Irish Bat Monitoring Schemes:
Daubenton's Bat Waterway Survey & Car-based Bat Monitoring
Northern Ireland

Annual Report for 2022

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1.0 EXECUTIVE SUMMARY

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

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

For detailed analysis of all-island data in 2022 see Aughney *et al*. (2023).

The first systematic car-based bat monitoring system in Europe was devised for the Republic of Ireland (ROI) in 2003 by the Bat Conservation Trust (BCT, UK). The scheme has been administered by Bat Conservation Ireland (BCIreland) since 2004 with funding from the National Parks and Wildlife Service (NPWS) of the Department of Housing, Local Government & Heritage and the Northern Ireland Environment Agency (NIEA). The main aim of the scheme is to monitor roadside populations of common pipistrelle, soprano pipistrelle and Leisler's bat and to collect sufficient data to identify trends in these bat populations.

The method involves driving a known survey route at 24kmph with a bat detector clamped to the open window of the passenger door. Each survey route consists of 15, 1.6km transects, separated by a 3.2km gap to minimise the possibility of repeat encounters with the same bats. Recordings are analysed by BCIreland using Kaleidoscope Pro software. In Northern Ireland, routes have been mapped in five, 30km blocks. Surveys are carried out in July and August by trained volunteers. In Northern Ireland, volunteers are mainly Northern Ireland Bat Group members and interested volunteers with their team-mates.

All-island trends show significant increases in the three target species since the beginning of the survey in 2003; these are common pipistrelle, soprano pipistrelle and Leisler's bat. We looked at NI only trends for both common and soprano pipistrelles in 2022 – these trends for the most part mirrored those of RoI only or All-Ireland, albeit with much wider error bars. In 2022 in Northern Ireland, encounter rates for most species (bat passes per hour) were lower than the island-wide average. Nathusius' pipistrelles occurred in high numbers in just one NI square (J06, east of Lough Neagh).

The upward trend in all-island Nathusius' pipistrelle and downward trend in all-island *Myotis* (combined species index) - both levelled out a little in 2022.

The All Ireland Daubenton's Bat Waterways Monitoring Scheme has been in operation in Northern Ireland since 2006 under Bat Conservation Ireland management. Since 2006, a total of 104 waterway sites have been surveyed in Northern Ireland. A small number of waterway surveys have also been on-going in Northern Ireland under the management of BCT, UK since their introduction of the survey since 1997.

All training completed in 2022 was online. BCIreland is required to survey a minimum of thirty waterways sites per year. Unfortunately in 2022, only 27 waterway sites were surveyed. A total of 50 surveys were completed with 1,436 Daubenton's bat passes recorded on 22 of the 27 waterway sites (81.5%) surveyed.

Despite some variation in yearly estimates, the all-Island Daubenton's bat trend appears to be fairly steady from year to year with error bars consistently encompassing the baseline. Trend analysis was also undertaken for Northern Ireland data only. Over the duration of the monitoring programme, there has been a higher increase in the population trend for Daubenton's bats in Northern Ireland compared to the Republic of Ireland and compared to the All-Ireland data set. But the difference is not statistically significant.

2.0 INTRODUCTION

Bats in Northern Ireland are protected under the Wildlife (Northern Ireland) Order 1985. The European Bats Agreement (EUROBATS) is an agreement under the Bonn Convention and Ireland and the UK are two of the 39 signatories. Devising strategies for monitoring of populations of selected bat species in Europe is among the resolutions of EUROBATS. Ireland, including Northern Ireland, holds important European populations of Leisler's bat (*Nyctalus leisleri*) (Stebbings, 1988).

To fulfill international obligations under the Convention on Biological Diversity and Agenda 21 agreed in 1992, Local Biodiversity Plans must be devised. The 1992 global agreement requires signatory parties to "identify components of biodiversity … and monitor, through sampling and other techniques, the components of biological diversity identified" (Article 7).

Scientifically rigorous methods of surveillance and monitoring are essential and require well-planned strategies to achieve statistically defensible results (Battersby, 2010). However, bats are difficult to monitor because they are nocturnal and difficult to identify when flying. In addition, individual species differ in their detectability (using bat detectors) and in their foraging and roosting strategies. Therefore, it is essential that appropriate methods of surveillance and monitoring are undertaken for specific species of bat (Battersby, 2010) and that the most appropriate method is chosen based on a general understanding of the roosting habitats, foraging behaviour, seasonal movements and the influence of environmental factors on local abundance and distribution (Kunz, 2003; Warren & Witter, 2002). Methods used to determine trends in bat populations can include foot-based bat detector surveys(e.g. BCT, 2011), car-based surveys (e.g. Roche et al., 2011) or roost counts either at summer roosts (Warren & Witter, 2002) or hibernacula (Tuttle, 2003).

This report presents the results of two monitoring schemes managed by BCIreland. The All Ireland Daubenton's Bat Waterway Monitoring Scheme is a foot-based survey designed by BCT, UK to monitor the Daubenton's bat (*Myotis daubentonii*). This scheme has proven to be a suitable monitoring tool for this bat species.

The second scheme, The Car-based Bat Monitoring Scheme, aims to be the primary tool for monitoring roadside populations of common pipistrelles (*Pipistrellus pipistrellus*), soprano pipistrelle (*P. pygmaeus*) and Leisler's bat (*Nyctalus leisleri*) in Ireland. The protocol was initially devised and piloted by The Bat Conservation Trust (BCT) in 2003 as an initiative of The Heritage Council and undertaken in the Republic of Ireland (Catto et al., 2004). It is a peer-assessed monitoring tool for these three bat species (Roche et al., 2011). Other species are also recorded during the surveys. We also analyse trends in species that occur less commonly along the roadside transects including Nathusius' pipistrelle (*P. nathusii*) and *Myotis* species (which may include any or a combination of *M. daubentonii, M. nattereri* and *M. mystacinus*). The error bars surrounding the trends in these species are much wider, however, and should therefore be approached with a high degree of caution.

2.1 Red and Amber Alerts

Monitoring and surveillance protocols need to be able to inform conservation bodies of the trends of the faunal group being investigated. Population trends are often used to identify species that require conservation measures (Dunn, 2002) and confirming a population decline can be used as a rationale to adopt or implement conservation measures. The degree of population decline is also considered to be a valuable evaluation tool with which to identify wildlife populations in trouble (Dunn, 2002). Rates of population change are regularly used as indicators of the conservation status of species e.g. the conservation alerts defined by The British Trust for Ornithology (BTO). The BTO has developed Alert Levels based on IUCN-developed criteria for measured population declines. Species are considered of high conservation priority (i.e. Red Alert) if their population declines by 50% or more over a 25-year period. Species are considered of medium conservation priority (i.e. Amber Alert) if there is a decline of 25-49% over 25 years (Marchant et al., 1997). A 50% and 25% decline over 25 years translates into an annual decline of 2.73% or 1.14% respectively. These Alerts are based on evidence of declines that have already occurred or can be predicted to occur based on statistically robust monitoring data that are sensitive enough to meet Alert Levels.

Monitoring data should be of sufficient statistical sensitivity (and better, if possible) to meet these Alert levels. In relation to the All-Ireland Daubenton's Bat Waterway Monitoring Scheme, the 2006-2008 Synthesis Report (Aughney et al., 2009) included power analysis to evaluate the number of waterway sites that need to be monitored to detect Red and Amber Alerts. Power Analysis indicated that if 150 to 200 waterway sites were surveyed each year, it should be possible to detect Red Alerts in around 6 years and Amber Alerts in 10 years. Results of Power Analysis also showed that a core of 67-75 waterway sites surveyed twice annually and additional 25-33 sites randomly surveyed each year are required to determine Amber Alerts after 15.4 years.

In relation to The Car-based Bat Monitoring Scheme, Power Analysis undertaken on the 2003-2008 All-Ireland dataset confirmed that when 20 x 30km squares are surveyed twice annually a Red Alert decline can be detected within 8, 11 and 12 years for common pipistrelles, soprano pipistrelles and Leisler's bats, respectively (Roche et al., 2009). Amber Alerts take roughly twice as long to detect. This time frame is considered acceptable to meet Alert levels in a sufficient length of time.

3.0 DAUBENTON'S WATERWAYS SURVEY

3.1 Introduction

The All Ireland Daubenton's Bat Waterway Monitoring Scheme is a project funded by the National Parks and Wildlife Service (NPWS) of the Department of Heritage, Housing and Local Government, Republic of Ireland and Northern Ireland Environment Agency (NIEA) Environment Fund. This scheme aims to be the primary tool for monitoring Daubenton's bats on the island of Ireland.

The All-Ireland Daubenton's Waterways Scheme has been carried out yearly since 2006 under the management of Bat Conservation Ireland.

3.1.1 Monitoring Daubenton's bats

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 Daubenton's bat prior to field work. Surveyors count the number 'bat passes' of this bat species for four minutes at each of the ten fixed points on linear waterways. All data collected for Northern Ireland by the All-Ireland Daubenton's Bat Waterway Monitoring Scheme also feeds into the BCT's UK reporting mechanisms.

The present report summarises the main results for Northern Ireland from 2006-2022 with emphasis on 2022 only. A sufficient number of waterway sites are now surveyed annually in Northern Ireland to allow trend analysis for this jurisdiction alone. For more details on all-island Daubenton's trends and details on variables affecting all-island Daubenton's activity and other results see Aughney *et al. (2023)*.

3.2 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). It is undertaken as an all-island survey.

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 PowerPoint presentation followed by a discussion of potential survey areas. Prior to Covid, these training courses were in person, but since the onset of the pandemic we have developed new training videos to illustrate the method and our training courses have taken place online.

An information pack consisting of a detailed description of the methodology, maps, survey forms and online training details are provided for each survey team. Heterodyne bat detectors are also available for loan for the duration of summer months.

Newly recruited surveyors are assigned a choice of starting points located within 10km of their home address or preferred survey area or are provided with a list of survey sites currently with no survey team. In order to have a more robust dataset for trend analysis BCIreland prefers to reallocate old survey sites where possible. Seasoned surveyors are reassigned starting points surveyed in previous years.

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

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

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

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

3.2.1 Statistical Methods

Trend analysis was carried out with data from 2006-2022 using Poisson Generalised Linear Model (GLM) which is applied to the data with the results expressed as an index and 2007 used as the base year. This model, which includes both sure and unsure passes, has the maximum number of passes set to 48 and includes covariates. The co-variates were determined using a binomial GLMM model. This trend method is used to facilitate comparison with BCT Daubenton's trend data from Britain.

