Irish Bat Monitoring Programme

All-Ireland Daubenton's Bat Waterway Survey 2006

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EXECUTIVE SUMMARY

Monitoring protocols for bat populations is essential due to the paucity of information on the present distribution of many of Ireland's resident bat species. Without such protocols, it is difficult to compile any comprehensive review of the current status of bat populations. Monitoring trends of bat populations also addresses obligations under the EU Habitats Directive and the EUROBATS Agreement.

The Bat Conservation Trust (BCT) Daubenton's Bat Waterways Survey is the current monitoring protocol in operation for monitoring Daubenton's bats on waterways in the UK. It was introduced in 1997 and focuses on Daubenton's bat activity along waterways such as rivers and streams (but excludes ponds and lakes) as this species is known to have a high dependency on such waterbodies for foraging. The survey methodology relies on the use of heterodyne bat detectors. The simplicity of their use makes participation in field surveys possible to a wider number of volunteers.

The Daubenton's bat is easy to see when foraging because it opportunistically feeds close to water especially over smooth water surface. It can be found foraging over rivers, streams, canals, pools and lakes. It forages very close to the water, typically within 30cm of the surface. A 'bat pass' is a sequence of echolocation calls registered indicating a bat in transit. The 'bat pass' is the unit generally measured when surveying for bats. The characteristic nature of Daubenton's bats flying along a regular 'beat' over the surface of water makes it an easy species to record 'bat passes'.

The All-Ireland Daubenton's Bat Waterway Survey pilot was undertaken in August 2006. Volunteers were assigned a location selected from a dataset of sites currently sampled for biological and chemical water quality parameters. From this starting location ten points, 100m apart, were surveyed by volunteers on two evenings in August 2006. At each of the 10 points volunteers recorded Daubenton's bat activity for 4 minutes. A Total of 134 waterway sites were surveyed in 27 counties. Daubenton's bat 'passes' were recorded on 122 waterway sites (91%).

To investigate the relationship between the log-transformed numbers of passes and other variables, an REML model was fitted to the data. Analysis of data suggests that there is an increase in passes with the width of waterways surveyed up to a maximum of 20m. Temperature has a significant influence on the number of passes recorded while rain significantly reduced the number of passes recorded. Power analysis indicates that after 10 years it may be possible to detect Red Alert declines with 90% power if 80 core sites are surveyed twice annually. After 25 years, Amber Alert declines can be detected with 90% power with 60 sites surveyed twice annually.

1. INTRODUCTION

1.1 Why Monitor the Daubenton's bat *Myotis daubentonii*?

Bats constitute a large proportion of the mammalian biodiversity in Ireland. Ten species of bat are known to occur 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, including the Daubenton's bat, are protected under Irish and EU legislation. Under the Wildlife Act (1976) and Wildlife (Amendment) Act 2000, it is an offence to intentionally harm a bat or disturb its resting place. Bats in Northern Ireland are protected under the Wildlife (Northern Ireland) Order 1985.

The EU Directive (92/43/EEC) on the Conservation of Natural and Semi-natural Habitats and of Wild Flora and Fauna (The Habitats Directive) lists all Irish bats species, including Daubenton's bat, in Annex IV while the lesser horseshoe bat *Rhinolophus hipposideros* is listed in Annex II. Member states must maintain or restore 'favourable conservation status' of species listed in Annex II, IV and V. Favourable conservation status is defined as 'the sum of the influences acting on the species concerned that may affect long-term distribution and abundance'. Articles 11 of the Directive requires 'Member States to undertake surveillance of the conservation status of all bat species.

Ireland is also a signatory to a number of conservation agreements pertaining to bats including the Bern and Bonn Conventions. Under the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals, 1979), Ireland and the UK (including Northern Ireland) are signatories of the European Bats Agreement (EUROBATS). This agreement recognises that endangered migratory species can only be fully protected if their migratory range is protected. Under this agreement, strategies for monitoring bat populations of selected species are part of its Conservation and Management Plan. Across Europe, they are further protected under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention 1982), which, in relation to bats, works to conserve all species and their habitats.

To fulfil 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).

The paucity of information on the present distribution of many of Ireland's resident bat species means that it is difficult to compile any comprehensive review of the current status of bat populations. Detailed population statistics are only available for the lesser horseshoe bat.

The Irish Red Data Book of vertebrates (Whilde, 1993) lists the populations of all Irish bats species that were known to occur at the time of publication as Internationally Important.

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. A 50% and 25% decline over 25 years translates into an annual decline of 2.73% or 1.14% respectively. Thus if a 1.14% decline rate is observed in less than 25 years, then the species is given Amber Alert status. 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 is sensitive enough to meet Alert Levels.

Recent EU Habitats Directive Guidelines for assessing conservation status have suggested that a population decline of >1% per annum would constitute a Red Alert decline.

The Car-based Bat Monitoring Protocol for the Republic of Ireland, in operation since 2003, provides a method of monitoring bat species that utilise habitats along road networks. Results from 2004 show that the current survey method and intensity is robust enough to highlight Red Alert declines in Leisler's bats *Nyctalus leisleri*, common pipistrelles *Pipistrellus pipistrellus* and soprano pipistrelles *P. pygmaeus* within approximately 10-15 years of monitoring sufficient numbers of survey squares (Roche *et al.,* 2005). However, this monitoring protocol has recorded very few *Myotis* bat calls. Further monitoring protocols are required to collate population trends on the *Myotis* and other Irish species (i.e. *Myotis daubentonii, M. nattereri, M. brandtii, M. mystacinus and Plecotus auritus)*.

The characteristic foraging style of Daubenton's bats makes it relatively easy to identify the species in the field and thus a suitable candidate for large scale volunteer-based surveys. This species actively select waterways as its preferred foraging habitat and it is also known to use stable (night-to-night) foraging sites in the summer.

1.2 Daubenton's bat *Myotis daubentonii*: a brief species profile

1.2.1 DISTRIBUTION

Daubenton's bat belongs to the Family Vespertilionidae and has a widespread distribution along a narrow band across Europe and Asia from Ireland, Britain, France, Iberian Peninsula to the Pacific Ocean and the northern islands of Japan (Altringham, 2003). It is widely distributed in Ireland (O'Sullivan, 1994). Daubenton's bat is often called the water bat due to its preference for hunting close to water (Fairley, 2001).

Factors affecting the population of Daubenton's bat include a reduction in water quality of surface waters and loss of riparian vegetation including mature trees that can be used as roosts. Factors that reduce roosts, both summer and hibernation, will also impact on this species (Walsh *et al.,* 2001). In Ireland, bridge maintenance involving the spraying of liquid concrete into crevices under the arches of bridges is a major contributor to roost destruction (Smiddy, 1991, O'Sullivan, 1994 and Shiel, 1999).

The recent discovery of a strain of European Bat Lyssavirus (EBLV2) within the UK Daubenton's bat population makes this species of interest from a Public Health point of view. The methodology of the All Ireland Daubenton's Bat Waterway Survey and the current BCT, UK Daubenton's Bat Waterway Survey do not involve the capture of live specimens so will not result in any potential EBLV exposure risk to volunteers.

1.2.2 SURVEYING DAUBENTON'S BATS

The Daubenton's bat foraging behaviour over waterways is exploited by the methodology of the All-Ireland Daubenton's Bat Waterways Survey. A description of this species foraging behaviour is described briefly below. A more detailed account is found in Aughney and Roche (2006).

1.2.2.1 Emergence behaviour in Daubenton's bats during summer months

Emergence times differ between species but Daubenton's bats have been recorded emerging only when it is fully dark rather than at dusk (Walsh *et al,* 2001) which can range from 30 to 120 minutes after sunset (Swift and Racey, 1983; Warren *et al,* 2000; Altringham, 2003). Daubenton's bats have also been reported to follow the most sheltered route to and from roosting sites to foraging areas, even if that means longer travelling times (Limpens and Kapteyn, 1991). This combined with a later emergence from a roost means that it can be 2 hours after sundown or later by the time this bat species arrives at a foraging site.

1.2.2.2 Feeding behaviour of Daubenton's bats during summer months

The Daubenton's bat is easy to see when foraging because it opportunistically feeds close to water, especially over smooth water surface. It can be found foraging over rivers, streams, canals, pools and lakes. It forages very close to the water, typically within 30cm of the surface. Here, it either trawls for insects from the surface of the water by gaffing them with its large feet or the tail membrane, or takes them directly out of the air (aerial hawking) (Jones and Rayner, 1988). Daubenton's bats can be observed flying continuously back and forth along a regular flight path.

