no bats exit the building for a full ten minutes of surveying.

On completion of surveys, survey forms are returned to BCIreland for analysis and reporting.

5.1.2 Statistical Analysis

To assess trends a Generalised Linear Model (GLM), with confidence limits based on bootstrapping at the site level, was applied to the 2007-2015 data. To allow for differences between Internal Counts and external Dusk Emergence Counts, and between the different survey periods (S1, S2 and S3), all counts for roosts monitored for at least two years, are included in the model.

The effects of Northings and Eastings, day number (i.e. survey date), weather data, start time, and internal/external counts were examined using a Generalised Linear Mixed Model (GLMM). The trend was smoothed using GAM smoothing and the yearly estimates were expressed as an index with 2008 as the base year. The models use a negative binomial distribution, rather than the Poisson distribution previously used (and as used for the GLMM), as it fitted the data better and gave slightly more precise results. The models were completed with and without covariates for drizzle/rain, for internal counts before mid-May and for external counts after mid-September.

5.1.3 Bat Droppings

As part of a larger project, BCIreland collected bat droppings of brown long-eared bats at known brown long-eared roosts, the majority of which are part of this monitored scheme. These droppings were collected for UCD's Bat Lab as part of their on-going project to establish a genetic bank for Irish bats species. Sterile containers were supplied by the Bat Lab.

5.2 Results

5.2.1 Volunteer Participation

For volunteer teams, training was provided on-site, with the scheme co-ordinator and new volunteer teams completing the first count together. Bat detectors and torches were provided by BCIreland, where required. In addition, the co-ordinator accompanied some volunteer team counts during the first survey of each new monitoring year to provide continued support. Forty six building roosts were surveyed in 2015, 25 of which were monitored by volunteer teams and/or roost owners. In total, 48 volunteers and four roost owners participated in the monitoring scheme in 2015.

The Kildare Bat Group was allocated three buildings to monitor. The Clare Bat Group, Cork County Bat Group, Wicklow Bat Group and the Galway Bat Group monitored one roost each while The County Waterford group and the Wexford Bat Group monitored three roosts each. Three roost owners participated in the scheme in 2015 while a further 10 roosts were monitored by seven additional volunteer teams. All other roost counts were completed by the co-ordinator of the scheme (n=21) with assistance from Giada Giacomini, an Italian Erasmus student.

5.2.2 Monitored Roosts in 2015

Brown long-eared roosts monitored in 2015 were distributed in 20 counties, the highest number of roosts was located in County Cork (n=7) and County Cavan (n=7). Six roosts, proposed to be monitored in 2015, were not completed due to time constraints, including the single roost representing County Limerick (Figure 5.1). Two new roosts, verified as suitable for inclusion in 2014, were monitored in 2015 (Counties Donegal and Cavan). In total there are 52 roosts currently registered for monitoring and these are distributed across 21 counties. The counties currently with no brown long-eared roosts are Counties Louth, Westmeath, Carlow, Leitrim and Monaghan. The Midlands Bat Group will be investigating potential buildings in County Westmeath in 2016.

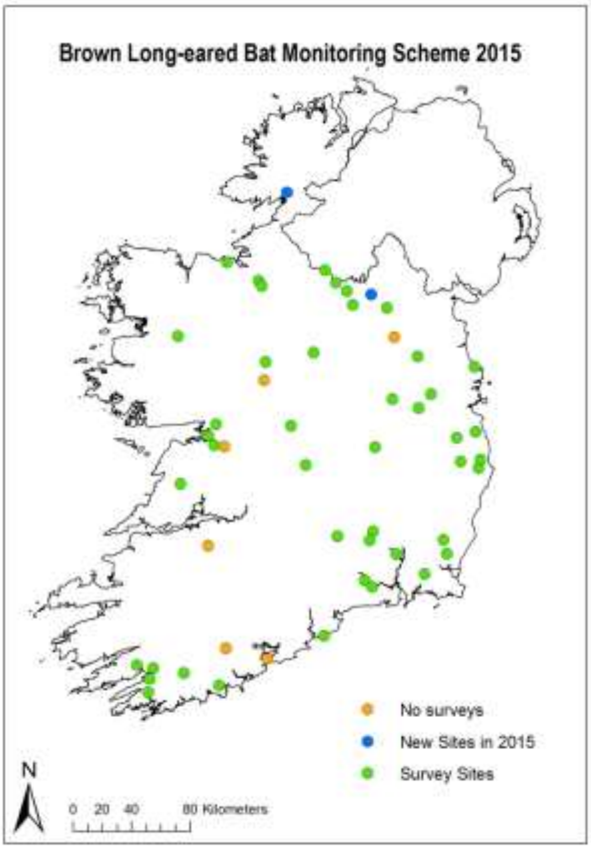

Figure 5.1: Brown long-eared roosts surveyed in 2015 as part of the Brown Long-eared Bat Roost Monitoring Scheme. Green circles = Roosts monitored in 2015; Blue circles = New roosts monitored in 2015 and Orange circles = Roosts not monitored in 2015.

The majority of roosts were surveyed by external Dusk Emergence Counts (n=35) while eight roosts were surveyed by Internal Counts (Figure 5.2 & Table A3.6, Appendix 3). Three roosts were surveyed by both Internal and Emergence counts.

The buildings surveyed included churches, houses, agricultural barns, large buildings/mansions and a category named “other” to represent a medieval tower and 12th century stone structure. The majority of the buildings surveyed were churches (Figures 5.3 & 5.4).

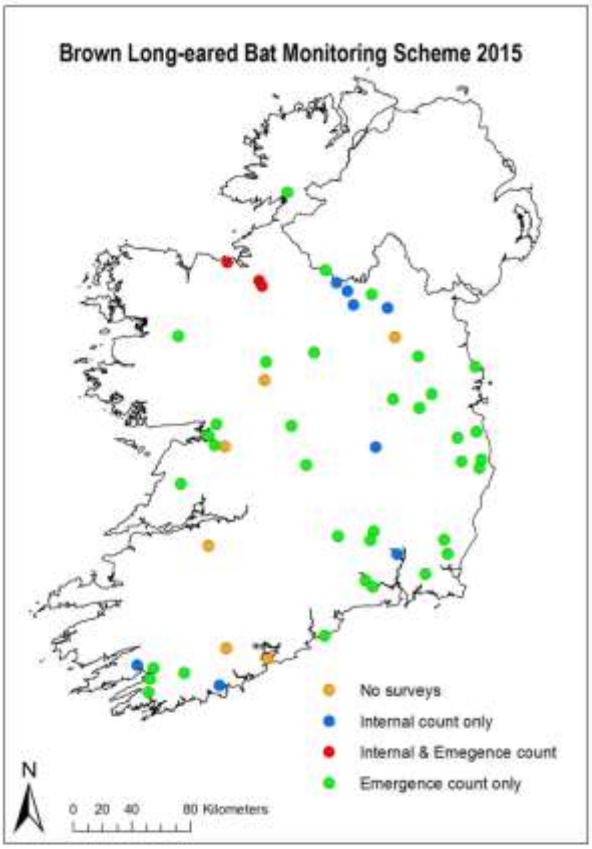

Figure 5.2: Type of Brown long-eared roosts surveys in 2015. Red circles = Emergence and Internal count; Blue Circles = Internal count only; Green circles = Emergence surveys only; Orange circles = Roost not monitored in 2015.

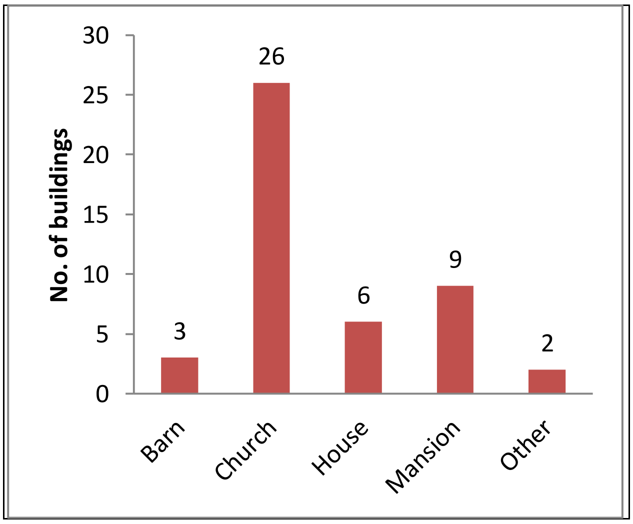

Figure 5.3: Type of buildings monitored in 2015.