Due to the much larger number of sites included, the All-Ireland trend is a much more robust dataset. However, Northern Ireland trend analysis was completed with the current 2006-2022 dataset.

3.3. Results

3.3.1 Training and Volunteer Participation: Northern Ireland 2022 & 2006-2022

Due to COVID-19 no physical training courses were organised in 2022. Instead, BCIreland set up five online training courses, via Zoom, for volunteers to participate. The online training presentations and training aids were also available on the BCIreland You Tube channel. A total of 50 volunteers participated in 2022.

3.3.2 Waterway Sites Surveyed in Northern Ireland

A total of 27 waterway sites were surveyed in Northern Ireland in 2022, the majority of which were located in County Antrim (Table 3.1). Waterway sites surveyed in 2022 are distributed throughout the six counties (Figure 3.1).

In 2022 a total of three canals (five waterway sites) and 15 rivers (24 waterway sites) were surveyed. The Lagan Canal had three waterway sites surveyed along its length and the River Lagan had six.

Table 3.1: Total number of waterway sites surveyed in Northern Ireland in 2022 and 2006-2022.

Counties	2006-2022	2022
Derry	17	4
Antrim	30	11
Armagh	9	2
Down	13	4
Fermanagh	10	3
Tyrone	25	3

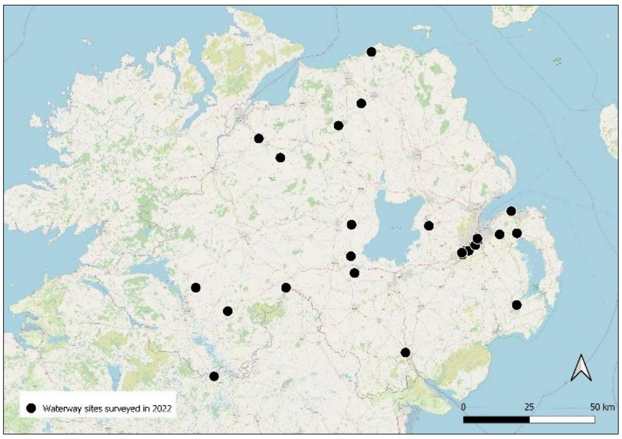

Figure 3.1: Location of waterway sites surveyed in Northern Ireland as part of the All-Ireland Daubenton's Bat Waterway Monitoring Scheme in 2022 (QGIS).

Of the 104 waterways sites that have been surveyed in Northern Ireland, no waterway site has been surveyed each year since 2006 (Figure 3.1). Over the 17 years of the scheme, most sites (72 waterway sites, 69%), have only been surveyed for six or fewer years. Nineteen sites have only been surveyed once since 2006. Waterway sites surveyed for two years or more are included in population trend analysis.

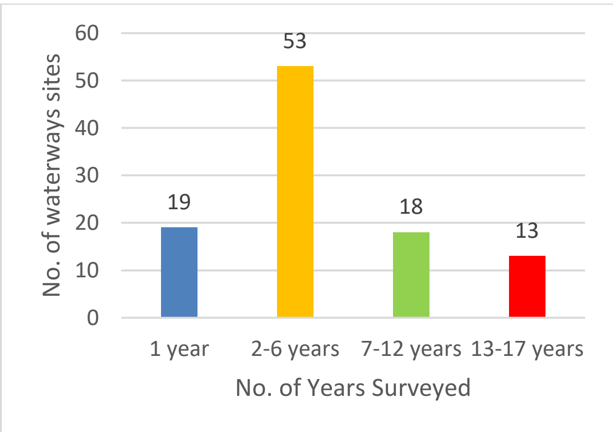

Figure 3.2: Total number of years each waterway site has been surveyed in Northern Ireland as part of the All-Ireland Daubenton's Bat Waterway Monitoring Scheme in 2006-2022, n = 104.

On a county by county basis, County Tyrone (41.7%, n=9) has the highest number of single sites.

Table 3.2: Number of years each waterway site has been surveyed as part of the Northern Ireland Daubenton's Bat Monitoring Scheme.

No. of Years	No. of waterway sites
1	19
2	12
3	17
4	14
5	7
6	3
7	5
8	2
9	3
10	2
11	4
12	2
13	4
14	5
15	2
16	1
17	0

Eighty-four (81%) of the 104 waterways sites that have been surveyed in Northern Ireland have at least two years of survey data (Figure 3.3). This dataset represents 13% of the total number of waterway sites surveyed on the island and makes an important contribution to the All-Ireland dataset.

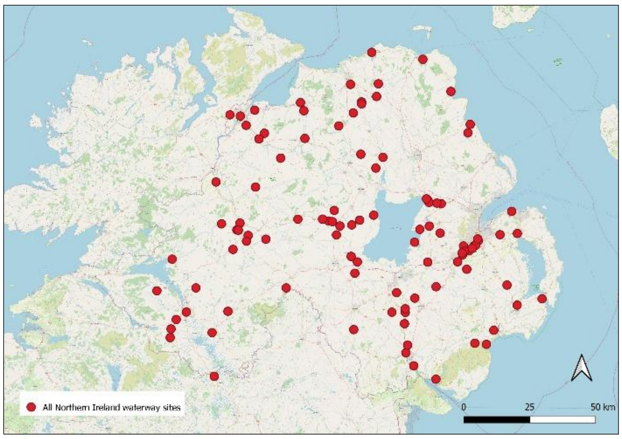

Figure 3.3: Location of all waterway sites surveyed in Northern Ireland during the 2006-2022 period (QGIS).

There are 643 waterway sites in the All-Ireland dataset and on average only 1/3 of those are surveyed annually. Many sites in the full dataset have only been surveyed for one year (n=111 waterways, 17.3%). This is similar for Northern Ireland with 19 waterway sites (18.3%) surveyed for one year only.

3.3.3 Completed Surveys 2022

A total of 50 completed surveys from 27 Northern Irish waterway sites were returned to BCIreland in 2022. For Survey 1 (1^{st} – 15^{th} August) 25 surveys were completed and 25 surveys were completed in Survey 2 (16^{th} – 30^{th} August). Waterway sites with repeated surveys (i.e. surveys completed in both sampling periods S1 and S2) provide more robust data for monitoring. In 2022, 25 repeated surveys (92.6% of waterway sites) were completed.

In 2022, 'Sure' Daubenton's bat passes were recorded on 22 Northern Ireland waterway sites (81.5%) (see Figure 3.4).

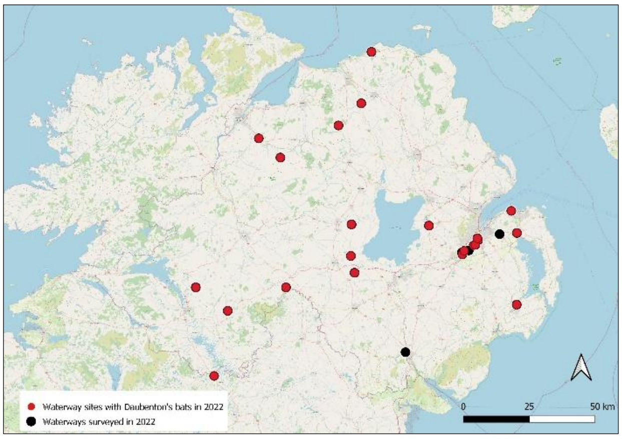

Figure 3.4: Waterway sites where Daubenton's bats were recorded (red circles) in Northern Ireland in 2022 (QGIS).

At each of the 10 survey spots volunteers record Daubenton's bat activity for four minutes, generating 40 minutes of data per completed survey. In total, 1,436 'Sure' Daubenton's bat passes and 319 'Unsure' Daubenton's bat passes were recorded during 33 hours and 20 minutes of surveying in Northern Ireland. The mean number of 'Sure' Daubenton's bats passes per survey in Northern Ireland in 2022 was 28.7 and was slightly lower than the average for Ulster in 2022 (n=29.4). The 2022 Northern Ireland average was lower than the 2022 All-Island average (n=44.4).

For a full break down of descriptive results for Ulster and All-Ireland in 2022 and 2006-2022 dataset see Table 1, Appendix 1.

3.3.4 Bat Records & Robustness of Dataset

All bat records derived from the Daubenton's Bat Waterway Monitoring Scheme for Northern Ireland were sent to the BCT and CEDaR in November 2022.

BCIreland encourages new survey teams to take on an "old" waterway sites in order to strengthen the data.

3.3.5 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 passes. This particular model is chosen to facilitate comparison with British data from the BCT. A total of 524 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.

On an All-Ireland level, there has been a fluctuating trend since 2006, levels troughed in 2008 and 2013-2014. A peak was observed in 2011 and then again 2015-2016. Since then, there has been a dip, but overall the species is showing a relatively stable trend. On average the numbers of passes recorded in 2022 were slightly up on 2021, but were comparatively low compared to most of the last ten years, so the Poisson trendlines continue the downward slope observed last year but there is a levelling off noted. The smoothed index is currently 5.86% above the 2007 base year value which is equivalent to an average 0.38% annual increase, although this increase is not considered significant as the lower confidence interval still encompasses the baseline index (Figure 3.5).