1.2.2.3 Echolocation calls and foraging style of Daubenton's bats

Exploitation of insect prey populations and orientation during the darkened hours means that bats rely on vocalisation or echolocation when commuting and foraging. Echolocation calls of a bat species is related to the foraging habitat, the shape of the wings and time of emergence (Russ, 1999). Daubenton's bats tend to use Frequency Modulated (FM) echolocation pulses ranging in a downward sweep on average from 79 to 33 kHz in a typical foraging habitat. FM pulses are usually used by bats in cluttered environments. While flying over water surface may not be considered as a cluttered environment in the true sense, the reflective properties of water combined with speed of the bat, means that for the Daubenton's bat a water surface can be considered as a cluttered environment.

1.2.2.4 Identifying the Daubenton's bat using bat detectors

The All-Ireland Daubenton's Bat Waterways Survey relies on the use of heterodyne bat detectors to identify the characteristic echolocation call of this bat species. Bat detectors are required because the human ear is sensitive to sound frequencies from approximately 40Hz to 20,000Hz (20kHz). As a result, the echolocation calls of bats tend to be outside the human hearing range. Bat detectors convert the echolocation calls of bats into sounds that are audible to humans (Elliott, 1998). The most commonly used bat detector type is the heterodyne bat detector. Other frequently used methods are Frequency Division and Time Expansion.

Heterodyne bat detectors tend to be tuneable so the frequency, to which the detector is set at, is subtracted from the incoming frequency. Therefore if the detector is tuned to 50 kHz and the incoming bat call is at 55 kHz then the resultant output sound is at 5 kHz (Elliot, 1998). The main advantage of this type of detector is that the resultant sound has tonal qualities (e.g. clicks and smacks) and allows determination of the pulse repetition rate that combined will aid identification (Russ, 1999).

To discriminate fully between many species, a combination of visual observations in relation to habitat type, bat flight pattern and detector noise output is used. Daubenton's bats echolocation call on a heterodyne bat detector can be described as a rapid series of clicks, often likened to the sound of a machine gun. The pulse repetition rate is very fast and very regular and loudest at 45kHz (Russ, 1999). The Daubenton's bat has a characteristic echolocation call when typically foraging over water.

Sampling the activity of Daubenton's bats along waterways using a heterodyne bat detector is relatively straight forward. The echolocation call is loudest when the detector is tuned to 45kHz. However to distinguish from foraging pipistrelle bats it is recommended to tune the detector to 35kHz. At this frequency, the pipistrelle bat echolocation calls lose much of its tonal qualities but the dry 'clicks' characteristic of Daubenton's bats are still clearly audible (Russ, 1999).

1.2.2.5 Bat passes: a tool for surveying Daubenton's bats

A 'bat pass' is a sequence of echolocation calls registered indicating a bat in transit (Fenton, 1970). The 'bat pass' is the unit generally measured when surveying for bats. A 'bat pass' is a unit of bat activity and is a sequence of at least two echolocation calls indicating a bat in transit. The characteristic nature of Daubenton's bats flying along a regular 'beat' over the surface of water makes it an easy species to record 'bat passes'.

1.2.3 THE BCT DAUBENTON'S BAT WATERWAY SURVEY

The Daubenton's Bat Waterway Survey is the current monitoring protocol in operation for monitoring bats at waterways in the UK and is under the management of The Bat Conservation Trust (BCT). It was introduced in the UK in 1997 and focuses on Daubenton's bat activity along waterways such as rivers and streams (but excludes ponds and lakes) as this species is known to have a high dependency on such waterbodies for foraging. It is considered that the Daubenton's Bat Waterway Survey is an ideal method to introduce inexperienced volunteers to bat surveying. Consequently, it is the first field-based volunteer-dependent monitoring programme to be piloted in Ireland for monitoring bats.

2. THE ALL-IRELAND DAUBENTON'S BAT WATERWAY SURVEY 2006: AIMS AND METHODS

BCIreland piloted the All-Ireland Daubenton's Bat Waterway Survey in the Republic of Ireland and Northern Ireland in August 2006.

2.1 Aims of report

This report is an essential tool to present the results gathered by the large number of diligent volunteers who participated in this scheme. In addition, the report will act as a reference source for policy makers in relation to future management of Daubenton's bat populations.

Information collated from the first year of monitoring will provide data on the distribution of this bat species in the sites surveyed. Population trends cannot be determined from one year's data. Some statistical analysis was undertaken to investigate the influence of selected parameters on Daubenton's bats distribution and activity. Power analysis was carried out to determine the number of survey sites that must be surveyed over the coming years to enable detection of Red and Amber Alert declines.

2.2 Methods

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

Methodology is as follows: Surveyors are assigned a choice of 2 or 3 survey starting points. These points lie within 10km of the surveyor's preferred area and are selected from the EPA's National Rivers Monitoring Programme in the Republic of Ireland and the Water Quality Management Unit dataset under the EHS, Northern Ireland.

Surveyors undertake a day visit (with landowner's permission) to assess if a site is suitable and safe to survey. One site is chosen and ten points approximately 100m apart are marked out along a 1km stretch. The surveyors then revisit the site on two evenings in August and starting surveying 40 minutes after sunset. At each of the ten points, the surveyor records Daubenton's bat activity for four minutes using a heterodyne bat detector and torchlight (Walsh *et al.,* 2001). The methodology is designed to be simple, robust and repeatable in order to meet the basic principles of monitoring theory (Catto *et al,* 2003).

Bat passes are either identified as Daubenton's bat or 'Unsure' Daubenton's bat. Daubenton's bat passes are identified only if the bat is heard and seen skimming the water surface. Bat passes that are heard and sound like Daubenton's but not seen skimming the water maybe another species. Therefore these heard but not seen bats are recorded as 'Unsure' Daubenton's bat passes. The number of times a bat passes the surveyor is counted and often this can be one individual bat passing back and forth along the same stretch of river. 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 record a number of parameters including air temperature, weather data and waterway characteristics. Volunteers are required to undertake surveying in pairs for safety reasons. One member of the team is designated as the Surveyor 1 and uses the bat detector and torch while Surveyor 2 documents the numbers of 'passes' and other information required to be submitted on recording sheets. Information on the bat detection skills of Surveyor 1 and make of bat detector is requested for incorporation into analyses. On completion of both survey nights, surveyors are requested to return completed recording sheets and map (with the ten survey spots marked out) to BCIreland for analysis and reporting.

2.3 Volunteer uptake and participation

BCIreland widely advertised the scheme in order to recruit volunteers to participate in the survey. An on-line registration system was also set up on the BCIreland website to facilitate volunteer participation.

Due to the paucity of bat workers in the Republic of Ireland, it was necessary to provide training for volunteers prior to surveying. This training was also essential to encourage members of the public to participate in the scheme. Training for EHS staff members was also provided in Northern Ireland. Each training course consisted of a one hour Power Point presentation followed by an informal session where sites were allocated to volunteers. An information pack was also provided for each volunteer team consisting of detailed description of the methodology. An outdoor practical session was then undertaken to demonstrate the survey methodology.

3. Results

3.1 Training

BCIreland organised training courses throughout the Republic of Ireland and Northern Ireland in July and August 2006. Fourteen training courses were organised in liaison with local bat groups, Co. Co. Heritage Officers, NPWS and EHS staff members and university departments (Appendix B, Table 1).

A total of 207 people attended the training courses. A total of 173 Volunteer Packs were delivered to volunteers. Sixteen teams were located in Northern Ireland with the remaining 157 teams in the Republic of Ireland. Two of the Northern Ireland teams were provided with BCT UK Daubenton's Bat Waterway Survey sites.

3.2 Volunteer particpation in 2006

A total of 131 volunteer teams participated in 2006. In relation to level of skills, 75 (57.3%) volunteers rated their skills as 'Okay' and 32 (24.4%) volunteers rated their levels of skills as 'Good' (Figure 1). A large proportion of volunteers (43 volunteers = 32.1%) had 1 year of experience of bat detector usage (Figure 2). A total of 10 bat detector models were used by volunteers. The most common detector type was the Bat Box III (46 volunteers = 34%) followed by the Magenta Mark III (31 volunteers = 23%) (Figure 3).

Figure 1: Level of skills of volunteers participating in All-Ireland Daubenton's Bat Waterway Survey 2006 (n=131 volunteer teams).