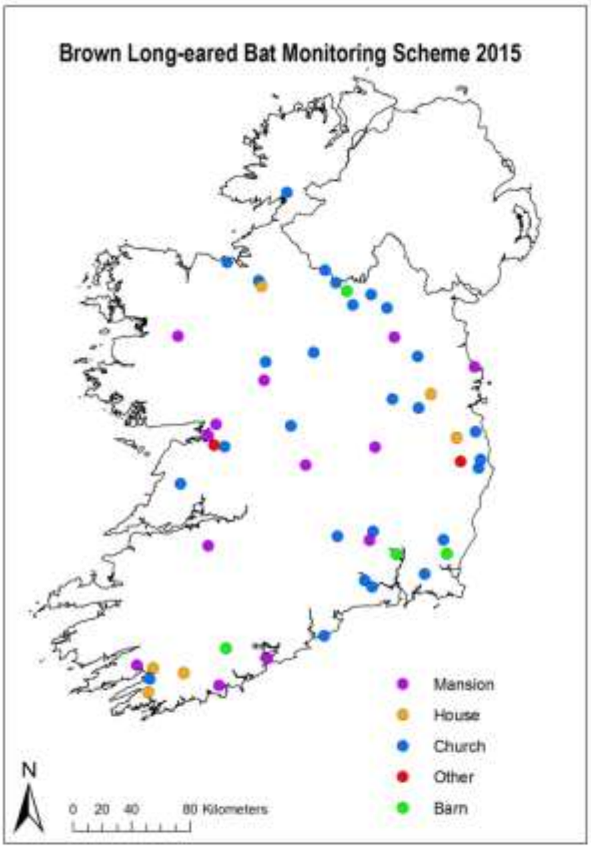

Figure 5.4: Type of buildings surveyed in 2015. Green circles = Barn; Blue circles = Church; Red circles = Other; Purple circles = Mansion/Large Building and Orange = House.

In 2015, a total of 1,657 individual bats were counted in the 46 roosts monitored. This is the second highest total over the nine years of the scheme. The mean number of bats per roost in 2015 was 30.62 individuals and the median was 29 individuals.

5.2.3 Monitored Roosts 2007-2015

The Brown Long-eared Bat Roost Monitoring Scheme was introduced in 2007 and continued until 2010. There was no funding available in 2011 to implement the scheme, but during this season, volunteer teams undertook a minimum of one survey at 34 roosts to ensure continuity in the data until additional funding was sought. The scheme was reinstated in 2012.

Over the nine years, a total of 71 buildings were monitored. Some buildings are no longer being monitored due to roost abandonment, roost renovation works and/or changes to the habitat adjacent to the building (e.g. removal of hedgerow preventing bats from commuting to/from the building. A total of 707 surveys have been undertaken to-date.

Table 5.1: Number of roosts monitored and surveys completed for each year of the Brown Long-eared Roost Monitoring Scheme 2007-2015.

Survey Year	Roosts	Surveys
2007	17	27
2008	35	55
2009	40	77
2010	43	92
2011	34	36
2012	40	91
2013	49	111
2014	47	111
2015	46	107

Nine roosts have been monitored for each of the nine years of the scheme while 12 buildings have data for one year only (See Table 5.2).

Table 5.2: Number of years of data for each roost monitored in 2007-2015 as part of the Brown Long-eared Roost Monitoring Scheme.

Number of years	Number of sites	% of total
1	12	17.1
2	6	8.6
3	7	10.0
4	8	11.4
5	4	5.7
6	4	5.7
7	10	14.3
8	10	14.3
9	9	12.9

The majority of surveys were completed by External Dusk Emergence Counts (n=508, 71.8%) compared to Internal Counts (n=199, 28.2%), see Table A3.4a, Appendix 3 for more details). From 2011 to 2015 the external Dusk Emergence Count was the preferred method of survey as this was shown by statistical analysis to be a more reliable method to collect information for this monitoring scheme (Aughney *et al.*, 2011). As shown in Figure 5.5, the percentage of roosts monitored by Internal Counts has reduced from year to year. In 2007, 47% of roosts were monitored by Internal Counts while in 2015, this figure decreased proportionately to 16%. See Table A3.6a,b, Appendix 3 for more details.

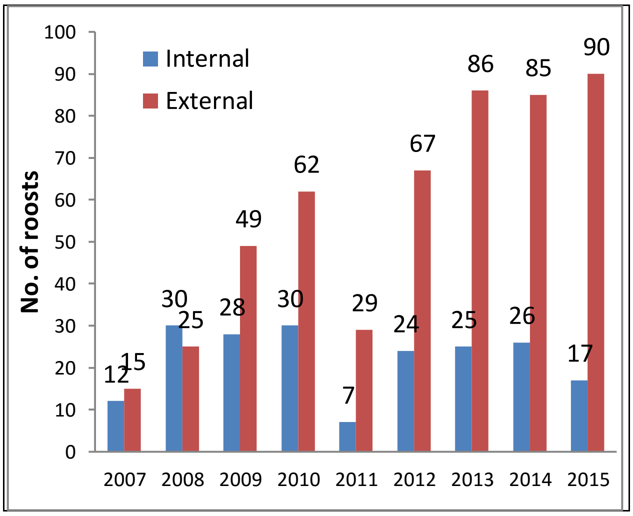

Figure 5.5: Type of survey completed in 2007-2015 as part of the Brown Long-eared Roost Monitoring Scheme.

5.2.4 Statistical Analysis

The effects of Northings and Eastings, day number (i.e. survey date), weather data, start time, and Internal Counts/external Dusk Emergence Counts are examined annually using a Generalised Linear Mixed Model (GLMM). From analysis of the 2007-2015 dataset, two terms were statistically significant or close; start time and daily temperature. In previous years, terms that were significant included survey period, weather conditions and type of survey (internal versus external roost counts). But these parameters are having less of an influence as the monitoring scheme progresses and surveys are surveyed in a more standardised manner (e.g. strictly adhering to completing surveys in the three set survey periods and surveying in good weather conditions).

Surveyors note the start time of the survey and are encouraged to undertake surveys 20 minutes after sunset. A sunset table was compiled for each roost and this table was sent to each survey team. Results indicate that start time is borderline significant in relation to its influence on mean counts (chi-squared = 4.62 with 1 d.f., P=0.032) with a positive coefficient. However, it is not significant when expressed relative to sunset, so it is suspected that this may be a seasonal effect, indicating numbers tend to be higher in mid-summer which has been reported that case in previous statistical analysis.

Types of survey (Internal Counts versus External Dusk Emergence Counts) were also included in the analysis because in the 2010 analysis it appeared that External Dusk Emergence Count data were significantly higher compared to Internal Count data (Aughney *et al*., 2011). While the type of survey does not have a significant influence on mean counts for this reporting period (F = 0.05 with 1 and 453 d.f., P=0.832, See Table A3.5b, Appendix 3 for more details), the analysis indicates that there are signs of an interaction between it and Survey Period (See Table A3.6, Appendix 3 for more details).

While surveyors recorded weather data, data is also received by Met Eireann for analysis. The daily maximum temperature from the Met Eireann dataset is now close to statistical significance (chi-squared = 3.30 with 1 d.f., P=0.070) indicating that there are slightly more bats at higher temperatures, after allowing for the other variables in the model.

5.2.5 Yearly Trends

Results from a GAM model, expressing the trend as an index with 2008 as the base year, is shown in Figure 5.5 (See Table A3.7, Appendix 3 for more details). The models use a negative binomial distribution, rather than the Poisson distribution used previously (and as used for the GLMM), as this seemed to fit the data better and gave slightly more precise results.

The models have been fitted with and without covariates for drizzle/rain, for Internal Counts before mid-May and for external Dusk Emergence Counts after mid-September. The model with covariates is slightly more precise (i.e. narrower confidence limits). Other than the slight difference in precision, results are similar with and without covariates, with an initial increase followed by stable results for the last couple of years. The index is currently significantly above the baseline value for 2008, as indicated by the fact that the confidence limits on the smoothed curve do not enclose 100. However there is a slight decrease in relation to previous years of monitoring.