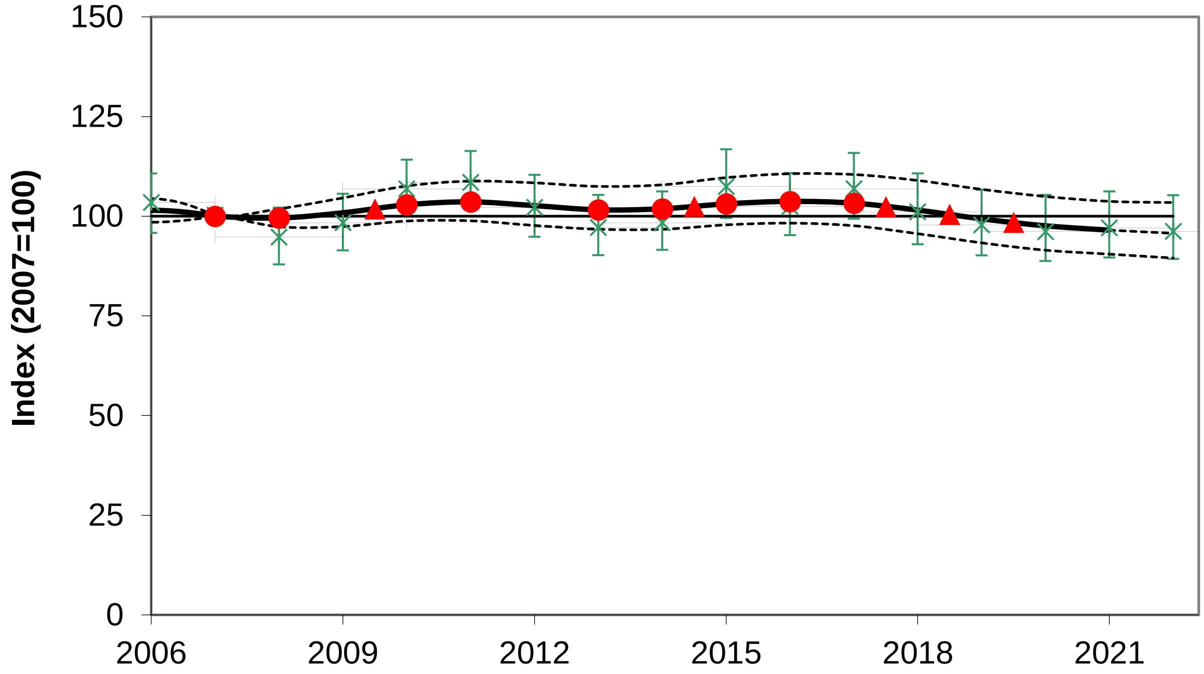

Figure 3.5: Results of Daubenton's bat Binomial GAM/GLM trend with covariates, for All-Ireland data. Green points are estimated annual proportions derived from the Generalised Linear Model (GLM) and the bars are bootstrapped 95% confidence limits. The black line is the fitted GAM curve with 95% confidence limits shown by the dotted lines. 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). Please see appendices for accompanying table.

Table 3.3 Poisson GAM results with 95% confidence limits for Daubenton's bats (2006-2022). Covariates include survey start time, surveyor skills and degree of smooth water as recorded by survey teams.

				Smoothed		95% conf limits		Unsmoothed		95% conf limits	
Year	**Sites**	**Surveys**	**Mean**	**Index**	**s.e.**	**Lower**	**Upper**	**Fitted**	**s.e.**	**Lower**	**Upper**
2006	109	208	56.10	99.69	3.25	93.63	106.67	107.86	11.05	88.33	131.09
2007	170	324	50.35	100.00	0.00	100.00	100.00	100.00	0.00	100.00	100.00
2008	170	294	42.70	101.94	2.47	97.31	106.76	91.05	5.83	80.48	102.79
2009	185	334	52.09	105.78	4.13	98.12	113.82	112.30	7.07	99.29	126.43
2010	204	389	57.93	108.57	5.10	99.16	118.35	117.66	8.22	103.65	135.10
2011	216	382	58.40	108.17	5.54	97.74	119.05	114.18	7.76	99.72	129.13
2012	212	387	52.71	105.79	5.76	94.82	117.39	104.74	7.22	92.09	119.38
2013	218	396	48.54	104.26	6.06	93.09	116.14	103.64	7.26	89.86	118.47
2014	239	443	45.42	105.04	6.47	93.01	117.82	101.13	7.92	85.97	117.39
2015	239	440	50.67	107.69	6.86	95.01	121.37	116.41	9.01	100.94	134.52
2016	238	430	50.09	109.65	7.23	96.75	124.84	110.87	8.13	96.33	127.55
2017	221	390	49.89	109.93	7.64	96.35	126.00	116.66	10.18	98.23	137.94
2018	223	385	48.01	107.99	7.74	94.23	124.05	113.65	9.83	96.37	134.79
2019	225	401	42.86	104.95	7.60	92.01	120.43	102.20	8.70	86.64	120.50
2020	225	399	43.64	102.78	7.52	89.67	119.02	103.62	9.42	87.11	123.24
2021	219	402	44.72	101.84	7.63	88.36	117.71	104.01	9.54	86.33	122.95
2022	234	421	48.86	101.58	8.14	87.41	118.77	105.23	8.76	90.01	123.65

3.3.6 Country Trend Models

A trend model for Northern Ireland was investigated separately. The trend analysis was completed for data from Northern Ireland (n=84 waterway sites) separately from the All-Ireland dataset using the Poisson model with covariates. For Northern Ireland, the smoothed trend indicates an increase of 23.34%, which represents a yearly increase of 1.41% (baseline year is 2007) (Figure 3.9, Table 3.9). Although the index value is greater for Northern Ireland in comparison to that for the Republic of Ireland (n=441 waterway sites), the confidence limits are wide due to the relatively small sample size. However, values are not significantly different using a randomisation test between the two datasets. For the Republic of Ireland data, the smoothed trend indicates a slight decrease of 0.61%, which represents a yearly decrease of 0.04% (baseline year is 2007).

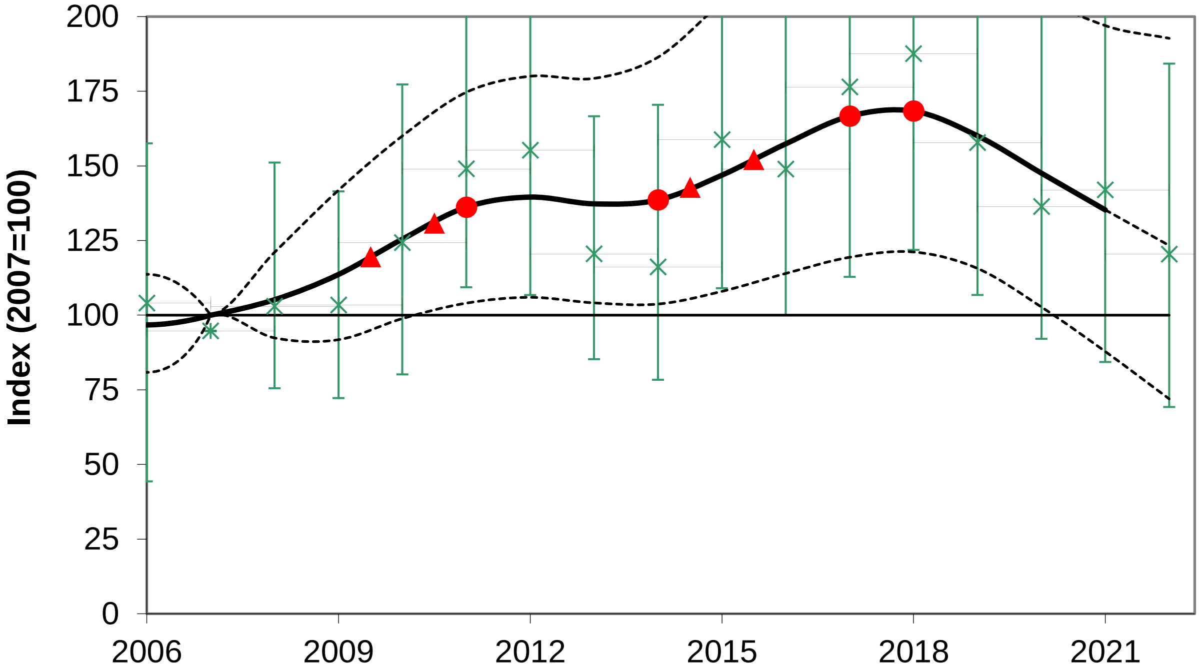

Figure 3.6 Northern Ireland results of Poisson GAM model (max 48 'sure' and 'unsure' passes), with covariates (survey start time, surveyor skills and degree of smooth water as recorded by survey teams), shown with 95% confidence limits. Green points are estimated annual means and are shown to illustrate the variation about the fitted line.

Table 3.4 Northern Ireland Poisson GAM results with 95% confidence limits for Daubenton's bats (2006-2022). Covariates include survey start time, surveyor skills and degree of smooth water as recorded by survey teams.

				Smoothed		95% conf limits		Unsmoothed		95% conf limits	
Year	**Sites**	**Surveys**	**Mean**	**Index**	**s.e.**	**Lower**	**Upper**	**Fitted**	**s.e.**	**Lower**	**Upper**
2006	10	20	57.10	96.74	8.77	80.86	113.68	109.33	28.73	49.63	96.74
2007	13	24	48.42	100.00	0.00	100.00	100.00	100.00	0.00	100.00	100.00
2008	28	48	46.04	105.18	7.41	92.38	121.05	108.19	18.81	80.83	105.18
2009	30	55	47.49	113.63	12.59	91.78	141.85	108.71	17.77	77.53	113.63
2010	35	68	44.50	125.47	15.68	98.86	160.03	129.60	23.96	85.46	125.47
2011	40	76	54.47	136.17	17.25	104.03	174.64	154.26	23.24	114.65	136.17
2012	33	59	61.29	139.55	18.15	105.97	180.02	160.46	26.66	112.03	139.55
2013	30	57	39.46	137.28	18.55	104.11	179.31	125.77	20.15	90.56	137.28
2014	34	65	37.26	138.58	20.29	103.72	186.38	121.41	23.85	83.66	138.58
2015	35	69	55.64	146.88	23.60	107.97	204.83	163.98	35.20	114.33	146.88
2016	32	61	48.48	157.38	27.37	113.97	222.42	154.14	27.64	105.25	157.38
2017	33	54	55.43	166.63	31.07	119.40	243.54	181.74	43.10	118.12	166.63
2018	32	60	50.65	168.33	31.51	121.16	243.63	192.89	38.72	127.14	168.33
2019	33	59	42.47	160.06	28.81	115.66	231.03	163.02	34.12	112.06	160.06
2020	34	57	36.89	147.57	26.80	102.74	207.87	141.68	28.74	97.37	147.57
2021	28	51	34.51	135.25	27.57	87.82	196.98	147.24	33.43	89.61	135.25
2022	24	45	34.36	123.34	29.90	71.97	192.72	125.66	30.80	74.54	123.34

3.4 Discussion

3.4.1 Volunteer Uptake in Northern Ireland

Two new volunteer teams for Northern Ireland participated in 2022. Twenty-five survey teams (minimum two individuals per team), a relatively large number of volunteers, undertook the survey in 2022 in Northern Ireland. There had been a reduction of teams participating from Northern Ireland since 2011. This decline was successfully reversed in 2015 and participation was remained consistent in the previous six years. Unfortunately this reduced in 2022.

While a core group of survey teams have participated in the programme since the early years, there is still need for a continued recruitment drive since a certain percentage of volunteers are lost to the survey every year. The recruitment drive usually involves approximately 3/4 training courses per year in Northern Ireland. However due to COVID-19 restrictions, all training was online in 2022.

In addition, BCIreland continues to work closely with the Lagan Valley Volunteers, which has proven very successful over the years with management of six volunteer teams in County Antrim completed by the volunteer co-ordinator. In 2018, a new link was formed with the Lagan Valley Rivers Trust and this continued in 2022.