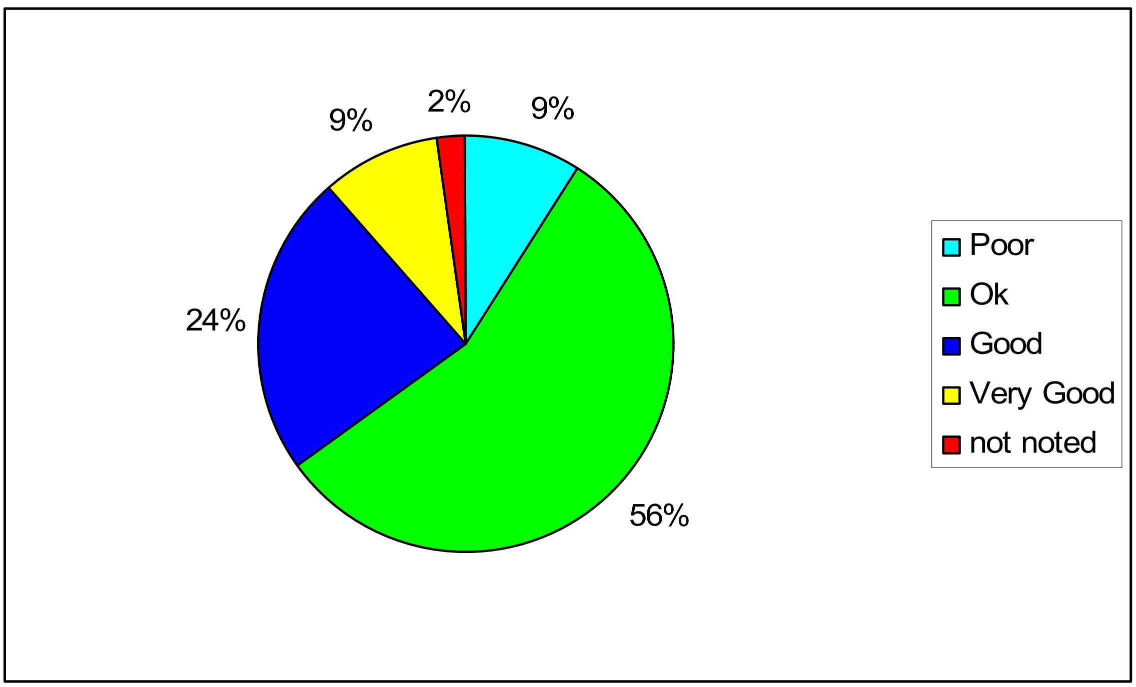


Figure 2: Level of experience of volunteers participating in All-Ireland Daubenton's Bat Waterway Survey 2006 (n=131 volunteer teams).

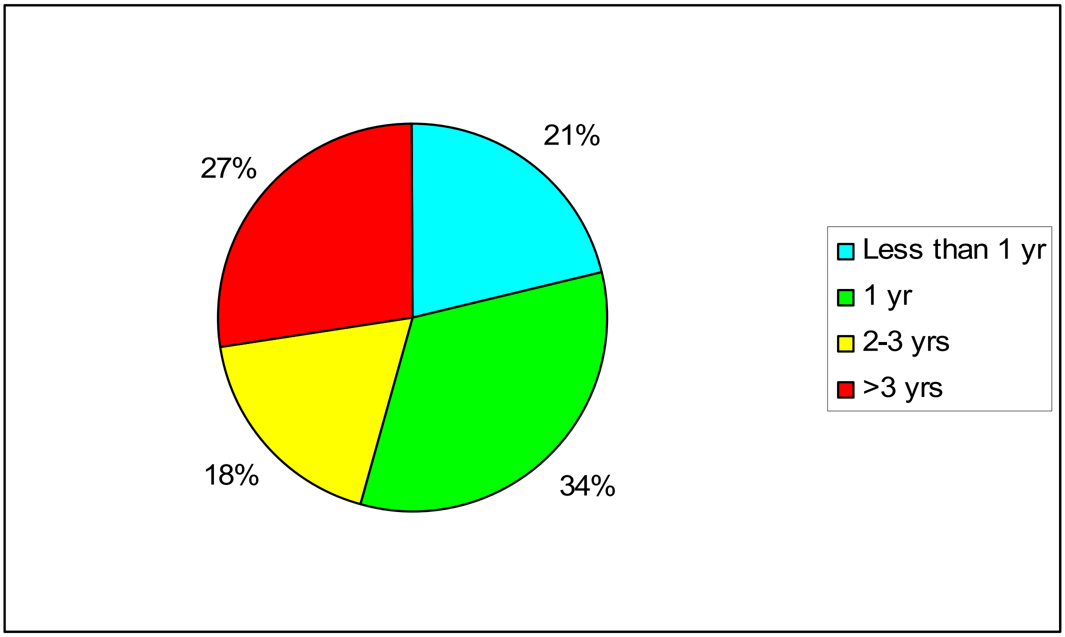
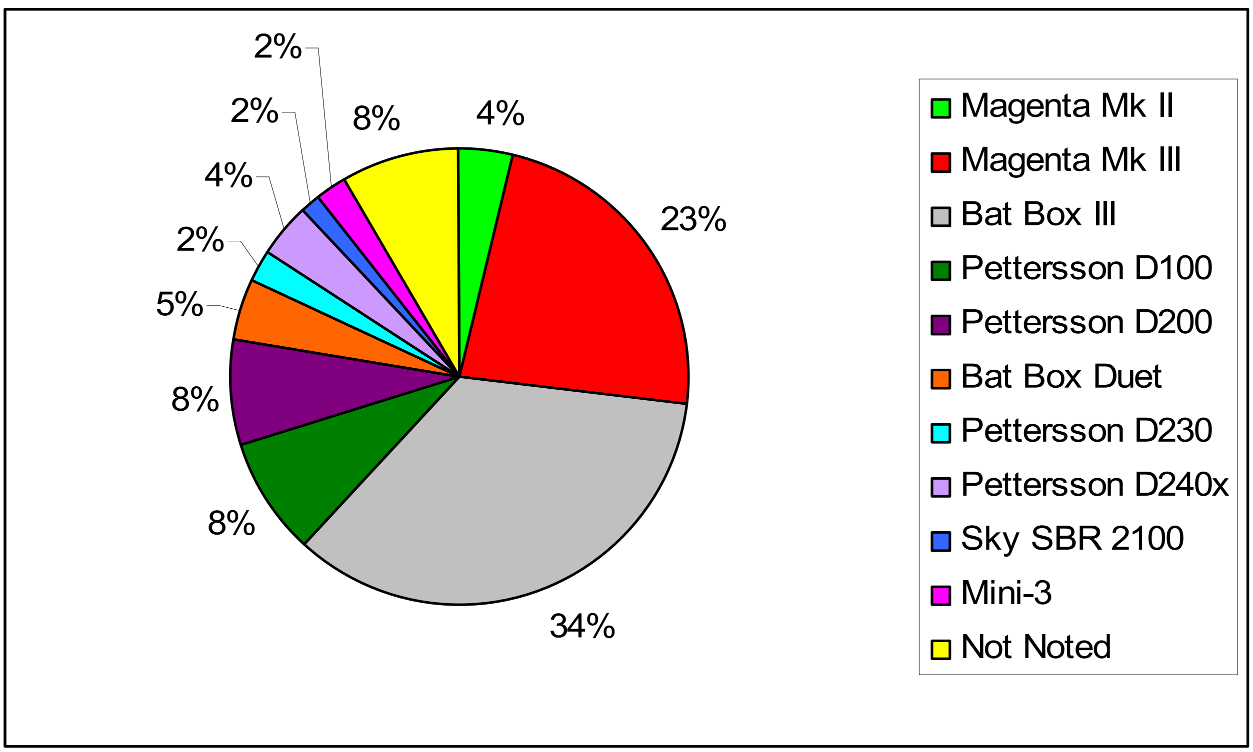