Overall the smoothed index using the model with covariates is currently 15.1% above the 2008 base year value which is equivalent to an average 2.03% annual increase (Figure 5.6). This is comparable to the trend data from the BCT National Bat Monitoring Scheme. The smoothed index reported by the BCT for brown long-eared bat roost counts (n=157 roosts) is currently 28.2% above the 2001 base year value, equivalent to an average annual increase of 1.8%. The trend has fluctuated since monitoring started, and is currently increasing. However the confidence intervals of the BCT trend have always overlapped with the index value of the base year meaning that the change has not been significant.

In previous years the trend from the Irish roost monitoring surveys was similar to that derived from Car-based Bat Monitoring data. However in 2015 the Car-based Bat Monitoring Scheme indicated a decrease in brown long-eared bat encounters while the trend from the roost monitoring is more stable. Error bars are much wider for Car-based Bat Monitoring data, however, since this scheme only picks up social calls of relatively few brown long-eared bats during July and August roadside surveys. In total, just seven brown long-eared bat passes were recorded from 790 x 1.6km transects across Ireland in 2015, compared with over 1600 individuals counted from 46 roosts during the Brown Long-eared Bat Roost Monitoring Scheme.

5.2.6 Biometrics

Genetic analysis of brown long-eared bat droppings collected in the 2015 summer season indicated that fresher droppings were required for analysis as the DNA material was too degraded. Therefore, a different bat dropping collection protocol was decided during a meeting with Dr. Emma Teeling in March 2016.

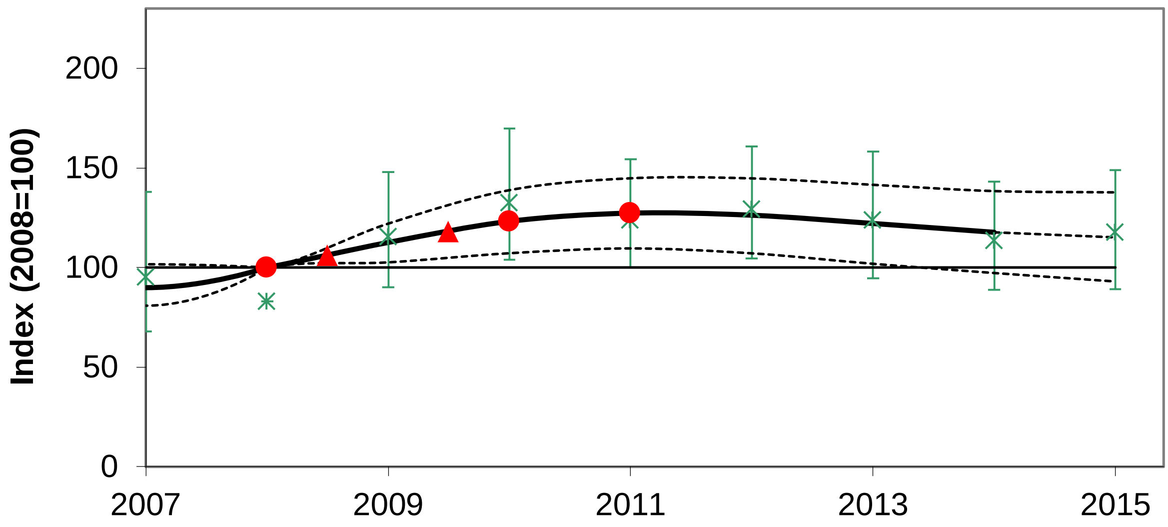

Figure 5.6: GAM curves with covariates. The black line is the smoothed GAM curve, with 95% confidence limits shown by the black dotted lines. Green points are estimated annual means and are shown to illustrate the variation about the fitted line.

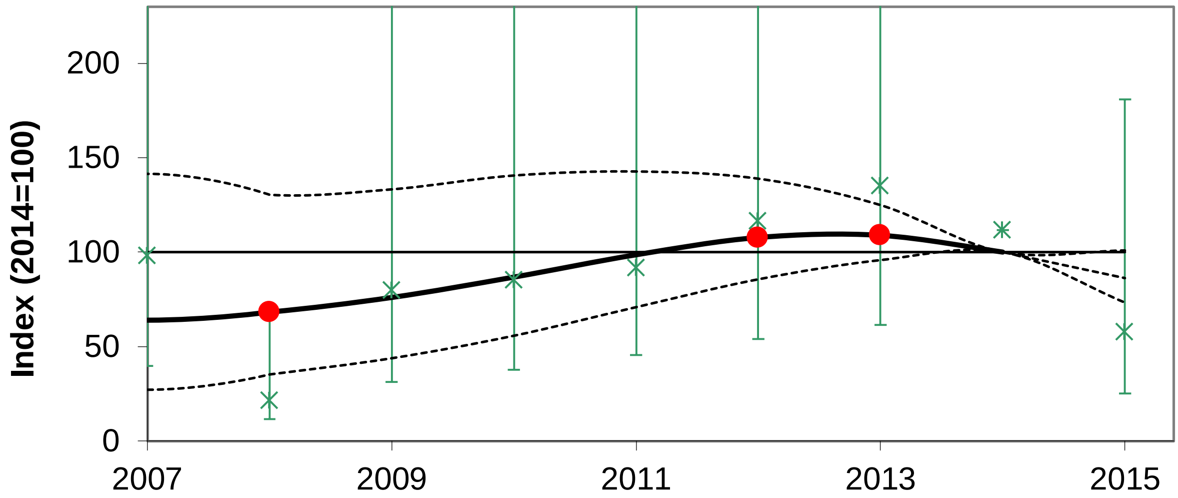

Figure 5.7: Results of Binomial GAM/GLM model for brown long-eared bat passes per survey, Car-based Bat Monitoring Scheme. The response variable is the proportion of one mile transects with the species present. Results are expressed as an index of 2014 values (since no brown long-eared bats were recorded in the second year of the survey). The trend line is, therefore, fitted 'backwards'. Points are estimated annual means derived from the Binomial GLM. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2014-2015 and the possibility that the slope will change with coming years' data.

.5.3 Discussion

5.3.1 Volunteer uptake

The main function of the co-ordinator in relation to volunteer teams is to ensure that the roosts that are assigned and monitored by these teams are suitable and that the volunteers are fully trained in the survey methodology. Volunteers recruited for this monitoring scheme need to have some experience in identifying bats using bat detectors. Therefore, there is a small potential pool of volunteers within the country with sufficient expertise available to participate in the scheme. However, teams organised to-date have carried out the counts very successfully, especially when they have been trained in situ by the co-ordinator and a team leader is assigned to organise survey dates, collate survey results and return datasheets to BCIreland. Working closely with local bat groups has also proven to be very effective and should continue for any future monitoring of brown long-eared bats.

Twenty seven (54.35%) of the roosts were monitored by volunteer teams in 2015. This number has remained stable over the last few years. Therefore, 2015 continued to be successful in recruiting additional teams, adding to the cost-effectiveness of the scheme. In addition, the majority of teams participating in the scheme have done so since 2007, greatly increasing the robustness of the data collated.

5.3.2 Survey Coverage in 2015

The second highest number of completed surveys was achieved in 2015 compared with all previous years of the survey. Currently, there are roosts being monitored in 21 counties across the country with a new county added to the mix in 2015 i.e. County Donegal. BCIreland aims to investigate further roosts in County Westmeath where there are currently no roosts being surveyed.

BCIreland will continue to carry out further volunteer recruitment with the aim of having more than 75% of roosts monitored by volunteer teams and roost owners. Volunteers participating in other monitoring schemes and people who have attended bat detector workshops will be contacted to determine their interest in joining a local team to monitor a roost within their county. This will help ensure that the scheme can continue to be carried out cost-effectively.

The participation of roost owners in the monitoring scheme has proven to be a very successful way of gathering data. It encourages roost owners to take a greater interest in their bat roosts and to contribute to the conservation of this species. It has also provided BCIreland with a valuable opportunity to answer queries with regard to bats roosting in housing. BCIreland will continue to encourage and assist roost owners with monitoring of their own roosts.