3.4.2 Survey Coverage in 2022 in Northern Ireland

A good number of surveys were completed in 2022. A total of 50 surveys were completed at 27 waterways sites. The waterway sites were located in all six counties in Northern Ireland with the largest coverage in County Antrim. The County Antrim coverage is primarily a consequence of BCIreland working closely with the Lagan Valley Volunteers, who surveyed six waterway sites in 2022 and have consistently participated in the scheme for many years.

The data collected is more robust when waterway sites are surveyed for two or more years. Therefore, waterway sites with only one survey year completed over the duration of the scheme will continue to be targeted for re-surveying in 2023 (n=19 waterway sites). This aim has been actioned in the last few years and as a result, the number of waterways sites only surveyed for one year has reduced.

3.4.3 Dataset & Distribution in Northern Ireland

The 2022 dataset consisted of over 1,400 'Sure' Daubenton's bat passes. Daubenton's bat was recorded on the majority of the waterway sites surveyed in 2022, thus re-confirming this species' wide distribution on linear waterways across Northern Ireland. Daubenton's bats were recorded in every county from the most northern sites in Antrim to waterway sites along the Fermanagh/Cavan border. A similar widespread distribution of this species was also reported by the BCT NBMP where Daubenton's bats were recorded from northern Scotland to southern England (www.bats.org.uk). This monitoring scheme continues, therefore, to make a considerable contribution to our knowledge of the distribution range of Daubenton's bat.

The large dataset currently held by BCIreland about this species is a potentially useful source of mapping information on a county, river catchment and river level. Such representation may prove useful for future county planning and conservation work in relation to waterways.

The dataset for Northern Ireland now stands at 104 waterway sites surveyed over the 17 years of the scheme. However, waterway sites need to be surveyed more consistently from year to year to provide statistically robust data. No waterway site has been surveyed in each of the 17 years of the scheme. BCIreland will be holding blended training courses in Northern Ireland in 2023 to increase the number of participating teams. A continued effort will be undertaken this year to survey waterway sites that have only been surveyed once in the 17 years of the scheme (n=18 sites). A repeat survey improves power of the data to detect trends.

3.4.4 Yearly Trends

While across the island Daubenton's bat has increased slightly since 2006, when the survey began, this increase is not considered significant. More recently, the trend from 2016-2022 has been relatively stable.

As sufficient data is now being collected in Northern Ireland on an annual basis, separate trend analysis for Northern Ireland was completed in 2017 and annually since. Over the duration of the monitoring programme, there was generally a higher increase in the population trend for Daubenton's bats in Northern Ireland compared to the Republic of Ireland but the differences are not significant.

4.0 CAR-BASED BAT MONITORING

4.1 Introduction

This project aims to be the primary tool for monitoring roadside populations of common pipistrelle (*Pipistrellus pipistrellus*), soprano pipistrelle (*P. pygmaeus*) and Leisler's bat (*Nyctalus leisleri*) in Ireland. The protocol was initially devised and piloted by The Bat Conservation Trust (BCT) in 2003 as an initiative of The Heritage Council and undertaken in the Republic of Ireland (Catto et al., 2004). Funding was provided by the Northern Ireland Environment Agency (NIEA) from 2006 to carry out surveys within Northern Ireland as part of an overall All-Ireland survey for the two countries, managed by Bat Conservation Ireland (BCIreland). Data from the Northern Ireland surveys are specifically the subject of this report. Within the context of monitoring aims, i.e. to use monitoring data to detect Amber and Red Alert declines of selected populations, the data collected from Northern Ireland alone would not be sufficient to provide statistically robust data. However, since some time has passed since we last tried to fit trends to the NI only data we took a look at this again, results are reported here.

The present report summarises the main results for Northern Ireland in the period 2006-2022 with some of the specific results for 2022.

4.1.1 What is a Car-based Bat Monitoring Scheme?

This protocol is a method of monitoring bats while driving. Monitoring is carried out using a bat detector which picks up the ultrasonic (high pitched) echolocation calls made by bats and converts them to a frequency audible to the human ear. From 2003 to 2019, time expansion detectors were used. These detectors essentially make short recordings of a broad range of ultrasound and replay the sounds at a slower speed. All sounds were recorded to minidiscs initially, and from 2012, smartphones were used to record bat detector sounds and georeferencing information.

From 2016 to 2019 a new type of bat detector was phased into the survey. Batlogger M (Elekon Electronics) full spectrum detectors record snapshots of ultrasound on a continuous basis along with GPS data, and all data is stored on the device's SD card. This removes the requirement for a secondary recording device.

Batloggers were first trialed in small numbers in 2016 and were then used in increasing numbers each year, each time in tandem with Tranquility detectors. This meant that sufficient data had been collected from 2016 to 2019 to allow a full swap over to Batloggers alone in 2020.

The monitoring is carried out along mapped routes with 15 transects each within in five survey squares in Northern Ireland. Each transect along the route is driven at a prescribed speed (15mph).

The continuing pandemic in 2022 did not impact the car monitoring scheme to any great extent, although the training of new teams, of which there were 4 in Northern Ireland in 2022, was still carried out remotely and equipment was posted to volunteers.

4.1.2 Overall Aims of Car-Based Bat Monitoring Scheme

1. Provide a method of monitoring that can be implemented by relatively few surveyors and that does not require highly trained individuals.
2. Provide a method of data collection that is

- objective
- easily repeatable
- cost effective.

3. Ensure sufficient data is collected that will allow early recognition of Red and Amber Alert declines in certain Irish bat species' populations.
4. The species targeted for monitoring are:
   - common pipistrelle
   - soprano pipistrelles
   - Leisler's bat
5. Nathusius' pipistrelle (*P. nathusii*) is not encountered in sufficiently high numbers to allow robust monitoring of its populations, nonetheless this species is recorded by the survey
6. *Myotis* bats, i.e. Daubenton's, Natterer's and whiskered bats (*Myotis daubentonii, M. nattereri* and *M. mystacinus*) are not identified to species level and are recorded in very low numbers. Nonetheless, we produce a trend index for this species group which is the subject of discussion in this report.
7. Record other vertebrate wildlife during survey periods.
8. To extrapolate information on bat activity within survey squares to determine 'hotspot' areas, and/or areas of high bat diversity.

4.2 Methods

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

Training of surveyors has been carried out in summer prior to Survey 1 each year. In 2022 four new Northern Ireland teams were trained in via Zoom. Issues and queries from teams were discussed via Zoom or email prior to the survey.

Starting 45 minutes after sundown, surveyors carry out surveys of a mapped route within a defined 30km ***Survey Square.*** The survey routes cover 15 x 1.609km (1 mile) ***Monitoring Transects*** each of which is separated by a minimum distance of 3.2km (2 miles). Surveyors are asked to carry out the survey on two dates, one in mid to late July (Survey 1, S1) and one in early to mid-August (Survey 2, S2). Each of the 1.609km transects is driven at 24km (15 miles) per hour while continuously recording using a Batlogger M detector.

In 2022 all surveyors across the island were provided with Batloggers, trained in their use and asked to complete the surveys with this system only. The Batloggers are pre-loaded with parameters for the survey. Surveyors are asked to affix the detector to the clamp so that the microphone is facing out of the window and slightly to the rear of the car in the same direction as the former set up (tranquillity). The Batlogger records audio and GPS location data to the device's SD card. Surveyors switch the Batlogger on to record at the start of each transect and switch it off at the end. The result is a folder containing multiple matched audio (.wav) and GPS (.xml) files for each survey evening.

On completion of surveys, data is forwarded to BCIreland for analysis. In 2022 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.

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

Data from Batloggers were analysed using Wildlife Acoustics Kaleidoscope Pro software (both automated and manual settings). At present, manual identifications from Kaleidoscope are being used for all data and trend analysis.

We will continue to assess automated analysis methods and at some point may retrospectively analyse all data when automated identification is considered to be sufficiently high enough quality.

Data from Batloggers were gathered into Excel spreadsheets imported to BCIreland's purpose-built Car-based Bat Monitoring MySQL database.

For the purposes of providing volunteer feedback, spreadsheets listing bat species, date, time, location and accuracy were uploaded to Google Maps and bat locations were pinned to a map for each route, with icons of differing colour and shape denoting a particular bat species.

In 2022 training videos continued to be available at the Facebook page (IrishCarBats) and on the Bat Conservation Ireland YouTube channel.

4.2.1 Analysis

For overall yearly trends of the island-wide populations a Generalised Linear Model with Poisson error distribution is applied to the data. Covariates are used to account for differences between the two detector types. For Nathusius' pipistrelles, however, trends are analysed using a binomial model of presence/absence data.

It is some time since we last fitted separate models to the Republic of Ireland and Northern Ireland data. Northern Ireland is problematic because there are only five squares with data, and less in some years. In the past we have dealt with this by using individual mile transects as the replicates for the bootstrapping process. This was done due to doubts about the reliability of bootstrapping with small numbers of squares, but is not ideal. This year therefore, we explored whether reliable bootstrap confidence limits can be obtained using the standard approach with just five squares. This was done by producing 1000 sets of simulated data for five sites over 15 years for both common and soprano pipistrelles, using a modified version of the programs used in 2009 for the power analyses for the Animal Conservation paper (Roche *et al*., 2011). Results were surprisingly good, with 95% confidence limits containing the true index value around 93% of the time. This standard method was applied, using 30km squares as replicates, in analyses for common and soprano pipistrelle in Northern Ireland alone.

For Northern Ireland the models were initially run with the usual base year (i.e. 2006, except for long-eareds which is 2010), but the confidence limits were wide because the 2006 data is at the start of the series when only three squares were surveyed in Northern Ireland. Using 2010 as the base instead gives tighter confidence limits. The results for NI and All-Ireland are presented in this report.

4.2.2 Other Vertebrates

Other vertebrates were also recorded by surveyors. From 2006, surveyors were asked to note all vertebrates including cats on their record sheets. In addition, observers had the facility to record whether each specimen was living or dead and whether each was observed during or after the driven transect. This means that recorders were observing living and dead vertebrates, other than bats, for approximately 43 miles (69km) on each survey evening.

4.3 Results

4.3.1 Volunteer Uptake in Northern Ireland

Since 2007 between 10 and 13 volunteers have carried out the car survey each year. Surveys are carried out in five 30 x 30km squares. The squares cover parts of Counties Fermanagh/Tyrone, Antrim, Down and Derry (see Figure 4.1).