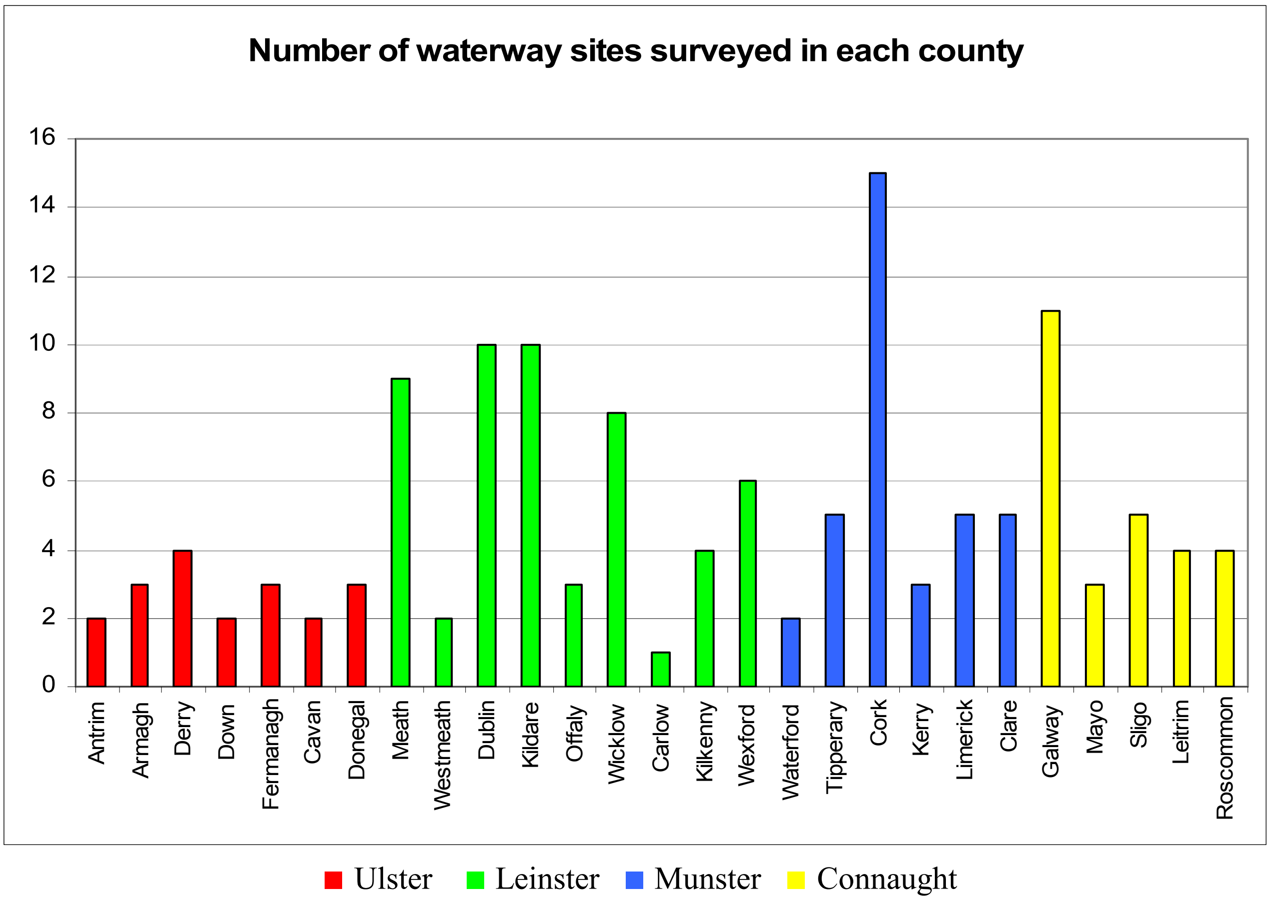
Figure 3: Bat detector models utilised by volunteers participating in All-Ireland Daubenton's Bat Waterway Survey 2006 (n=133, 131 volunteer teams, two teams used a different bat detector model for Survey 1 and Survey 2).



3.3 Waterway sites surveyed in 2006

A total of 134 waterway sites were surveyed by 131 survey teams using heterodyne bat detectors in 27 counties on Ireland (Republic of Ireland: 26 counties, 22 of which were surveyed, Northern Ireland; 6 counties, 5 of which were surveyed). The largest number of waterway sites surveyed were located in County Cork (n=15) followed by County Galway (n=11), County Dublin (n=10) and County Kildare (n=10) (Figure 4 & Appendix B, Table 2.

Figure 4: Number of waterway sites surveyed (n=134) in each county surveyed (n=27) in August 2006. Five counties were not surveyed in 2006: Monaghan (RoI), Louth (RoI), Longford (RoI), Laois (RoI) and Tyrone (NI).



One hundred and twenty-two waterway sites were surveyed twice with the remaining 12 waterway sites surveyed once. A total of 89 rivers, 6 canals and one channel (North Slobs) were surveyed. Twenty-one waterways had more than one surveyed site (e.g. 8 survey sites along the length of the Grand Canal).

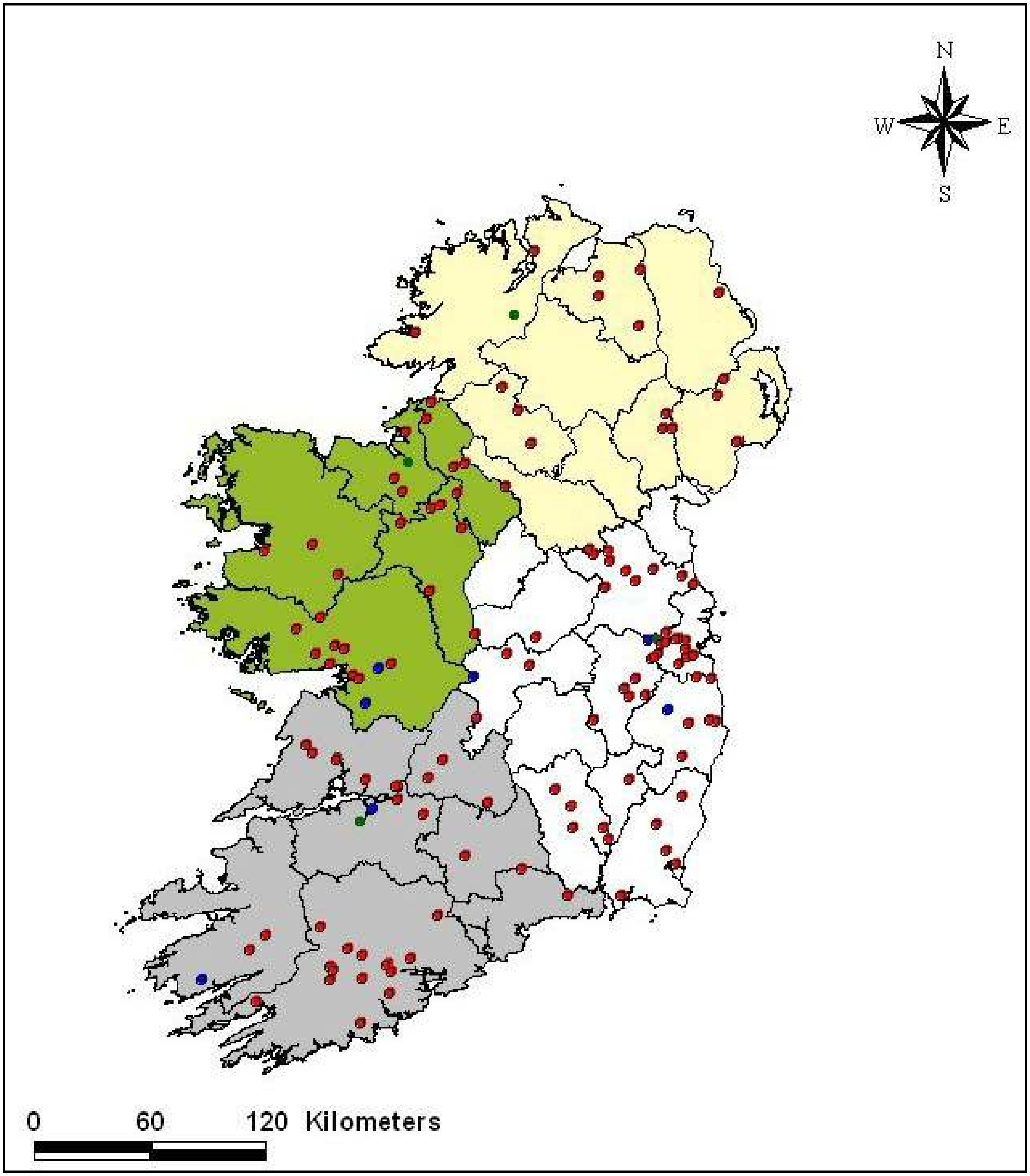


Figure 5: Waterway sites surveyed in 2006 (n=134). **Red** indicates those 1km transects in which surveys were repeated (n=122). **Blue** circles represent those waterway sites surveyed in Survey 1 only (n=7) and **Green** circles were surveyed in Survey 2 only (n=5).