5.3.3 Dataset & Distribution

Roosts were not chosen at random, due to the constraints of locating suitable roosts for surveying. However, the current roost dataset covers a good geographic range across 21 counties. It would, however, be desirable to ensure that the entire geographic spread of the species in the country is covered by the scheme in the coming years so BCIreland proposes to identify additional brown long-eared roosts in the remaining counties of the Republic of Ireland. Currently there are gaps in the location of monitored roosts, principally Counties Louth, Westmeath, Leitrim, Carlow and Monaghan.

The 2015 dataset consisted of 107 surveys of 46 roosts. Taking the highest count for each roost, a total of 1657 individuals were counted in 2015. While the dataset accumulates annual data for a specific set of sites, new roosts are continuously sought thereby adding new distribution data to the BCIreland database. Two new roosts were identified in 2015 and added to the monitoring scheme. An additional three roosts were investigated but only one will be surveyed in 2016.

5.3.4 Statistical Analysis

Statistical analysis undertaken in 2011 indicated that Dusk Emergence Counts resulted in more reliable data compared to that collated by Internal Counts (Aughney *et al.,* 2011). As a consequence, where possible, Dusk Emergence Counts are the preferred survey method for this monitoring scheme. Since 2011 more than 75% of roosts monitored were surveyed by this preferred method with 84% of surveys competed by Dusk Emergence Counts in 2015. This type of survey requires more volunteer teams and time but it is proving manageable at present.

The timing of the surveys has a significant influence on mean counts. While the surveyors are encouraged to survey within the time frame specified, occasionally, due to weather factors etc., surveys are completed outside the specified dates. BCIreland will continue to emphasise the importance of completing as many of the surveys as possible within the recommended Survey Periods in addition to completing at least two counts at each roost.

In 2015, the majority of surveys were completed during good weather conditions. However, occasionally weather conditions change during the survey and this has been shown to reduce the mean counts. BCIreland will continue to emphasise the importance of completing surveys on nights where weather is forecasted to remain dry for the entire survey.

Volunteers are also instructed to ensure that start times of Dusk Emergence Surveys are completed 20 minutes after sunset. This term was borderline significant in the 2015 analysis. Therefore BCIreland will continue to provide sunset time tables for volunteer teams to ensure that start times are as accurate as possible.

5.3.5 Yearly Trends

Results from a GAM model, expressing the trend as an index with 2008 as the base year indicates that there was an increase from 2008 followed by stable results for the last couple of years. The index is currently above the baseline value for 2008 with a slight decrease in 2015. It is of interest that brown long-eared bat trends observed during car-based bat monitoring recorded a greater dip in numbers in 2015.

The stable trend is an encouraging outcome from the first few years of the survey. This suggests that trends from the data scheme are being derived independently of mobility between roosts. Trends from the BCT NBMP also indicated increasing population figures from the first few years of the survey followed by a slight decline from 2007-2009 with a stable increase over the last few years (www.bats.org).

6.0 LESSER HORSESHOE BAT ROOST MONITORING SCHEME

6.1 Methods

Surveyors were trained in survey methodology prior to BCIreland's involvement in the scheme (which began in November 2013). Surveyors are provided with equipment needed for the survey by the NPWS or Vincent Wildlife Trust (VWT).

Each year survey teams complete surveys of specific sites within their district. Surveys take place in summer from dusk and are carried out using bat detectors. Some sites are counted internally. The dates for surveying in summer are May 23rd to July 7th, although counts outside these dates are included in the overall trend series. Winter surveys are carried out in January and February each year.

A field meeting with regional NPWS and VWT staff who carry out the lesser horseshoe bat counts was held in Limerick in January 2016. During this meeting the issue of roost conservation measures was discussed.

Data was provided in Excel spreadsheets by NPWS regional staff for summer 2015 and winter 2016. These data were cleaned, queried (where necessary) and imported to the database using the Excel to Access Import function in MS Access.

Some modifications were made to the Access dataset on the basis of discussions with Jochen Roller, NPWS.

- LHB database Recorder upload Nov15_NRComments_v2.docx

Any further modifications made to site names, grid references and other details as discussed with NPWS regional staff is detailed in

- LHBdatabase_recordofchanges.doc.

6.1.1 Statistical Analysis

For overall yearly trends, a Generalised Linear Model (GLM) with a Poisson error distribution (see Glossary) was applied to the data. Confidence intervals are generated by bootstrapping (Fewster *et al*., 2000), as used in Generalised Additive Model (GAM) analysis.

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.

This year we also examined yearly trends in Vincent Wildlife Trust reserve sites, as well as trends in the dataset with data from VWT sites removed. This was done to determine the extent of the impact of these sites on the overall trends.

6.2 Results

6.2.1 Monitoring Dataset

Following requests for data that were circulated to the regions, the following survey records were sent to BCIreland and added to the main database.

Year	Season	Sites	Counts
2015	Summer	94	128
2016	Winter	85	96

These records include null counts where no access was possible and multiple counts in the same season at some sites.

The number of records on the database currently stands at 4,308 but this includes some records for other species and data that cannot be used in trend analysis due, for example, to insufficient information in the CorrectDate field.

Data for 2015 and 2016 received from the NPWS and VWT was of a very high standard and had very few issues that needed to be queried, thus ensuring efficient processing and importing.

For summer 2015, 129 discrete survey records were provided. At twelve of these, lesser horseshoe bats were absent. Three of these zero count sites are located in Co. Limerick and five in west Cork. Counts were carried out at 94 sites (i.e. dual counts were carried out at seven sites). In total, a maximum of 9,273 bats were counted during the summer in 2015 at these 94 sites. The maximum count at any one site was of 460 bats at the VWT site William King, Kilgarvan, Killarney, (Site Code 522) on June 15th 2015. Overall, the mean summer roost size was 98.7 and median roost size was 59.5 in 2015.

In winter 2016 counts were carried out at 85 sites with additional repeat counts conducted at five sites. The sum of maximum counts for all 85 sites in winter 2016 was 5,736. The maximum number of bats recorded in a single hibernacula was 540 in Kilkishen House (Site Code 27), although it should be noted that counts for Newgrove (Site Code 56) in 2016 had well exceeded this but details had not been submitted to BCIreland prior to statistical analysis being carried out. The mean number of bats per winter site was 66.7. Counts at 80 sites contributed to the winter trend analysis because some sites had no bats. Sites are only included in the monitoring scheme when lesser horseshoe bats have been recorded at the site at least once and where counts have been carried out at a site in at least two years.

6.2.2 Winter Trends

To contribute to the winter trend analysis a site must have had the species present at some point and must be counted in at least two years. The average date of observation does vary between years and average counts vary with the observation date, so this is allowed-for in the analysis.

Data from surveys conducted between 26th December and 7th March were used. Roche *et al.* (2012) highlighted the effect of day number during the survey period on mean winter counts with numbers falling off towards spring. In order to account for this, a linear trend with day number in the survey period is used below.

For the 2012 report (Roche *et al.*), 2009 was used as the base year and this has been retained in the current analysis, as it has one of the biggest sample sizes. The fitted curve has six degrees of freedom; this is rather less than the default suggested by the Fewster *et al.* (2000), but seems sensible given that, while there is a long run of data, the sample size is small for many of the earlier years.

Results are shown below in Figure 6.1 and Table 6.1. There was a fairly consistent increase in winter counts from 1990 onwards which levelled out between 2003 and 2010. More recently, since 2012, we have seen consistent and significant increases.