In 2022, 11 surveyors who are members of Northern Ireland Bat Group (NIBG), Bat Conservation Ireland and interested volunteers along with their team partners, surveyed five routes in Northern Ireland. H13 was surveyed in July 2022 but the team ran into equipment issues during Survey 2 so had to abandon the survey.

4.3.2 Survey Coverage in 2022 in Northern Ireland

Approximately 209km of monitoring transects were covered in Northern Ireland in 2022. Overall the sound recordings made by the Northern Ireland survey teams were of very high quality. In 2022, approximately 619km of roads were surveyed for vertebrates other than bats (vertebrate sightings are noted along the entire route driven and therefore includes the distances in between transects).

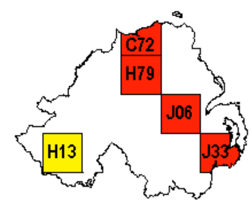

Figure 4.1: Locations of Survey Squares, surveyed for bats in Northern Ireland as part of the Car-based Bat Monitoring Scheme. Red squares were successfully surveyed twice in 2022, the yellow square (H13) was successfully surveyed in July only.

For surveys where GPS data was successfully recorded, it was possible to map bat locations using Google Maps see Figure 4.2.

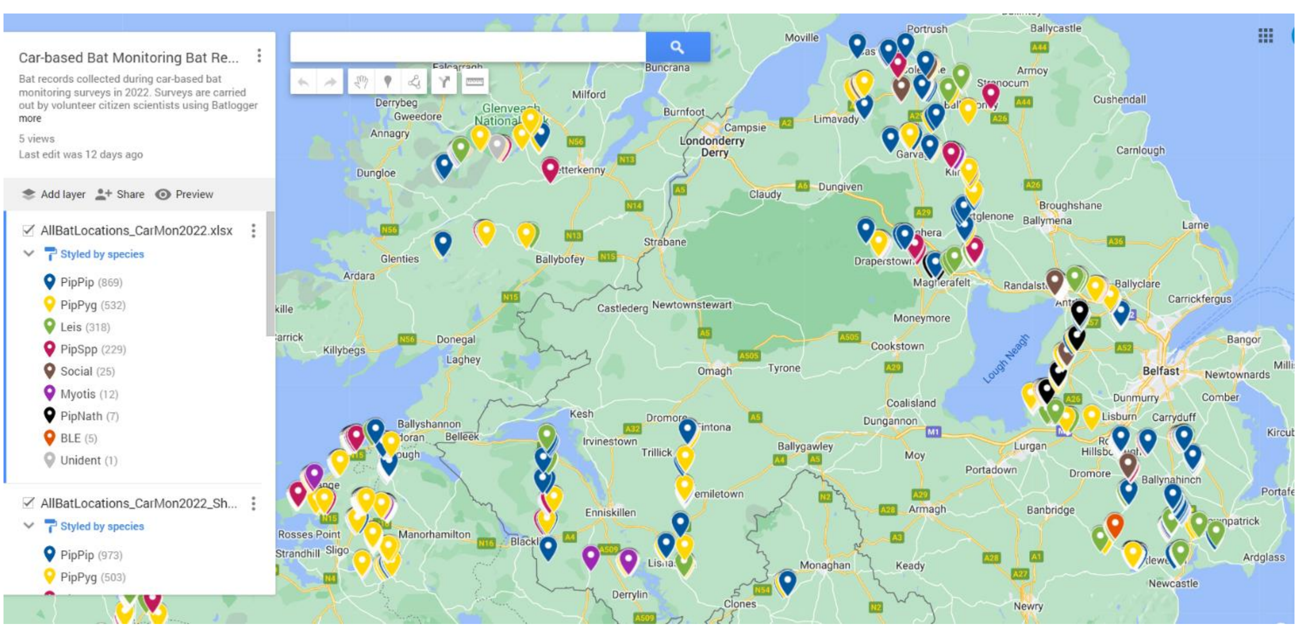

Figure 4.2: Locations of bat records from the car-based bat monitoring scheme in Northern Ireland, 2022, Batlogger Detectors. Map produced using Google Maps.

4.3.3 Roadside Bat Species in 2022 in Northern Ireland

A pie-chart illustrating overall proportions of bat species encountered in Northern Ireland in 2022 is shown in Figure 4.3. Figure 4.4 shows the same breakdown, but for the entire island. The proportion of passes per species varies somewhat between the whole island and Northern Ireland. For example, Leisler's bats and Nathusius' pipistrelles account for a greater proportion of bat passes in Northern Ireland, while the proportion of common pipistrelles encountered is lower in Northern Ireland than in the island as a whole.

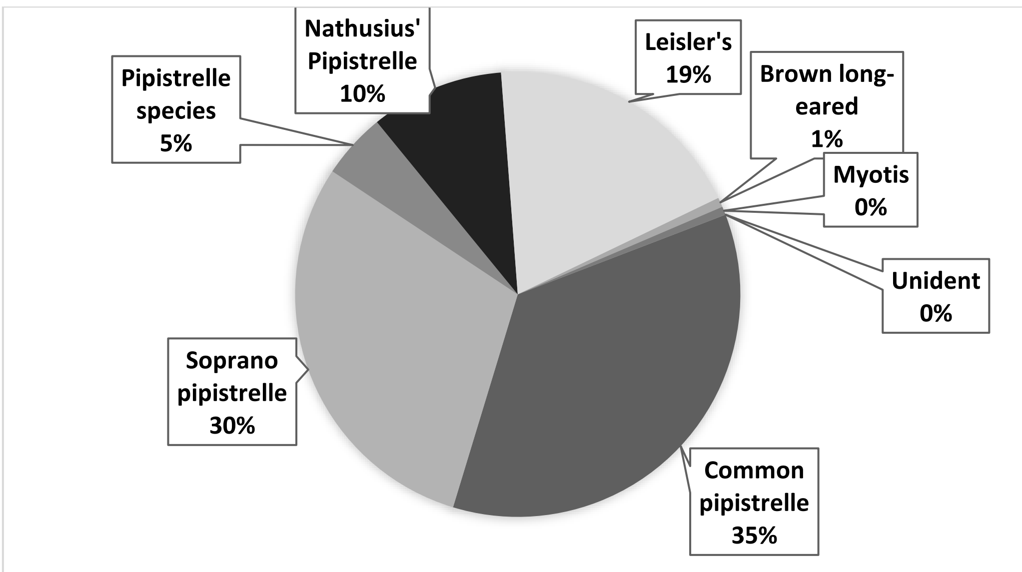

Figure 4.3: Proportion of bat species encountered during the 2022 survey from nine surveys in Northern Ireland using Batlogger detectors. Total number of encounters n=1,154. Excepting social calls of Leisler's bats and brown long-eared bats, which are unlikely to be mistaken for those of other species, bat social calls were noted during sonogram analysis but are not included in the above pie chart or in any statistical analyses

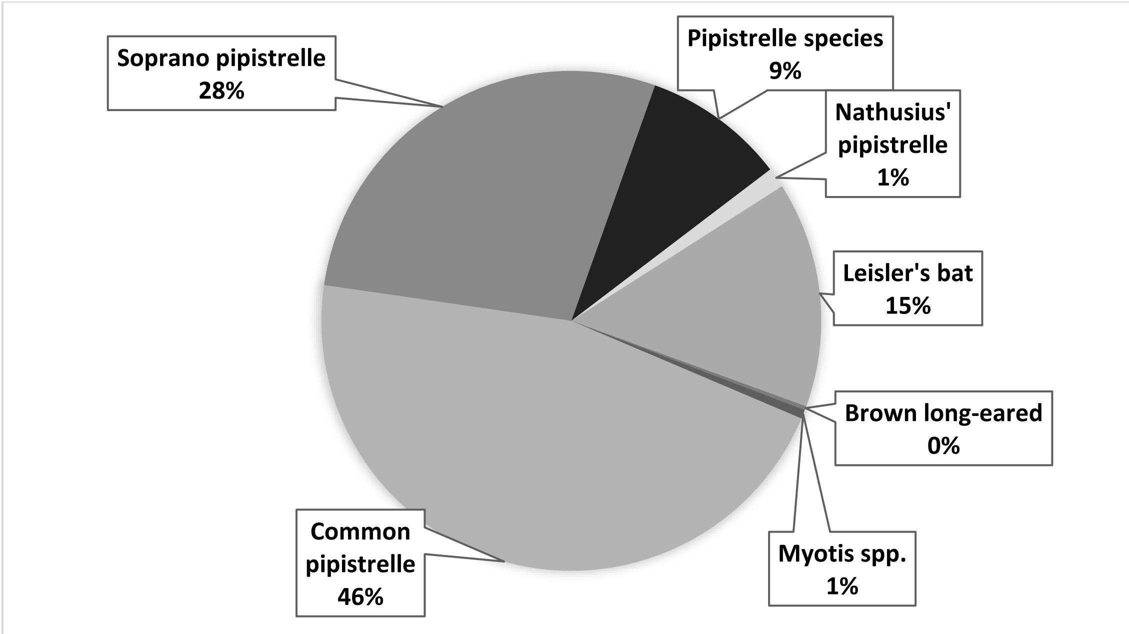

Figure 4.4: Proportion of bat species encountered (Batlogger Detectors) during the survey of the entire island of Ireland in 2022. Total number of bat encounters n=10,220. Excepting social calls of Leisler's bats and brown long-eared bats, which are unlikely to be mistaken for those of other species, bat social calls are not included in the above pie chart or in any statistical analyses.

A detailed break-down of Batlogger detector results for each survey square in Northern Ireland in 2022, not corrected to number of bat encounters per hour or per square, is shown in Table 4.1. Average encounter rates (per hour) for Northern Ireland in 2022, in comparison with the whole island are shown in Table 4.2. While encounter rates for some bat species in Northern Ireland are typically lower than the island-wide average, in 2022 average encounter rates were much higher here for Nathusius' pipistrelles.

Table 4.1: All bat encounters from Northern Ireland car-based bat monitoring survey squares, 2022.