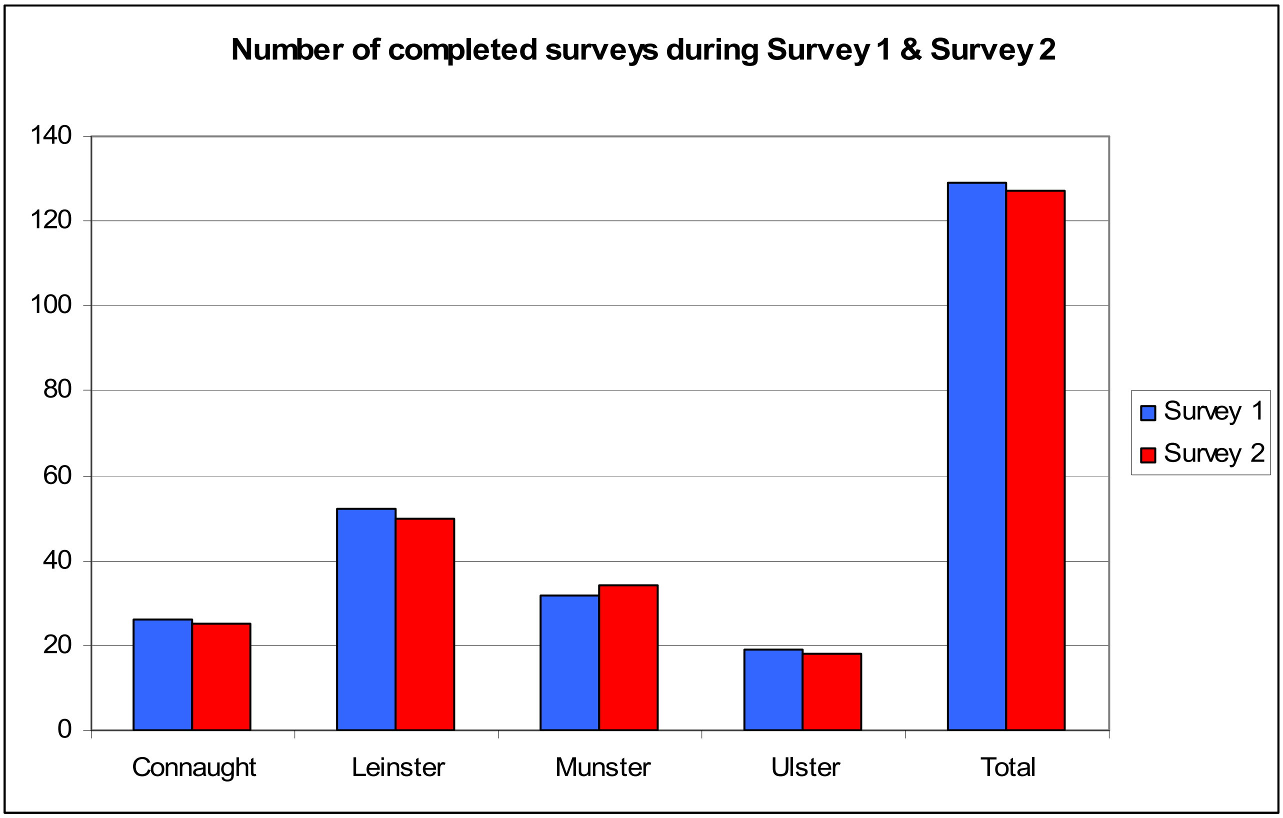
Provinces are shaded the following colours:
Green = Connaught; White = Leinster; Grey = Munster & Yellow = Ulster.

3.4 Number of completed surveys

A total of 256 completed surveys from the 134 waterway sites were returned to BCIreland. The month of August was spilt into two sampling periods: Survey 1 (1st August to 15th August) and Survey 2 (16th August to 31st August). One hundred and twenty-nine surveys were completed during Survey 1 and 127 surveys were completed in Survey 2. While 122 waterways sites were surveyed twice, 7 waterways sites were surveyed during Survey 1 only and an additional 5 waterways sites were surveyed only during Survey 2 (Figure 5).

Overall, a greater number of waterway sites and completed surveys were undertaken in Leinster (n= 53 waterway sites, n=102 completed surveys) (Figure 6).

Figure 6: Number of completed surveys undertaken in August 2006 during Survey 1 and Survey 2.



3.5 Number of bat 'passes' recorded in 2006

Daubenton's bat 'bat passes' were recorded on 122 waterway sites (91%) while 'Unsure' Daubenton's bat 'bat passes' were recorded on 114 waterway sites (85%). In total, bat passes were recorded on a total of 128 waterway sites (95.5%) surveyed (Table 1).

One hundred and eight surveyed waterway sites recorded both types of passes while Daubenton's bat 'passes' were solely recorded on 14 waterway sites and 'Unsures' were solely recorded on 6 waterway sites (Figure 7) No bat 'passes' were recorded on 6 waterway sites surveyed.

While Daubenton's bat 'passes', in general, were recorded on more waterway sites than 'Unsure' Daubenton's bat 'passes', 'Unsure' Daubenton's bat 'passes' were recorded on a greater number of waterway sites located in Leinster (Figure 8).