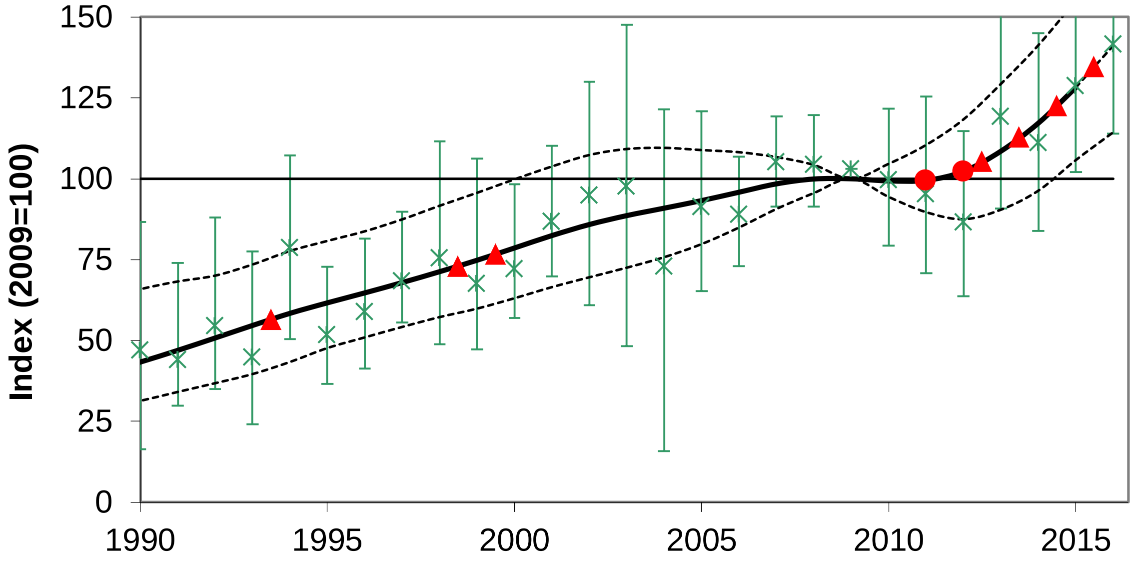

Figure 6.1: Results of the GAM/GLM model for lesser horseshoe **hibernation** data. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2015-2016 and the possibility that the slope will change with coming years' data. Red circles indicate significant ($p<0.05$) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant ($p<0.05$).

Table 6.1: GAM results for winter counts of lesser horseshoe bat sites with 95% confidence limits.

	smoothed		95% limits		unsmoothed			
year	**index**	**s.e.**	**lower**	**upper**	**fit**	**s.e.**	**sites**	**counts**
1986	31.77	11.40	19.33	61.70	36.81	13.49	16	17
1987	34.11	10.32	22.10	61.17	24.16	10.74	10	14
1988	36.83	9.51	25.41	60.64	34.41	9.06	16	17
1989	39.94	8.69	28.87	62.63	47.34	9.95	3	3
1990	43.33	8.73	31.33	65.86	44.06	17.70	5	7
1991	46.96	8.62	34.10	68.25	41.12	10.86	5	7
1992	50.78	8.76	36.80	70.05	51.60	13.44	9	12
1993	54.66	8.98	39.63	73.50	41.75	13.96	13	15
1994	58.40	8.99	43.37	77.68	75.69	15.39	34	38
1995	61.65	8.66	47.67	80.79	48.74	9.55	12	16
1996	64.72	8.42	50.96	83.77	55.86	10.10	16	16
1997	67.92	8.63	54.20	87.46	65.49	9.06	20	21
1998	71.28	9.18	57.24	91.67	72.45	16.69	6	6
1999	74.82	9.63	59.86	95.66	64.62	15.71	12	13
2000	78.61	9.82	63.07	99.84	69.21	11.11	12	12
2001	82.44	9.89	66.51	103.81	83.75	10.28	25	25
2002	85.86	9.90	69.55	107.35	91.92	16.95	9	9
2003	88.62	9.62	72.52	109.20	94.76	25.92	9	10
2004	90.92	8.81	75.76	109.56	70.01	29.84	8	10
2005	93.26	7.54	79.82	108.87	88.30	14.17	12	21
2006	95.85	5.95	84.94	108.22	86.02	8.72	82	83
2007	98.43	4.18	90.67	106.71	102.29	7.04	46	46
2008	99.93	2.23	95.59	104.28	101.33	7.09	49	49
2009	100.00	0.00	100.00	100.00	100.00	0.00	87	92
2010	99.34	2.59	94.39	104.64	96.66	10.79	84	91
2011	99.51	5.27	89.68	110.47	92.27	14.07	86	93
2012	102.29	7.83	87.51	118.38	83.57	13.14	77	85
2013	108.54	10.05	90.44	129.36	116.21	16.08	86	89
2014	117.22	11.57	96.33	141.32	108.21	15.48	94	99
2015	128.25	12.66	105.77	155.20	125.69	15.38	96	103
2016	141.15	14.32	114.38	170.02	138.66	16.09	80	86

6.2.3 Summer Trends

The results presented here use the full May to August period, with a covariate to adjust for the linear effect of day number in the year. The GAM curve is fitted with six degrees of freedom. As for hibernation trends, the data showed significant increases in early years of the survey, although from 2005-2013 numbers were relatively stable with error bars encompassing the baseline. More recently, the trend has curved upwards mimicking the winter data, albeit on a shallower trajectory. This year the lower error bars were just slightly higher than the 2009 baseline.

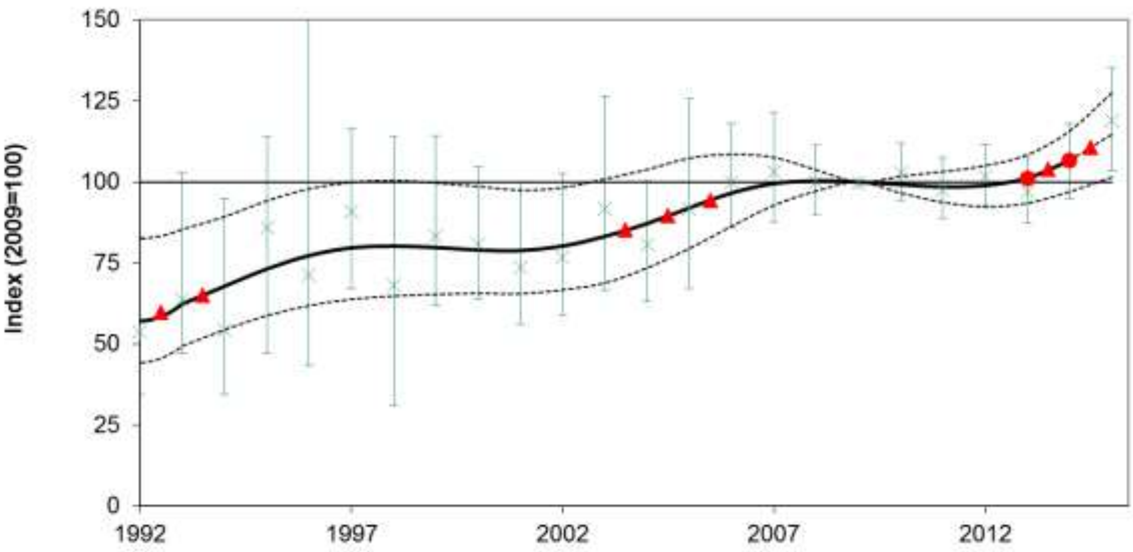

Figure 6.2: Results of the GAM/GLM model for lesser horseshoe **summer** data. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2014-2015 and the possibility that the slope will change with coming years' data. Red circles indicate significant ($p<0.05$) change points, where the slope of the smoothed trend line changes. Red triangles indicate that the difference in the smoothed index between consecutive years is statistically significant ($p<0.05$).

Table 6.2: GAM results for summer counts of lesser horseshoe bat sites with 95% confidence limits.