Square – Survey	Transects	Common pip *	Soprano pip*	Unknown pip*	Nath pip*	Leisler's bat	Brown long-eared	Myotis species	All bats
C72_1	15	16	30	2		9			57
C72_2	15	13	24	6		14			57
H13_1	15	53	45	10		15		2	125
H79_1	15	39	29	7		24		1	100
H79_2	14	56	30	5	7	9	1		108
J06_1	15	21	25	1	20	59	1		127
J06_2	13	26	24	4	85	25	1	1	166
J33_1	14	117	47	12		39		1	216
J33_2	15	69	88	8		26	5	2	198
TOTAL		**410**	**342**	**55**	**112**	**220**	**8**	**7**	**1154**

*Common pip: common pipistrelle (*Pipistrellus pipistrellus*); Soprano pip: soprano pipistrelle (*P. pygmaeus*); Unknown pip: Unknown pipistrelle; Nath pip: Nathusius' pipistrelle (*P. nathusii*)

Table 4.2: Average bat encounter rates (per hour) in 2022 in each Northern Ireland survey square, for Northern Ireland as a whole (n=9), and the whole island (n=47).

	Common pip *	Soprano pip*	Unknown pip*	Nath pip*	Leisler's bat	Brown long-eared	Myotis spp.	All bats
C72	11.51	21.41	3.44	0.00	9.53	0.00	0.00	45.90
H13	48.57	41.24	9.16	0.00	13.75	0.00	1.83	114.56
H79	41.75	25.78	5.21	3.17	14.18	0.45	0.42	90.97
J06	22.45	23.20	2.47	51.94	38.70	0.95	0.51	140.22
J33	70.46	47.84	7.53	0.00	24.46	1.62	1.06	152.96
Northern Ireland	**38.94**	**31.89**	**5.56**	**11.02**	**20.12**	**0.60**	**0.76**	**108.92**
All-Ireland	*87.30*	*53.82*	*17.89*	*2.65*	*27.88*	*0.45*	*1.12*	*191.45*

*Common pip: common pipistrelle (*Pipistrellus pipistrellus)*; Soprano pip: soprano pipistrelle (*P. pygmaeus*); Unknown pip: Unknown pipistrelle; Nath pip: Nathusius' pipistrelle (*P. nathusii*)

As in previous years, the overall common pipistrelle encounter rate recorded from Northern Ireland squares in 2022 (38.9hr^{-1}) was lower than the island-wide average (87hr^{-1}) (See Table 4.2).

The average encounter rate for soprano pipistrelles for Northern Ireland (31.9hr^{-1}) was also lower than the island-wide average (53.8hr^{-1}).

Encounter rates with Leisler's bat have been variable over the years and Northern Ireland's encounter rate of 20.1hr^{-1} in 2022 was slightly lower than the island-wide average of 27.9hr^{-1}, although square J06 well exceeded the island wide average.

While Nathusius' pipistrelles were absent from the Car-based Bat Monitoring survey recordings in Northern Ireland in 2008, in 2009 this species was recorded from three Northern Irish 30km squares. It has been recorded in Northern Ireland every year since then, generally in one or two survey squares, one of which usually includes J06 which is situated along the eastern shores of Lough Neagh. In 2022 Nathusius' pipistrelle was recorded from J06 and H79.

4.3.4 Bat Records

All bat records derived from the Car-based-bat Monitoring Scheme for Northern Ireland will be forwarded to the BCT and CEDaR, as in previous years.

4.3.5 Roadside Bat Trends

The following graphics for both all-island and Northern Ireland roadside bat trends from both Tranquility and Batlogger detectors are derived from Poisson GLM models with GAM smoothing (for common pipistrelle, soprano pipistrelle, Leisler's bat and Myotis spp.) and a covariate for detector type.

The trend for Nathusius' pipistrelle (all-Ireland), however, is a binomial GLM model (also with a covariate for detector) based on the proportion of one mile transects passes of this species.

The baseline is set to 2010 for the Northern Ireland-only trends because just 3 squares were surveyed in Northern Ireland in 2006, the baseline year for the all-Ireland trends. Using 2010 as a baseline instead, results in tighter error bars. A Northern Ireland-only trend (Poisson GLM) is shown just for common pipistrelle and soprano pipistrelle since these are the only species that occur in large enough numbers to facilitate trend analysis for Northern Ireland alone. Trends for remaining species in Northern Ireland alone are not provided due to the very wide confidence limits.

As can be seen from the graphs (Figures 4.5-4.8), common pipistrelles and soprano pipistrelles significantly increased during the monitoring period (2004-2022) across Ireland. The trends for Northern Ireland show similar levels of increase, albeit with much wider error bars.

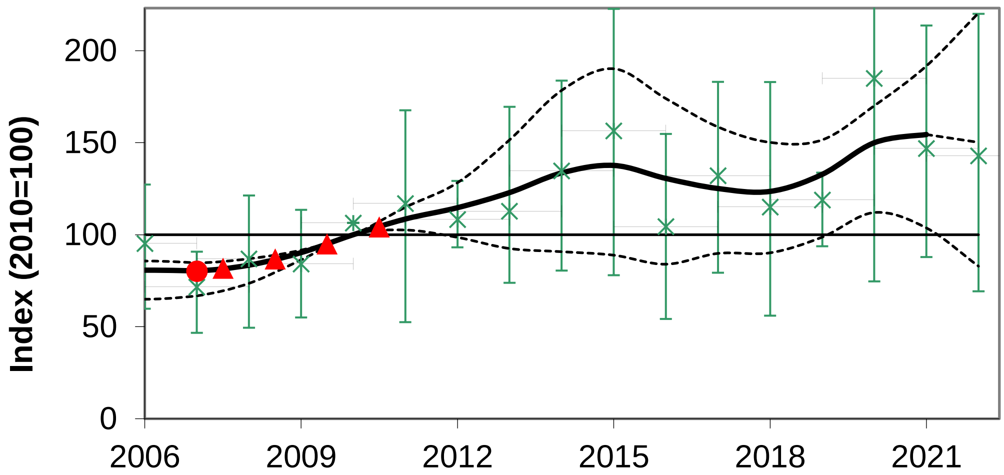

Figure 4.5: Results of the GAM/GLM model for **common pipistrelle**, **Northern Ireland** only. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. Both Tranquility and Batlogger data are included, with a covariate for detector to adjust for their different sensitivities. The response variable is the number of snapshots/soundfiles with the species present. The log of total survey time is used as an offset. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2021-2022 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).

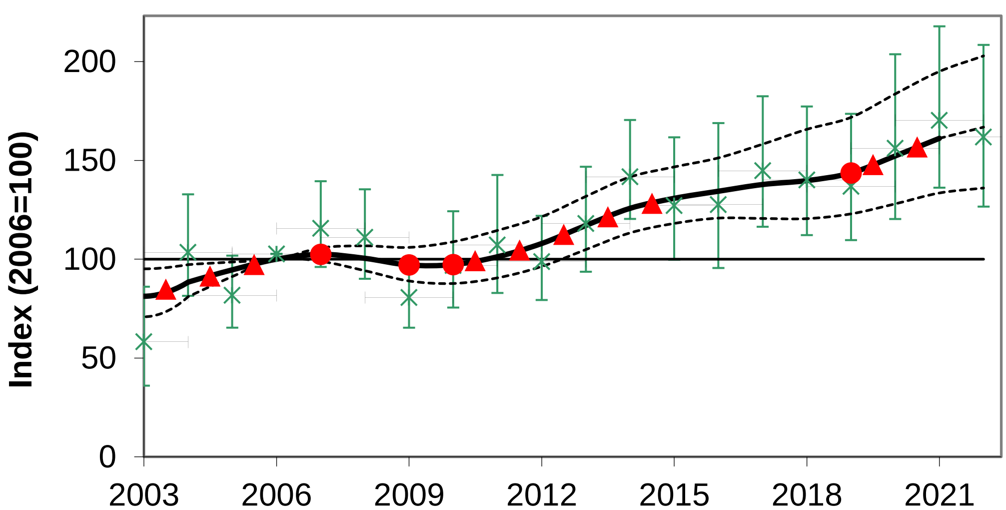

Figure 4.6: Results of the GAM/GLM model for **common pipistrelle**, **all-Ireland**. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. Both Tranquility and Batlogger data are included, with a covariate for detector to adjust for

their different sensitivities. The response variable is the number of snapshots/soundfiles with the species present. The log of total survey time is used as an offset. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2021-2022 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).

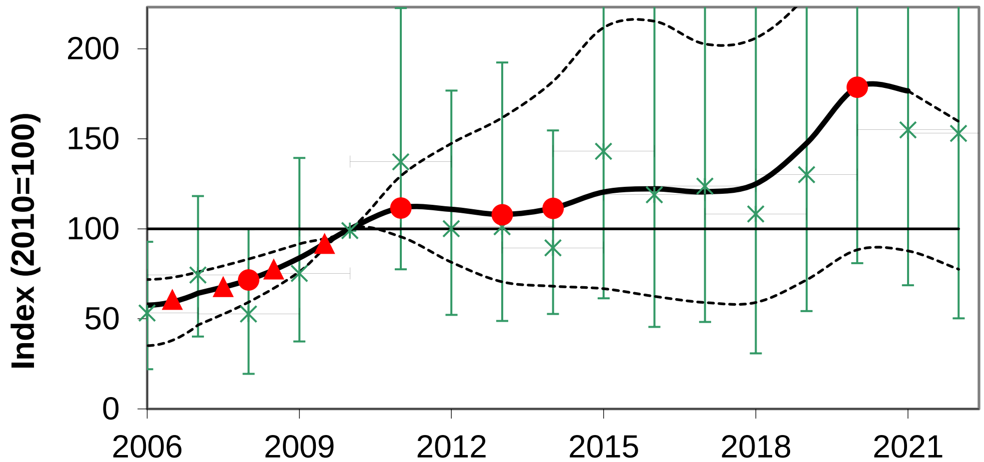

Figure 4.7: Results of the GAM/GLM model for **soprano pipistrelle**, **Northern Ireland only**. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. Both Tranquility and Batlogger data are included, with a covariate for detector to adjust for their different sensitivities. The response variable is the number of snapshots/soundfiles with the species present. The log of total survey time is used as an offset. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2021-2022 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).