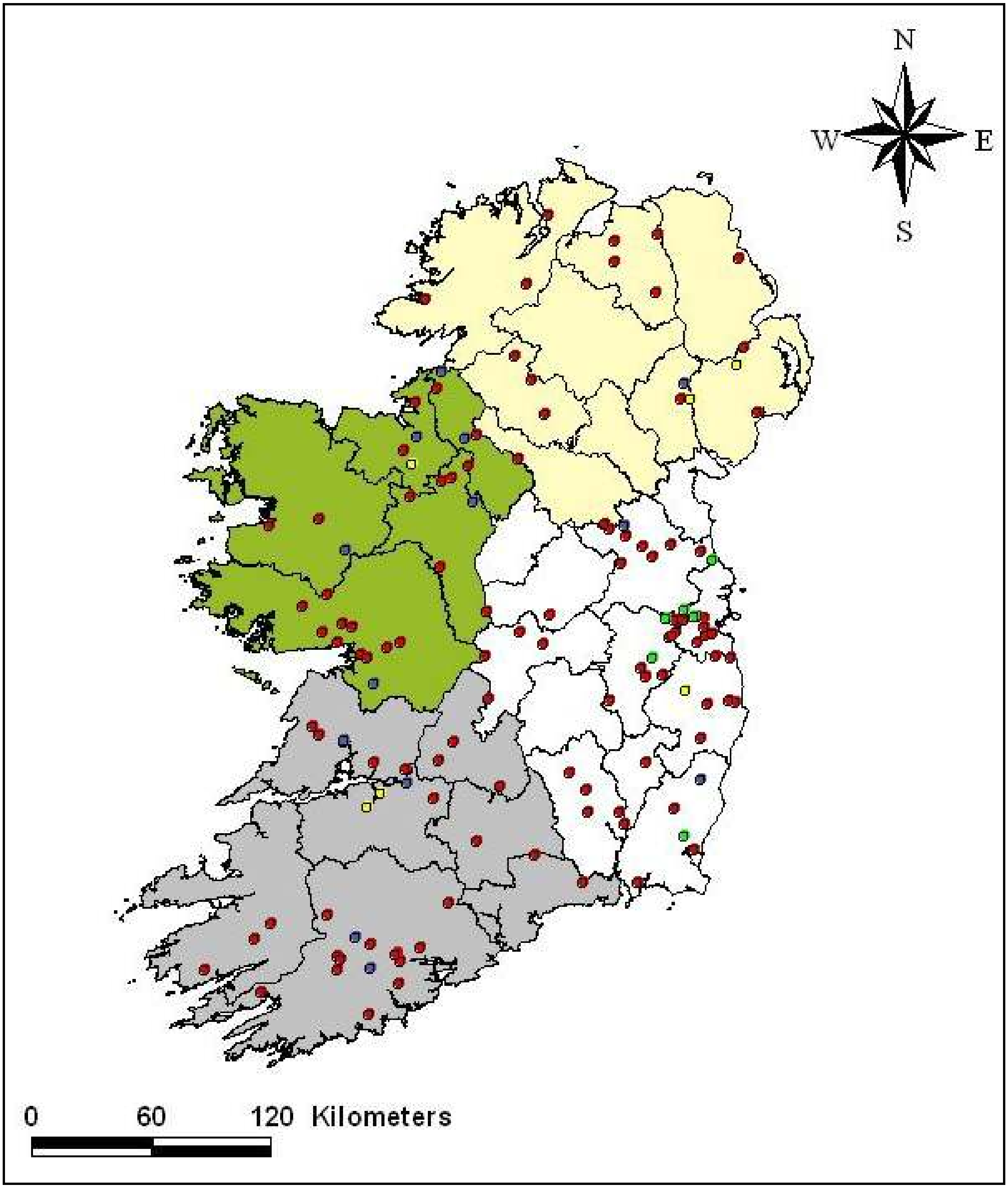
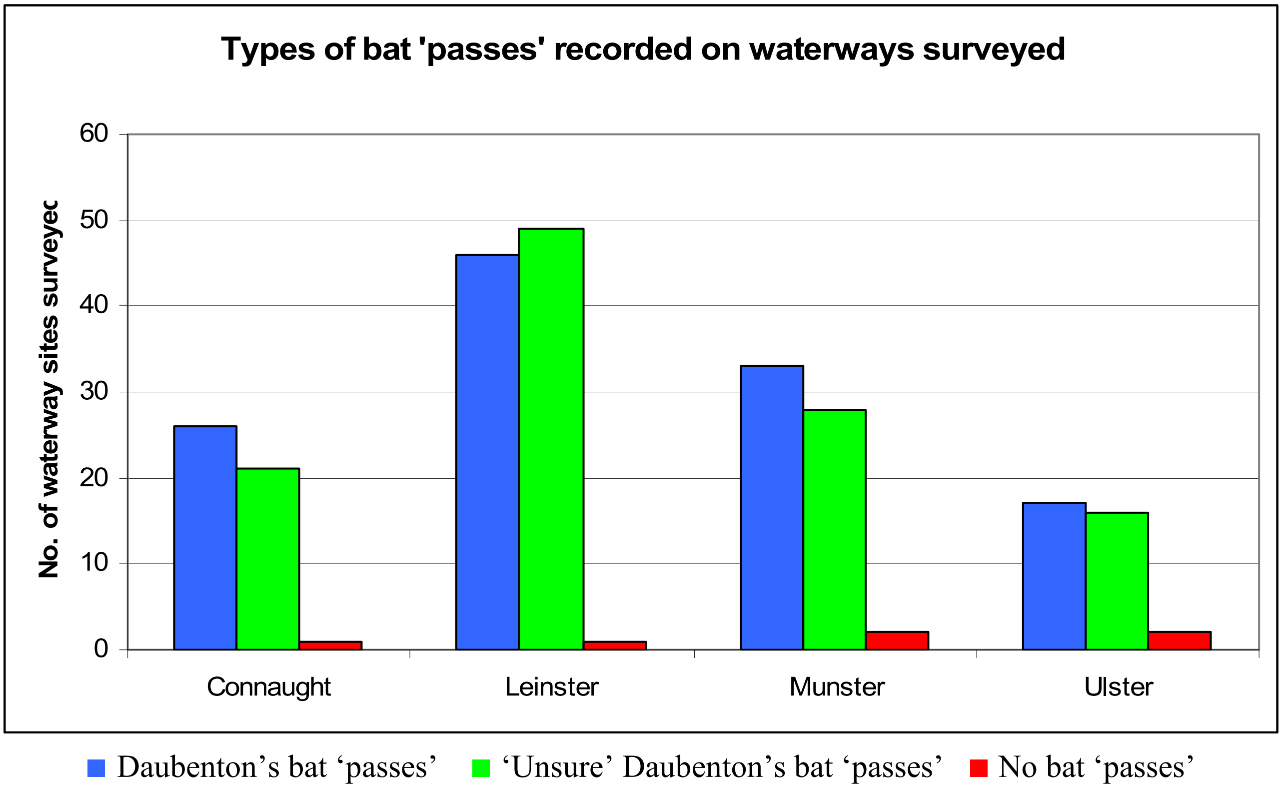


Figure 7: Waterway sites where bat passes were recorded during surveys completed in 2006. **Red** indicates those 1km transects in which surveys recorded both Daubenton's bat 'passes' and 'Unsure' Daubenton's bat 'passes' (n=108). **Blue** circles represent those waterway sites where only Daubenton's bats were recorded (n=14) and **Green** circles are those sites where 'Unsure' Daubenton's bat 'passes' were recorded (n=6). Yellow circles indicated waterway sites surveyed where no bat passes were recorded (n=6).

Table 1: Details of waterway sites surveyed where bat 'passes' were recorded in 2006.

Province	N surveyed waterways	No. of waterway sites with Daubenton's bat 'passes'	No. of waterway sites with 'Unsure' bat 'passes'	No. of waterway sites with bat 'passes'	No. of waterway sites with no bat 'passes'
Connaught	27	26	21	26	1
Leinster	53	46	49	52	1
Munster	35	33	28	33	2
Ulster	19	17	16	17	2
All counties	**134**	**122**	**114**	**128**	**6**

Figure 8: Types of bat 'passes' recorded on waterway sites surveyed located in the four provinces.



Daubenton's bat 'passes' were recorded during 224 completed surveys (87.5%) while 'Unsure' Daubenton's bat 'passes' were recorded during 202 completed surveys (78.9%). A total of 238 completed surveys (93%) recorded bat 'passes'.

Bat 'passes' and Daubenton's bat 'passes' were recorded on a similar number of waterways in both Survey 1 and Survey 2 (n=119 completed surveys and n=112 completed surveys respectively) (Table 2).

Table 2: Details of completed surveys where bat 'passes' were recorded in 2006 during survey periods (Survey 1 = 1st August to 15th August; Survey 2 = 16th August to 31st August).

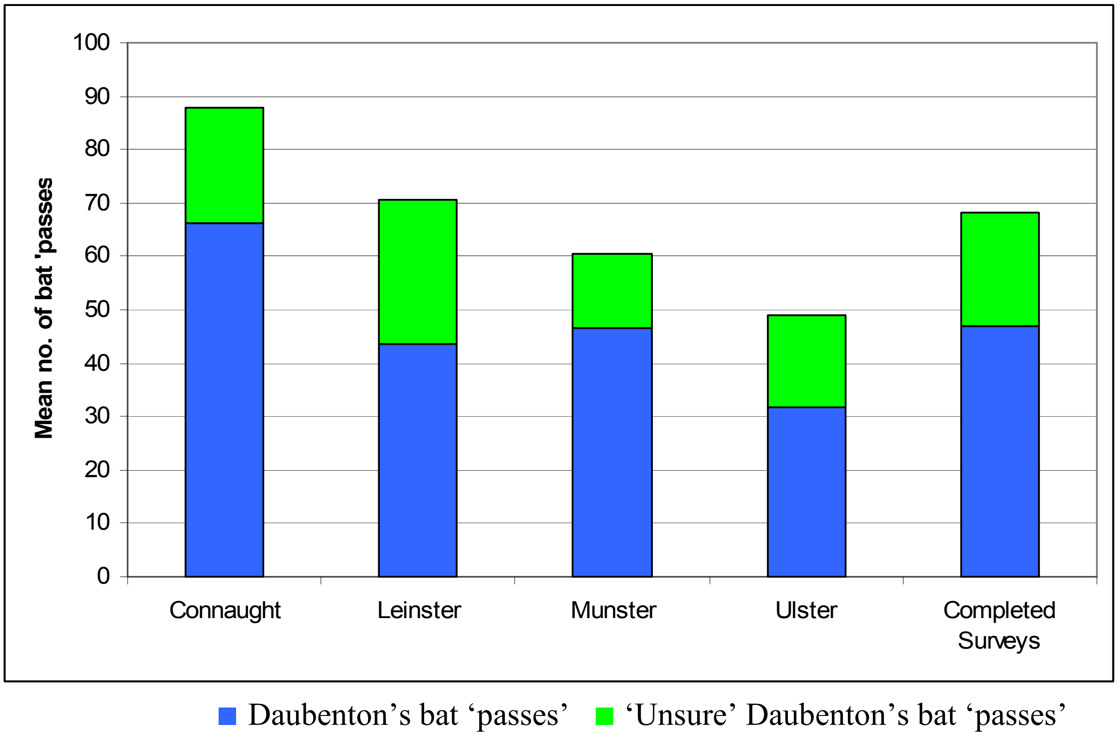
Province	N completed surveys	Daubenton's 'passes'	Unsure 'passes'	Daubenton's 'passes' only	Unsure 'passes' only	Bats recorded	No bats
	ALL SITES SURVEYED						
Connaught	51	44	36	11	3	47	4
Leinster	102	85	88	7	10	95	7
Munster	66	62	49	14	1	63	3
Ulster	37	33	29	4	0	33	4
Total	**256**	**224**	**202**	**36**	**14**	**238**	**18**
	SURVEY 1						
Connaught	26	24	19	5	0	24	2
Leinster	52	42	45	3	6	48	4
Munster	32	29	24	6	1	30	2
Ulster	19	17	14	3	0	17	2
Total	**129**	**112**	**102**	**17**	**7**	**119**	**10**
	SURVEY 2						
Connaught	25	20	17	6	3	23	2
Leinster	50	43	43	4	4	47	3
Munster	34	33	25	8	0	33	1
Ulster	18	16	15	1	0	16	2
Total	**127**	**112**	**100**	**19**	**7**	**119**	**8**