	Smoothed		95% limit		Unsmoothed			
year	**index**	**s.e.**	**lower**	**upper**	**fit**	**s.e.**	**sites**	**counts**
1992	57.13	10.14	44.29	82.54	54.05	12.85	12	16
1993	62.39	9.48	49.41	85.45	63.86	14.51	11	24
1994	67.87	9.14	54.44	89.29	54.73	16.20	9	12
1995	73.18	9.13	58.78	94.20	86.07	16.01	15	19
1996	77.31	9.17	61.89	97.87	71.45	71.38	3	3
1997	79.69	9.19	63.83	99.91	91.16	12.23	25	33
1998	80.23	8.99	64.83	100.49	68.44	20.94	20	26
1999	79.81	8.67	65.34	99.70	83.67	13.30	59	79
2000	79.03	8.30	65.65	98.66	81.08	10.49	37	41
2001	78.85	8.16	65.54	97.49	73.92	11.17	29	49
2002	80.24	8.14	66.73	98.26	77.16	11.44	37	42
2003	83.21	8.08	68.87	100.94	92.13	14.94	24	36
2004	87.20	7.76	73.48	103.86	81.03	9.53	45	55
2005	92.01	7.00	79.49	107.36	91.96	15.00	25	32

2006	96.60	5.70	86.37	108.53	100.13	8.22	119	126
2007	99.52	3.85	92.81	107.56	103.55	8.69	87	102
2008	100.35	1.69	97.21	103.77	100.24	5.36	71	89
2009	100.00	0.00	100.00	100.00	100.00	0.00	121	151
2010	99.24	1.29	96.62	101.72	103.23	4.35	50	70
2011	98.54	2.38	93.76	103.19	97.74	4.88	103	131
2012	98.95	3.18	92.38	105.06	101.90	4.96	98	131
2013	101.24	3.82	93.45	108.41	97.23	5.20	107	129
2014	106.68	4.80	97.02	115.73	106.57	5.85	111	145
2015	114.68	6.53	101.50	127.53	119.09	7.97	89	115

6.2.2 VWT Sites

Trends at the VWT sites were modelled separately, and trends in all sites minus VWT data were also examined. VWT sites tend to have substantially larger than average roost numbers in summer, compared with the overall dataset. Winter sites were examined but data are only available from seven VWT sites that have winter counts so a comparison of winter sites was not considered useful.

Comparison of summer data is shown below.

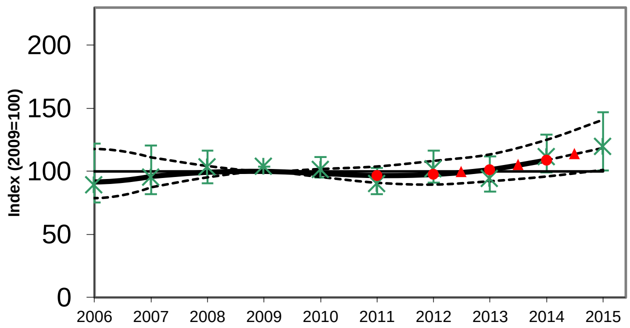

Figure 6.3: Results of the trend model for lesser horseshoe **VWT summer data** (n=12 sites).

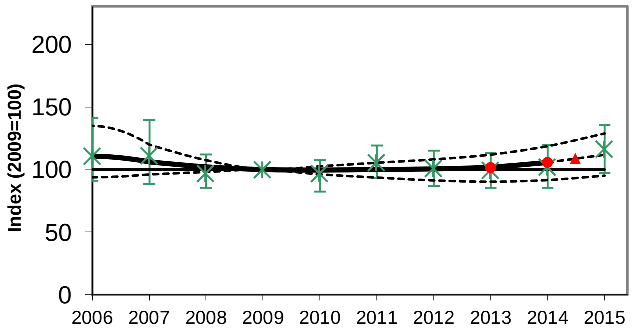

Figure 6.4: Results of the trend model for lesser horseshoe **summer data without VWT sites** (n=125 sites).

These two figures show that the trends since 2006 have been similar in summer, whether looking at the VWT sites alone, or all sites without VWT data. However, there has been a less significant increase in the dataset without VWT sites in the past few years. This difference is not significantly different (randomisation test P=0.380), however.

6.3 Discussion

6.3.1 Survey Coverage in 2015 and 2016

Excellent coverage was achieved in both summer 2015 and winter 2016. Both seasons have contributed a huge body of information to the dataset. Consistent year-on-year surveying means that annual trends are more reliable and precise.

6.3.2 Yearly Trends

According to the trend models the lesser horseshoe bat increased significantly from the early years of the survey in the early 1990s. While some caution is needed when interpreting trends from early years due to low sample sizes, we can be reassured by the fact that summer and winter trends have tended to converge, increasing up to the early 2000s, levelling out somewhat in the mid-2000s and more recently increasing again. Recent summer increases have somewhat lagged behind those observed from winter counts.

Overall in Ireland – over the past 20 years, from the GAM smoothed model, the species increased by between 61% (summer) and 118% (winter). The UK NBMP reported a difference in the extent of increase recorded by winter versus summer counts. Between 1997 and 2011 the population change was 104% from winter counts and 67.4% from summer counts (BCT, 2012).

The yearly trend over the past six years in Ireland has been for a 7.2% annual increase in winter sites and a 2.9% yearly increase in summer sites. This mirrors the current situation in Britain where hibernation and summer trends have recently diverged for the species (S. Langton *pers. comm.*).

The suite of Vincent Wildlife Trust reserves that are located across the lesser horseshoe bat's range in Ireland are well maintained and may be expected to show increases above those observed at other non-VWT roosts. Our analysis shows that the mean number of bats at these sites is substantially higher than the mean in roosts across the island. Since 2006, summer trends at these 12 VWT sites have shown a slightly steeper increase than the remaining dataset, however, the difference between trends in the VWT and non-VWT datasets is not statistically significant.

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7.0 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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● All Ireland Daubenton's Bat Waterway Monitoring Scheme
● Brown Long-eared Bat Roost monitoring Scheme (Republic of Ireland)

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APPENDIX 1

Car-Based Bat Monitoring

Table A1.1: Average number of bat encounters per hour for each survey square, Survey 1, 2015 (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	Pnath	Leislers	BLE	Myo	Total
C72	12.25	13.27	3.06	1.02	1.02	0.00	0.00	30.63
G20 (n=14)	9.57	11.31	2.61	0.00	3.48	0.00	0.00	26.96
G53 (n=11)	11.41	10.14	10.14	0.00	0.00	0.00	0.00	31.69
G89	13.27	10.43	3.79	0.00	0.00	0.00	0.00	27.50
H13	16.01	5.60	3.20	0.00	3.20	0.00	1.60	29.61
H40	15.77	11.39	2.63	0.00	3.50	0.88	0.88	35.91
H79	28.23	8.39	2.29	0.00	17.55	0.00	5.34	61.81
J06	1.92	11.54	0.96	1.92	11.54	0.00	0.00	27.89
J33	19.19	15.99	6.40	0.00	10.40	0.00	0.00	51.98
L64 (n=14)	1.16	8.11	3.48	0.00	0.00	0.00	0.00	12.75
M24	29.54	17.54	6.46	0.00	7.38	0.00	0.00	60.92
M87	21.51	17.20	4.30	1.72	41.29	0.00	0.86	86.88
N11	1.48	0.00	0.74	0.00	0.00	0.00	0.00	2.23
N74	97.24	20.53	3.24	1.08	27.01	0.00	0.00	149.10
N77	42.22	18.23	5.76	0.00	11.51	0.00	0.00	77.72
O04 (n=7)	32.59	7.67	3.83	0.00	5.75	0.00	0.00	49.84
R22	10.30	12.17	6.55	0.00	4.68	0.00	0.94	34.63
R28	12.26	12.26	7.88	0.00	21.90	0.00	2.63	56.93
R88	28.47	7.85	4.91	0.00	4.91	0.00	0.00	46.14
S12	11.07	6.46	4.61	0.00	9.22	0.00	0.92	32.28
S15	56.83	2.47	4.94	0.00	9.88	0.00	0.00	74.12
S78 (n=14)	12.65	4.52	4.52	0.00	0.90	0.00	0.00	22.58
T05	53.12	12.72	6.73	0.00	44.89	1.50	0.75	119.70
V93	33.58	24.25	6.53	0.00	17.72	0.93	0.93	83.94
V96	19.88	9.51	2.59	0.00	15.55	0.00	0.00	47.53
V99	11.31	5.66	7.54	0.00	20.74	0.00	0.94	46.20
W56	51.92	23.37	7.79	0.00	27.69	0.00	0.87	111.63
X49 (n=14)	23.58	8.73	5.24	0.00	2.62	0.00	1.75	41.91
Average	24.23	11.33	4.74	0.21	11.58	0.12	0.66	52.89
Stdev	±20.84	±5.92	±2.23	±0.53	±12.12	±0.36	±1.14	±33.52