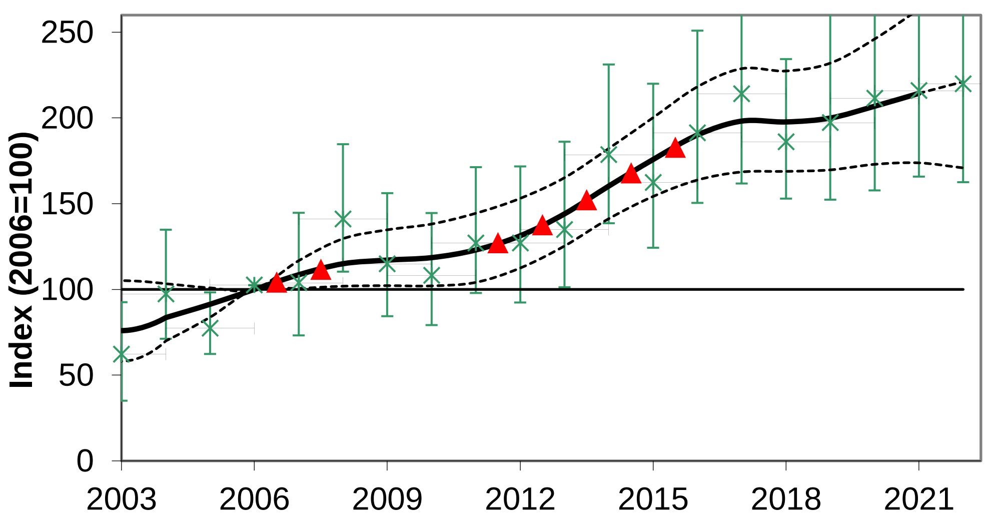

Figure 4.8: Results of the GAM/GLM model for **soprano pipistrelle** **all-Ireland**. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by lighter black lines. Both Tranquility and Batlogger data are included, with a covariate for detector to adjust for

their different sensitivities. The response variable is the number of snapshots/soundfiles with the species present. The log of total survey time is used as an offset. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2021-2022 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).

From Figure 4.9 Leisler's bat has also increased significantly since surveys began and, while it fluctuated for a number of years, it has increased very steeply in the past few years.

Nathusius' pipistrelle (Figure 4.10) also appears to be significantly increasing. Error bars are particularly wide for Nathusius' pipistrelle, however, due to the low number of records for the species.

Relatively few encounters with *Myotis* spp. are recorded every year. Nonetheless the use of the Batlogger has resulted in reduced error bars for this species group index. The decline we observed in this species group for six years running levelled out a little in 2022. Nonetheless, the trend is still significantly below the baseline, see Figure 4.11.

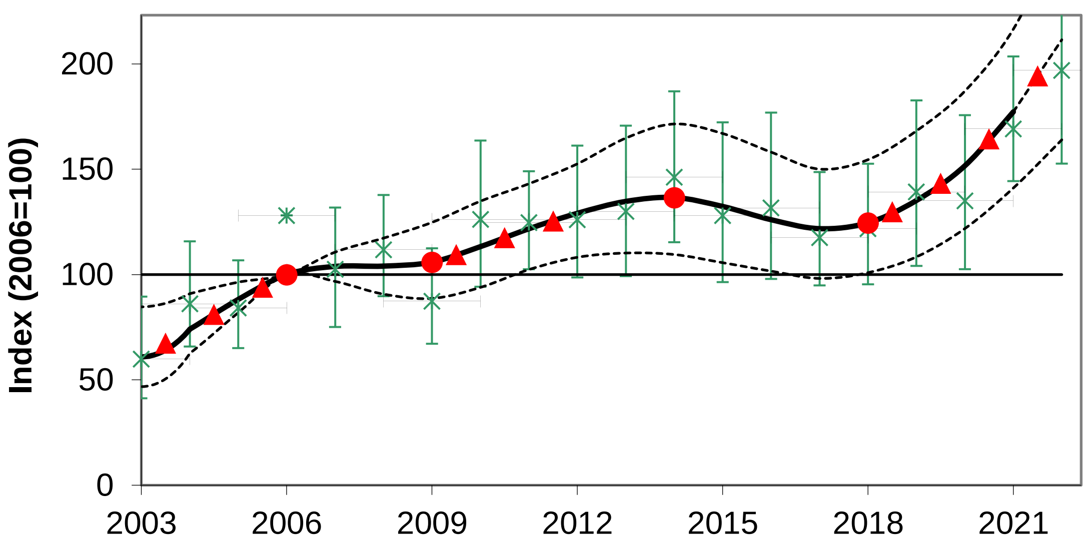

Figure 4.9: Results of the GAM/GLM model for **Leisler's bat** passes per survey (all Ireland). Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. Both Tranquility and Batlogger data are included, with a covariate for detector to adjust for their different sensitivities. The response variable is the number of snapshots/soundfiles with the species present. The log of total survey time is used as an offset. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2021-2022 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).

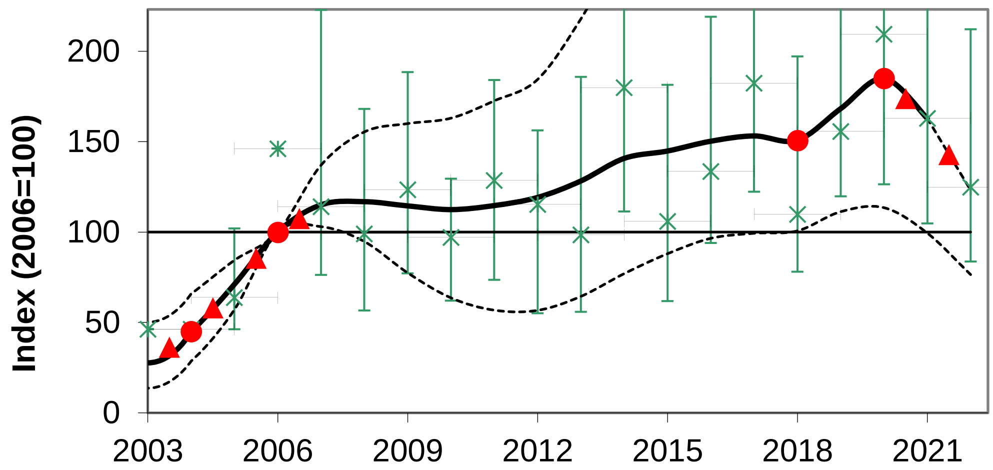

Figure 4.10: Results of Binomial GLM modeling for proportion of transects with **Nathusius' pipistrelle** present, all-Ireland. The black line is the smoothed GAM curve, with 95% confidence limits shown by the lighter black lines. Points are estimated annual means and are shown to illustrate the variation about the fitted line. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2021-2022 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).

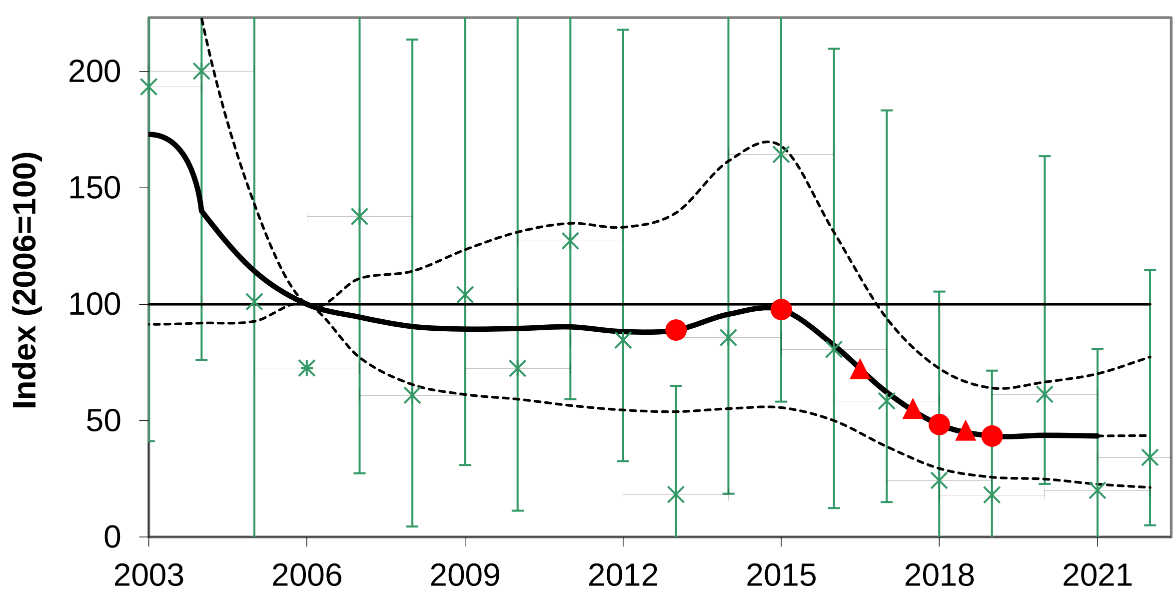

Figure 4.11: Results of the GAM/GLM model for ***Myotis* spp.** passes per survey. Points are estimated annual means derived from the Generalised Linear Model (GLM) and the bars are 95% bootstrapped confidence limits. The heavy black line is the fitted Generalised Additive Model (GAM) curve with 95% confidence limits shown by the lighter black lines. Both Tranquility and Batlogger data are included, with a covariate for detector to adjust for their different sensitivities. The response variable is the number of snapshots/soundfiles with the species present. The log of total survey time is used as an offset. The end of the smoothed trend is shown with a broken line to illustrate uncertainty for 2021-2022 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).

4.3.6 Other Vertebrates on Roadsides in Northern Ireland in 2022

Domestic cats were the most frequently encountered vertebrate species during the car surveys (n=29, 47%). Foxes were the second most frequently encountered species (n=8, 15%). Other species recorded were dogs, rabbits, mice, badgers and one hedgehog. Seven dead vertebrates were recorded by surveyors in Northern Ireland in 2022, two grey squirrels, one hedgehog, three rabbits and one cat.

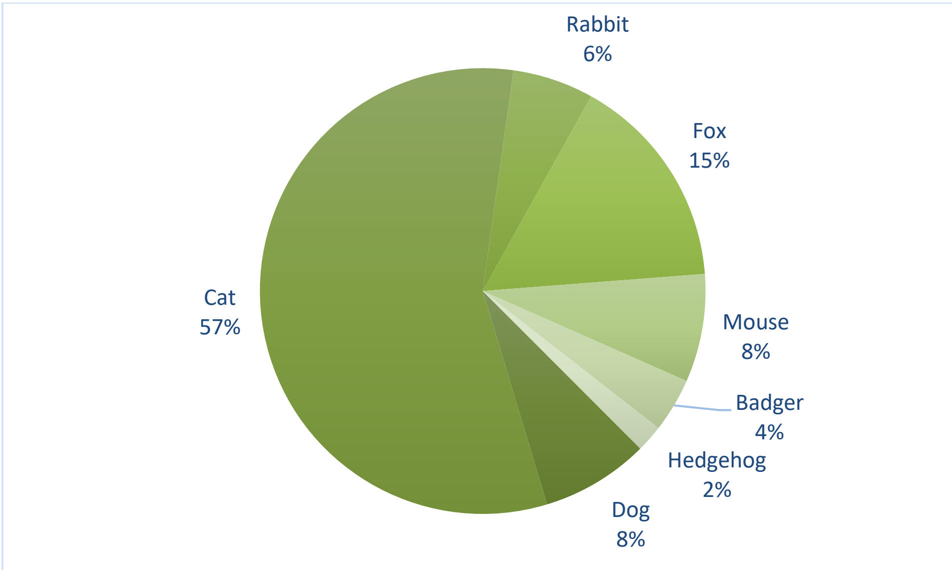

Figure 4.12: Living vertebrates, other than bats, observed during car-based bat monitoring surveys in Northern Ireland, 2022, n=51 from 9 surveys.