At each of the 10 points of each completed survey (n=256) volunteers recorded Daubenton's bat activity for 4 minutes generating 40 minutes of data per completed survey (total time sampled is 170 hours, 40 minutes in 2006). These 256 (ten points per survey) completed surveys recorded 12,051 Daubenton's bat passes (Mean number of 'passes'= 47.1) and 5,413 'Unsure' Daubenton's bat passes (Mean number of 'passes' = 21.1). Details are presented in Table 3 according to each of the four provinces. Connaught has the highest mean number of Daubenton' bat 'passes' and bat 'passes' per survey (66.1 and 87.7 respectively) (Table 3 & Figure 9). Leinster, on the other hand, has the highest mean number of 'Unsure' Daubenton's bat 'passes' (27.0) in comparison to the three other provinces.

Table 3: Mean number of bat 'passes' recorded during completed surveys in 2006 (ten survey spots/completed survey, 4 minutes/spot, total 40 minutes sample time/completed survey).

Province	N completed surveys	Mean no. of Daubenton's 'passes'	Mean no. of Unsure 'passes'	Mean Total bat 'passes'	% surveys with Daubenton's	% surveys with bats
Connaught	51	66.1	21.6	87.7	86.3	92.2
Leinster	102	43.5	27.0	70.5	83.3	93.1
Munster	66	46.6	13.8	60.5	93.9	95.5
Ulster	37	31.6	17.4	49.0	89.2	89.2
All counties	**256**	**47.1**	**21.1**	**68.2**	**87.5**	**93.0**

Figure 9: Mean number of bat 'passes' recorded during completed surveys in 2006 (ten survey spots/completed survey, 4 minutes/spot, total 40 minutes sample time/completed survey).



3.6 Statistical Analysis of Results

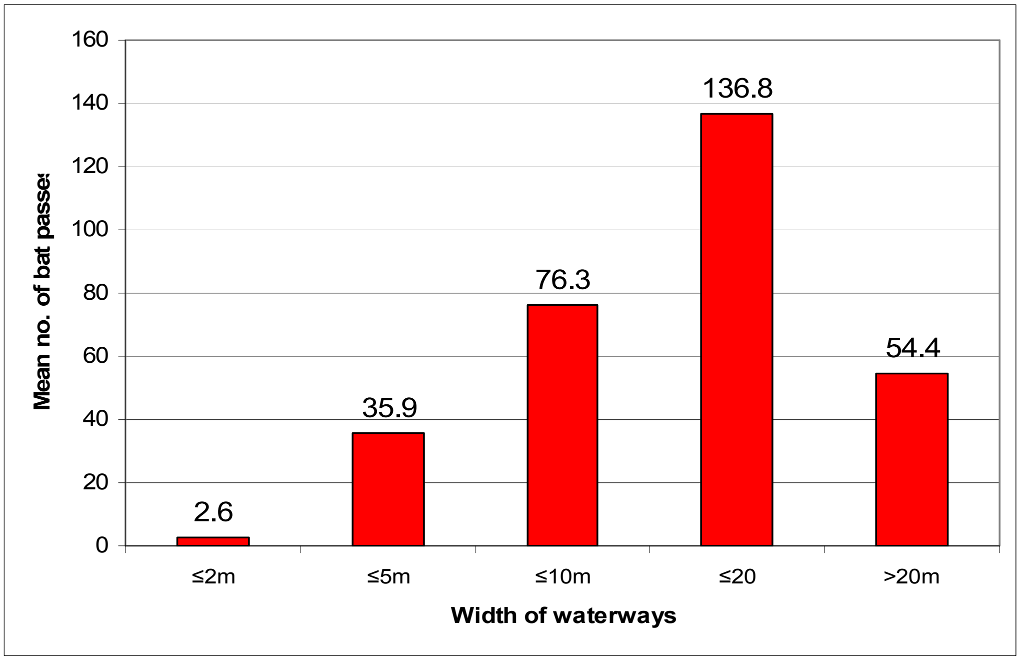
Survey results were submitted for statistical analysis in January 2007. At that time, only 131 survey forms were returned. Therefore statistical analysis was completed on the number of bat 'passes' from this set of completed surveys (n=250) (Appendix C, Table 1).

The number of bat 'passes' recorded were log-transformed in order to investigate the relationship between the number of bat 'passes' and other variables collated by volunteers (e.g. air temperature). A REML model was fitted to the data in order to allow for the two surveys completed at each site (Survey 1 & Survey 2). For analysis, the number of Daubenton's bat 'passes' and 'Unsure' Daubenton's bat 'passes' were used. The proportion of 'Unsure' Daubenton's bat 'passes' recorded are high when compared to those 'Unsures' recorded by volunteers participating in the BCT NBMP Daubenton's Bat Waterway Survey. However, analysis by the BCT has shown that volunteers record more 'Unsures' in their first year of surveying. In the context of the present report over 50% of surveyors reported having 1 year or less survey experience with bat detectors.

An array of parameters were fitted to a REML model to investigate their effects on the number of bat 'passes' recorded for completed surveys (n=250). A forward stepwise fitting procedure was undertaken and this suggested using a model containing terms for waterway site width, air temperature, rain and identification skills of volunteers. To ease fitting, continuous variables were grouped (e.g. temperature values grouped into five categories). Details of these four parameters are displayed in Appendix C, Table 2a-d.

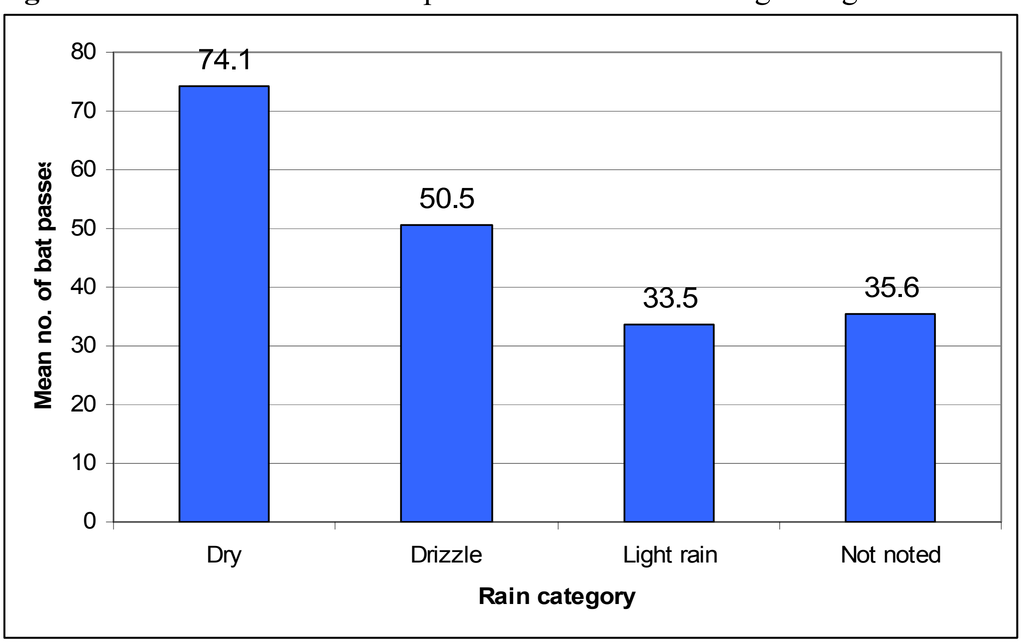
Volunteers were requested to estimate the width of the waterway site (in metres) surveyed. These values were categorised into five groups (e.g. 2m or less; <5m, etc.). The majority of waterway sites were entered into the 5m-10m group (n=105). While this parameter was not found to be significant at the conventional $P<0.05$ level, it was found to be very close to significant (χ^2 = 9.45 with 4 d.f., P=0.051) and so is retained as an important influence on the number of bat 'passes' recorded by volunteers. Log values suggest a steady increase in bat 'passes' with waterway width reaching a maximum at 20m.