Table A1.2: Average number of bat encounters per hour for each survey square, Survey 2, 2015 (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	Pnath	Nl	BLE	Myotis	Total
C72	18.79	12.22	2.82	0.00	5.64	0.00	0.00	39.47
G20	7.95	25.45	9.54	0.00	5.57	0.00	0.00	48.52
G53 (n=12)	6.50	30.33	15.17	0.00	19.50	0.00	0.00	71.50
G89	31.87	21.24	7.73	0.00	10.62	0.00	0.00	71.46
H13	29.31	10.30	3.17	0.00	0.79	0.00	1.58	45.15
H40	33.04	48.35	5.64	0.00	5.64	0.00	4.03	96.71
H79 (n=14)	18.51	8.81	4.41	0.00	14.99	0.00	0.00	46.72
J06	1.96	8.81	4.89	3.91	10.76	0.00	2.94	33.27
J33	32.27	27.55	11.81	0.00	3.94	0.00	0.00	75.56
L64	0.00	3.97	0.00	0.00	0.00	0.00	0.99	4.96
M24 (n=12)	11.55	8.40	2.10	0.00	9.45	1.05	0.00	33.61
M87	23.17	5.35	5.35	0.00	14.26	0.00	0.00	48.13
N11	15.73	4.29	1.43	0.00	0.71	0.00	0.00	22.16
N74 (n=14)	36.71	8.93	3.97	0.00	1.98	0.00	0.00	51.60
N77	46.31	15.76	7.88	0.00	17.73	0.00	0.00	87.68
O04	43.37	6.60	0.94	0.00	9.43	0.94	0.00	61.29
R22	35.90	23.29	1.94	0.00	21.35	0.97	0.97	85.39
R28	13.49	11.81	5.06	0.00	5.90	0.00	0.84	37.10
R88	38.08	4.01	10.02	0.00	11.02	0.00	0.00	63.14
S12	29.26	7.32	2.74	0.00	7.32	0.00	0.00	46.63
S15								
S78	46.59	23.29	16.39	0.00	14.67	0.00	0.00	101.80
T05	24.58	31.09	5.78	0.00	36.15	0.00	0.00	98.33
V93								
V96	27.17	7.64	3.40	0.00	16.13	0.00	0.00	54.34
V99	65.44	9.09	6.36	0.91	20.90	0.00	0.00	102.70
W56	53.07	23.88	7.08	0.00	12.38	0.00	0.00	96.41
X49	31.91	20.74	10.37	0.00	11.17	0.00	1.60	75.78
Average	27.79	15.71	6.00	0.19	11.08	0.11	0.50	61.52
StDev	±16.04	±10.98	±4.20	±0.78	±8.04	±0.32	±1.02	±26.53

APPENDIX 2

All-Ireland Daubenton's Bat Waterway Survey

Table A2.1: Total number of waterway sites surveyed (2006-2015) and returned by April 2016.

a) Province and country

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Connaught	27	31	29	30	30	33	32	26	36	40	89
Munster	35	42	38	46	40	48	46	46	46	56	113
Leinster	53	103	77	87	96	97	95	109	113	103	230
Ulster	19	26	37	45	48	54	47	47	60	51	124
Northern Ireland	14	20	31	36	36	46	36	34	36	36	92
Republic of Ireland	120	182	150	172	178	186	184	194	219	214	464
Total	**134**	**202**	**181**	**208**	**214**	**232**	**220**	**228**	**255**	**250**	**556**

b) Leinster

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Meath	9	10	10	12	16	16	9	9	12	15	28
Dublin	10	11	12	15	10	10	13	17	17	18	24
Wicklow	8	14	11	11	13	10	14	10	8	6	22
Longford	0	8	5	7	5	6	6	9	8	7	12
Westmeath	2	10	5	7	6	6	11	10	13	11	26
Kildare	10	9	8	7	9	13	12	19	17	14	33
Louth	0	8	2	4	7	5	6	5	5	4	12
Wexford	5	5	6	5	6	5	5	6	8	6	11
Offaly	3	7	4	7	4	4	6	4	7	6	17
Kilkenny	4	9	6	4	11	6	5	4	7	6	17
Carlow	2	5	5	4	5	13	5	12	5	4	19
Laois	0	7	3	4	4	3	3	4	6	6	9
Leinster	**53**	**103**	**77**	**87**	**96**	**97**	**95**	**109**	**113**	**103**	**230**

c) Ulster

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Galway	11	12	10	8	8	11	9	6	10	10	26
Leitrim	4	4	3	3	4	4	5	5	5	4	12
Mayo	3	5	6	1	4	7	4	3	5	9	20
Roscommon	5	5	5	13	7	4	7	4	5	8	17
Sligo	4	5	5	5	7	7	7	8	11	9	14
Connaught	**27**	**31**	**29**	**30**	**30**	**33**	**32**	**26**	**36**	**40**	**89**

d) Munster

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Clare	6	5	5	8	4	4	3	5	4	5	13
Tipperary	5	7	6	8	4	8	8	5	7	10	14
Cork	15	14	11	15	13	20	16	15	17	13	41
Kerry	3	6	5	4	8	7	11	6	7	16	19
Waterford	2	7	6	6	5	5	4	10	6	8	13
Limerick	4	3	5	5	6	4	4	5	5	4	13
Munster	**35**	**42**	**38**	**46**	**40**	**48**	**46**	**46**	**46**	**56**	**113**

e) Ulster

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Cavan	2	3	3	5	7	6	8	9	10	9	11
Monaghan	0	1	1	2	1	0	0	1	4	1	6
Donegal	3	2	2	2	4	2	3	3	10	5	15
Derry	3	2	7	11	10	7	5	7	5	6	14
Antrim	3	6	10	9	11	16	13	14	14	11	30
Armagh	3	4	2	4	4	4	4	3	4	4	5
Down	2	3	2	3	2	6	5	4	7	3	14
Fermanagh	3	3	3	4	6	3	4	2	2	3	8
Tyrone	0	2	7	5	3	10	5	4	4	9	21
Ulster	**19**	**26**	**37**	**45**	**48**	**54**	**47**	**47**	**60**	**51**	**124**

Note: Tables A2.1a-e detail the total number of waterway sites returned to BCIreland by April 2016. This is greater than the number of waterway sites reported in statistical tables below as statistical analysis was completed on surveys returned by February 2016. In addition, total numbers of waterways sites reported in previous reports will also differ as survey sheets returned late are added to the dataset for the next year of reporting. Only surveys completed within the Day 205-250 are also only included in the statistical analysis.

Table A2.2: Bat detector models used by survey teams in different years (2006-2015).
The table shows numbers of sites, and percentages, excluding those outside the usual date range.

a) **Numbers of sites**
b) **Percentage of surveys**

Table A2.3: 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.

a) Connaght

Year	n complete 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
2011	59	58.8	5.4	64.3	61.6	89.8	60.5
2012	59	53.0	6.3	59.3	57.0	93.2	59.2
2013	44	61.8	2.5	64.3	58.2	79.1	50.9
2014	69	47.6	9.9	57.5	53.6	88.4	57.7
2015	75	42.5	8.2	50.7	47.0	85.3	54.9
All years	**570**	**56.4**	**8.6**	**65.0**	**60.3**	**90.0**	**57.6**

b) Leinster

Year	n complete surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats	% spots with bats
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	165	38.1	7.9	46.0	45.0	90.1	54.9
2010	178	49.4	10.0	59.3	55.7	95.5	63.5
2011	167	45.3	9.3	54.6	53.7	95.2	63.1
2012	179	36.0	9.5	45.6	44.7	89.9	55.9
2013	203	37.6	7.9	45.5	44.0	89.6	52.8
2014	213	38.3	8.3	46.6	42.4	89.2	52.8
2015	186	40.4	8.1	48.5	45.9	92.5	53.9
All years	**1722**	**39.9**	**9.3**	**49.2**	**46.2**	**91.1**	**56.3**

c) Munster

Year	n complete surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats	% spots with bats
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
2011	85	57.6	17.4	75.0	68.4	97.6	63.4
2012	84	48.7	12.2	60.8	59.3	98.8	62.1
2013	84	50.5	11.9	62.4	60.2	95.2	62.1
2014	80	50.8	8.2	59.0	53.4	89.9	58.8
2015	96	49.3	11.1	60.4	57.7	93.7	63.1
All years	**795**	**48.5**	**10.9**	**59.4**	**55.8**	**93.7**	**58.0**

d) Ulster

Year	n complete surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats	% spots with bats
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	80	46.0	9.6	55.6	53.1	95.0	60.2
2010	93	48.8	7.5	56.3	53.0	90.3	58.2
2011	96	54.1	9.5	63.6	59.5	92.7	62.7
2012	81	50.7	9.4	60.1	57.0	93.8	60.7
2013	81	32.4	8.4	40.9	39.3	88.9	53.3
2014	110	30.8	6.6	37.4	34.4	91.8	45.0
2015	88	50.8	6.9	57.7	55.6	94.3	61.8
All years	**774**	**42.7**	**8.7**	**51.4**	**48.9**	**92.8**	**56.9**

e) All Ireland

Year	n complete surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats	% spots with bats
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	375	45.8	8.1	53.9	50.8	90.5	55.2
2010	402	51.7	9.3	60.9	57.8	93.8	61.6
2011	407	51.9	10.5	62.4	59.3	94.3	62.7
2012	403	44.1	9.6	53.7	52.0	93.1	58.7
2013	412	41.8	8.3	50.0	47.9	89.5	54.6
2014	472	40.0	8.1	48.1	44.0	89.8	52.7
2015	445	44.7	8.5	53.3	50.5	91.9	57.6
All years	**3861**	**44.7**	**9.4**	**54.1**	**50.8**	**91.8**	**57.0**