4.4 Discussion

Car-based Bat Monitoring surveys have been successfully carried out in Northern Ireland from 2006 to 2022. A slightly lower number of surveys than average were carried out in 2020. This was at least in part due to the nature the Covid 19 pandemic; some losses to the survey were perhaps to be expected. We trained in four new Northern Irish survey teams in 2022 via Zoom. With the exception of one survey in August where the team experienced an equipment failure, all surveys were successfully carried out in July and August 2022.

While yearly encounter rates vary widely, in general, common pipistrelles are usually recorded less frequently in Northern Ireland than on the island as a whole. Since the common pipistrelle is more abundant towards the centre and south of the island (e.g. see Lundy *et al.* 2011), lower encounter rates with this species may be anticipated in the north. This may be due to cooler climate and/or differing habitat types in northern parts of the island. While the trend dipped slightly from 2017-2019, 2020 to 2022 saw a resumption of an increasing trend in this species. This increasing trend is evident in both All-Ireland and Northern Ireland-only trends. The island-wide roadside population of the common pipistrelle has shown a significantly increasing trend in the past twelve years. It has increased by 64.8% in that timeframe (2011-2022), which is equivalent to a yearly 4.3% increase.

Average roadside encounter rates of soprano pipistrelles in Northern Ireland vary somewhat but, on the whole, tend to be roughly similar to that island-wide. The soprano pipistrelle has increased significantly since the start of the survey – its all-island roadside population increased by 79.8% from 2011-2022, a per annum increase of 5%. The Northern Ireland only trend showed a slight dip in recent years although overall its trendline is not significantly different to the All-Ireland one.

Nathusius' pipistrelles are recorded more often in Northern Ireland than the island-wide or Republic of Ireland average. Nathusius' pipistrelle was recorded from squares J06 and H79 in Northern Ireland in 2022. The species has been recorded in square J06 in most years of the survey. This survey route is situated close to Lough Neagh which is considered the stronghold for the species. Nathusius' pipistrelle is not specifically targeted by this monitoring scheme due to its overall low encounter rate. However, a binomial model of Nathusius' encounters for the whole island is used (e.g. see Roche *et al.*, 2013). Nathusius' pipistrelle showed an increasing trend in the early years of the survey. This then stabilized somewhat and has very recently shown a slight decrease so the error bars again encompass the baseline. (despite correcting for the change in bat detector type).

Numbers of Leisler's bats increased significantly from 2003 to a peak in 2014 and then declined from 2015 to 2018. However, 2019 to 2022 saw a resumption of the increasing trend which has become even steeper. Over the past 12 years (2011-2022) the roadside population of Leisler's bats has increased by 73.7%, or 4.7% per annum.

This year we noted that the concerning decline in *Myotis* species composite index has levelled out somewhat, but the index is still well below the baseline for the species group.

5.0 REFERENCES AND SOURCES OF INFORMATION

Anon (2020) The National Monitoring Programme, Annual Report 2019. Bat Conservation Trust, UK.

Anon (2010) The National Monitoring Programme, Annual Report 2009. Bat Conservation Trust, UK.

Anon (2004) The National Monitoring Programme, Annual Report 2003. Bat Conservation Trust, UK.

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

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

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

Aughney, T., Roche, N. And Langton, S. (2010) Irish Bat Monitoring and Recording Schemes: Annual Report 2009. Bat Conservation Ireland. www.batconservationireland.org.

Aughney, T., Roche, N. And Langton, S. (2011) Irish Bat Monitoring and Recording Schemes: Annual Report 2010. Bat Conservation Ireland. www.batconservationireland.org.

Aughney, T., Langton, S. and Roche, N. (2012) All Ireland Daubenton's Bat Waterway Monitoring Scheme: Synthesis Report for 2006-2011. *Irish Wildlife Manuals No. 61*. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government.

Aughney, T., Roche, N. And Langton, S. (2013) Irish Bat Monitoring and Recording Schemes: Annual Report 2012. Bat Conservation Ireland. www.batconservationireland.org.

Aughney, T., Roche, N. And Langton, S. (2014) Irish Bat Monitoring and Recording Schemes: Annual Report 2013. Bat Conservation Ireland. www.batconservationireland.org.

Aughney, T., Roche, N. And Langton, S. (2015) Irish Bat Monitoring and Recording Schemes: Annual Report 2014. Bat Conservation Ireland. www.batconservationireland.org.

Aughney, T., Roche, N. And Langton, S. (2016) Irish Bat Monitoring and Recording Schemes: Annual Report 2015. Bat Conservation Ireland. www.batconservationireland.org.

Aughney, T., Roche, N. And Langton, S. (2017) Irish Bat Monitoring and Recording Schemes: Annual Report 2016. Bat Conservation Ireland. www.batconservationireland.org.

Aughney, T., Langton, S. and Roche, N. (2018) Irish Bat Monitoring and Recording Schemes: Synthesis Report for 2006-2017. *Irish Wildlife Manuals No. 103*. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht.

Aughney, T., Roche, N. And Langton, S. (2020) Irish Bat Monitoring and Recording Schemes: Annual Report 2019. Bat Conservation Ireland. www.batconservationireland.org.

Aughney, T., Langton, S. and Roche, N. (2022) Irish Bat Monitoring and Recording Schemes: Synthesis Report for 2006-2021. *Irish Wildlife Manuals* 137. National Parks and Wildlife Service.

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

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

Dunn, E. H. (2002) *Using decline in bird populations to identify needs for conservation action.* Conservation Biology, 16 (6): 1632-1637.

Fenton, M. B. (1990) The foraging behaviour and ecology of animal-eating bats. *Canadian Journal of Zoology* 75: 131-136.

Lundy M.G., Aughney T., Montgomery W.I., and Roche N. (2011). *Landscape conservation for Irish bats & species specific roosting characteristics*. Bat Conservation Ireland.

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

Mitchell-Jones, A. J., Cooke, A. S., Boyd, I. L. and Stebbings, R. E. (1989) Bats and remedial timber treatment chemicals – a review. *Mammal Review* 19: 93-110.

Norberg U.M. and Rayner, J.M.V. (1987) Ecological morphology and flight in bats (Mammalia: Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. *Phil. Trans. Roy. Soc. Lond. B.* 316: 335-427.

Racey, P. A. (1988) Reproductive assessment in bats. In: Ecological and behavioural methods for the study of bats. Edited by T. H. Kunz, Smithsonian Institute Press, Washington, D. C. pp. 31-43.

Racey, P. A. and Stebbings, R.E. (1972) Bats in Britain – a status report. *Oryx* 11: 93-110.

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

Roche N., Langton S. and Aughney T. (2012). Car-based bat monitoring in Ireland 2003-2011. *Irish Wildlife Manuals*, No 60. National Parks and Wildlife Service, Department of the Arts, Heritage and the Gaeltacht.

Roche N., Langton S., Aughney T., Russ J.M., Marnell F., Lynn D., Catto C. (2011). A car based bat monitoring method reveals new information on bat populations and distributions in Ireland. *Animal Conservation*. **14**: 642-651.

Russ, J. M. & Montgomery, W. I. (2002) Habitat associations of bats in Northern Ireland: implications for conservation. *Biological Conservation* **108**: 49-58.

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

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

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

Tuttle, M. D. (2003) Estimating population size of hibernating bats in caves and mines. In Monitoring trends in bat populations of the United States and *Territories: problems and prospects.* U.S. Geological Survey, Biological Resources Discipline, Information and Technology Report, Fort Collins, CO, USA. USGS/BRD/ITR 2003, 0003, 274 pp.

Walsh, A., and Harris, S. (1996) Foraging habitat preference of Vespertilionid bats in Britain. *Journal of Applied Ecology* 33, 508-518.

Warren, R. D. & Witter, M. S. (2002) Monitoring trends in bat populations through roost surveys: methods and data from *Rhinolophus hipposideros. Biological Conservation*, **105**: 255 261.

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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.

8.0 APPENDIX 1

All-Ireland Daubenton's Bat Waterway Survey

Note: All waterway site results received by February 2023 were submitted for analysis. Similarly, waterway sites received late from previous years of monitoring will have been added, subsequently, to the dataset for future analysis. Consequently, the totals for each year will differ from previous reports.

Summary statistics

Table 1: basic stats 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) 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	83	32.2	8.2	40.5	38.9	89.2	53.3
2014	110	30.8	6.6	37.4	34.4	91.8	45.0
2015	97	47.4	6.3	53.6	51.8	88.7	58.0
2016	87	42.0	5.9	47.9	46.7	92.0	56.3
2017	72	47.9	8.9	56.8	52.2	95.7	61.6
2018	96	37.5	7.0	44.5	43.2	90.3	56.0
2019	93	30.7	6.8	37.5	36.7	90.3	52.9
2020	96	33.3	3.8	37.1	36.6	92.7	51.5
2021	96	27.6	4.7	32.3	32.2	89.6	49.9
2022	74	29.4	4.2	33.6	32.6	87.8	49.6
All years	1399	39.1	7.4	46.5	44.6	91.7	55.3

b) 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	409	51.6	10.4	62.1	59.0	93.9	62.4
2012	399	44.0	9.6	53.6	51.9	93.2	58.9
2013	414	41.7	8.2	49.9	47.8	89.6	54.6
2014	474	40.2	8.1	48.3	44.2	89.9	52.9
2015	467	44.5	8.2	52.7	49.9	91.0	56.7
2016	442	45.8	7.9	53.7	49.5	89.4	56.1
2017	416	47.2	8.7	55.9	50.8	91.8	57.2
2018	426	45.9	7.0	52.9	49.2	88.0	54.3
2019	424	37.5	6.9	44.4	42.6	89.1	51.8
2020	415	38.8	6.1	44.9	43.3	92.0	52.4
2021	418	38.4	7.0	45.4	44.1	90.4	52.2
2022	435	44.4	8.1	52.5	48.1	89.6	54.1
All years	6861	43.7	8.5	52.3	49.0	91.0	55.6