APPENDIX 3

Brown Long-eared Bat Roost Monitoring Scheme

Preliminary Roost Assessment

Brown long-eared roosts selected and surveyed in this monitoring scheme were collated from a number of sources:

- BCIreland database
- BCIreland committee members
- NPWS regional staff
- General survey of buildings deemed suitable for this bat species

All new roosts, when first considered for inclusion in the monitoring scheme, were assessed by completing a daytime check of the building. This involved a survey of the roof space and when the building was accessible, safe, and brown long-eared droppings or actual brown long-eared bats were observed, then a preliminary assessment was undertaken. The preliminary assessment involved surveying the building by using at least two of the methods listed in Table A3.1 below. Once a site was deemed suitable for inclusion in the scheme (i.e. more than eight individuals were present and it was possible to safely count bats at the site by watching emerging bats or by entering the roof space), monitoring was then completed year-on-year using the most suitable method with an aim of counting the colony at each roost twice per year.

Table A3.1: Methods of assessing the most suitable protocol for counting brown long-eared bats at each roost. The assessment is carried out using at least two of Methods A-C below. Dates for surveying: Survey 1 1st May to June 15th, Survey 2 June 16th to July 31st, Survey 3 August 1st to Sept 15th.

	Method A	**Method B**	**Method C**
Description	Interior daytime count	Emergence Dusk Count	Interior Post Emergence Count
No. of counts per season	2	2 or 3	2 (usually in conjunction with Method B)
Dates when counts can be conducted	Survey Period1 & Survey Period 3	Survey Period 1 (preferred), Period 2 and Period 3 (preferred)	Survey Period 1 & Survey Period 3
Surveyor	Licensed	Licence not necessary	Licensed
Method	Count of bats present in roost.	Surveyors present at all known exit points, surveying starts 20 minutes after sunset. Count in 10min blocks. Count for 60mins or stop when no bats emerge for 10mins. Note if bats are seen or just heard. Direction of flight also noted.	Enter roost at start and end of emergence. Count bats present on both occasions. Numbers of bats before and after emergence are compared with total observed emerging.
Equipment	Red-light torch	Bat detector and red-light torch	Red-light torch
Other recorded details	Internal roof details, dimensions, presence of roof felt etc.	Weather conditions.	Weather conditions
Other info	Dead bats collected	Fine weather survey only.	Only undertaken in buildings with safe access in hours of darkness.

Table A3.2: Types of roost in different survey years. Numbers of roosts monitored as part of the Brown Long-eared Roost Monitoring Scheme 2007-2015.

a) numbers of roosts

	2007	2008	2009	2010	2011	2012	2013	2014	2015	All years
Barn	0	2	4	2	2	2	4	3	3	6
Church	5	12	20	19	16	20	24	24	26	32
House	2	4	4	6	2	5	6	6	6	9
Large bld/mansion	7	15	9	13	13	12	13	12	9	20
Other	3	2	2	3	2	2	2	2	2	4
All types	17	35	39	43	35	41	49	47	46	71

b) percentage of all roosts in each year

	2007	2008	2009	2010	2011	2012	2013	2014	2015	All years
Barn	0.0	5.7	10.3	4.7	5.7	4.9	8.2	6.4	6.5	8.5
Church	29.4	34.3	51.3	44.2	45.7	48.8	49.0	51.1	56.5	45.1
House	11.8	11.4	10.3	14.0	5.7	12.2	12.2	12.8	13.0	12.7
Large bld/mansion	41.2	42.9	23.1	30.2	37.1	29.3	26.5	25.5	19.6	28.2
Other	17.6	5.7	5.1	7.0	5.7	4.9	4.1	4.3	4.3	5.6

Table A3.3: Numbers of years of data from each roost. Brown Long-eared Roost Monitoring Scheme 2007-2015.

Number of years	Number of sites	% of total	Cumulative %
1	12	17.1	17.1
2	6	8.6	25.7
3	7	10.0	35.7
4	8	11.4	47.1
5	4	5.7	52.9
6	4	5.7	58.6
7	10	14.3	72.9
8	10	14.3	87.1
9	9	12.9	100.0

Table A3.4: numbers of roosts monitored in each year (diagonal in italics) and common to each pair of years (off diagonal). Brown Long-eared Roost Monitoring Scheme 2007-2015.

2007	*17*								
2008	16	*35*							
2009	11	24	*39*						
2010	13	26	35	*43*					
2011	11	22	31	34	*35*				
2012	10	22	32	34	33	*41*			
2013	11	25	33	36	34	40	*49*		
2014	10	22	31	33	32	40	46	*47*	
2015	9	20	29	31	29	37	43	44	*46*
	2007	2008	2009	2010	2011	2012	2013	2014	2015

Table A3.5: Highest of individuals recorded for each year. Mean and Median Roost Counts as part of the Brown Long-eared Roost Monitoring Scheme 2007-2015.

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of individuals	348	759	1125	1481	1064	1469	1727	1625	1657
Mean Roost Count	17.74	15.97	23.38	28.75	31.10	30.81	29.53	29.63	30.62
Median Roost Count	17.00	12.00	19.75	26.5	27.00	26.75	30.00	29.00	29

Table A3.6: Types of surveys in different survey years. Numbers of surveys completed and roosts monitored as part of the Brown Long-eared Roost Monitoring Scheme 2007-2015.

a. All Surveys

	2007	2008	2009	2010	2011	2012	2013	2014	2015	All years
Internal Counts	12	30	28	30	7	24	25	26	17	199
Dusk Emergence Counts	15	25	49	62	29	67	86	85	90	508
Total	27	55	77	92	36	91	111	111	107	707

b. All Roosts

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Internal Counts	7	13	16	14	7	10	10	7	8
Dusk Emergence Counts	8	18	23	27	27	30	35	36	35
Combination	2	4	1	2	0	0	3	3	3
Total	17	35	40	43	34	40	48	46	46

Table A3.7: GAM results with 95% confidence limits.

With covariates for rain, internal counts early in the year, and external counts late in the year

			Mean passes		Index 2008 = 100					
					smoothed		95% conf limits		unsmoothed	
year	counts	sites	Mean	s.e.	estimate	s.e.	lower	upper	estimate	s.e.
2007	25	16	18.3	2.3	89.85	5.31	80.81	101.60	112.24	18.05
2008	51	31	18.6	2.3	100.00	0.00	100.00	100.00	100.00	0.00
2009	73	36	25.6	2.0	112.57	4.94	102.57	122.02	132.32	14.41
2010	87	41	31.4	2.2	123.16	8.03	107.15	138.82	149.64	16.82
2011	36	35	31.6	2.9	127.29	9.00	109.56	144.78	140.72	14.03
2012	91	41	32.0	2.1	126.24	9.51	107.09	144.73	146.41	14.25
2013	111	49	30.4	2.1	122.08	10.16	101.85	141.51	140.77	15.59
2014	111	47	29.63	2.1	117.66	10.51	97.22	138.36	130.52	14.08
2015	100	44	30.62	2.1	115.11	11.37	92.97	137.72	134.60	15.26