Figure 10: Mean number of bat 'passes' recorded according to width of waterway sites surveyed.



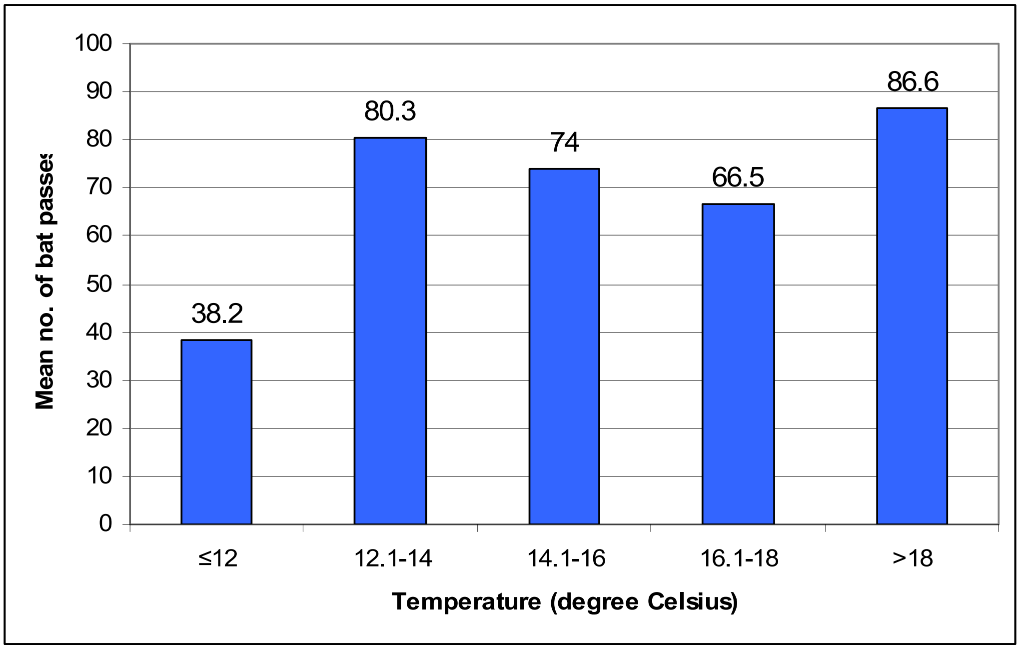
The 'Rain' parameter is comprised of four categories with the majority of surveys undertaken during dry weather (i.e. Dry category, n=213). This relationship was highly significant (χ^2 = 14.21 with 3 d.f., P=0.003) suggesting that a higher number of bat 'passes' were recorded during dry weather when compared to the two less than dry categories (drizzle and light rain categories).

Figure 11: Mean number of bat 'passes' recorded according to degree of 'Rain' categories.



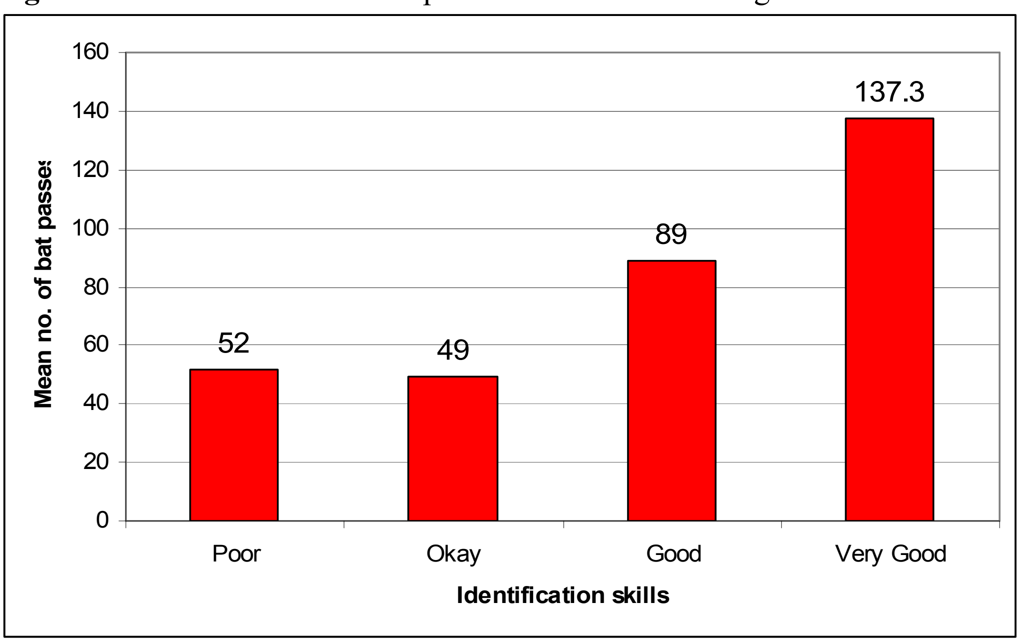
Air temperature was recorded by volunteers at the start of each survey night. The values recorded were grouped into five categories (e.g. <12 °C; 12.1-14.0 °C, etc.). This parameter has a significant influence on the number of bat 'passes' recorded (χ^2 = 10.72 with 4 d.f., P=0.030). Mean number of bat 'passes' were highest for the category >18 °C (n=22, mean=86.6).

Figure 12: Mean number of bat 'passes' recorded according to Temperature (°C) categories.



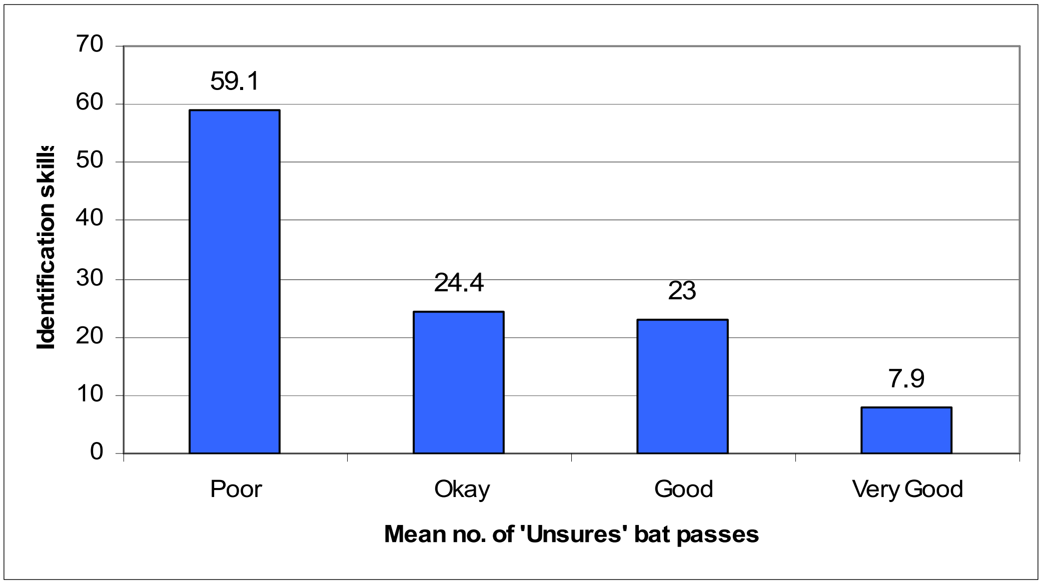
Identification skills of volunteers are borderline in terms of significance (χ^2 = 10.18 with d.f., P=0.017). Results indicate a contrast between 'poor' and 'okay' identification skills on one hand and 'good' and 'very good' identification skills on the other hand.

Figure 13: Mean number of bat 'passes' recorded according to Identification skills of volunteers.



As the proportion of 'Unsure' Daubenton's bat 'passes' was high, a separate analysis was undertaken to investigate the variables affecting the proportion of 'Unsures'. A Generalised Linear Mixed Model (GLMM) with binomial errors and logit link (a mixed logistic regression model) was fitted to the data. Identification skills were highly significant (χ^2 = 22.23 with 3 d.f., P=0.001) with volunteers rating their skills as 'poor' recording a higher proportion of 'Unsures'. Details of this are presented in Appendix C, Table 3.

Figure 14: Percentage of bat 'passes' recorded by volunteers as 'Unsure' Daubenton's bat 'passes' by level of identification skills.



Other variables tested and found to be non-significant include detector model, volunteer experience, time taken to complete survey. Details of all other variables tested are listed in Appendix C, Table 4.

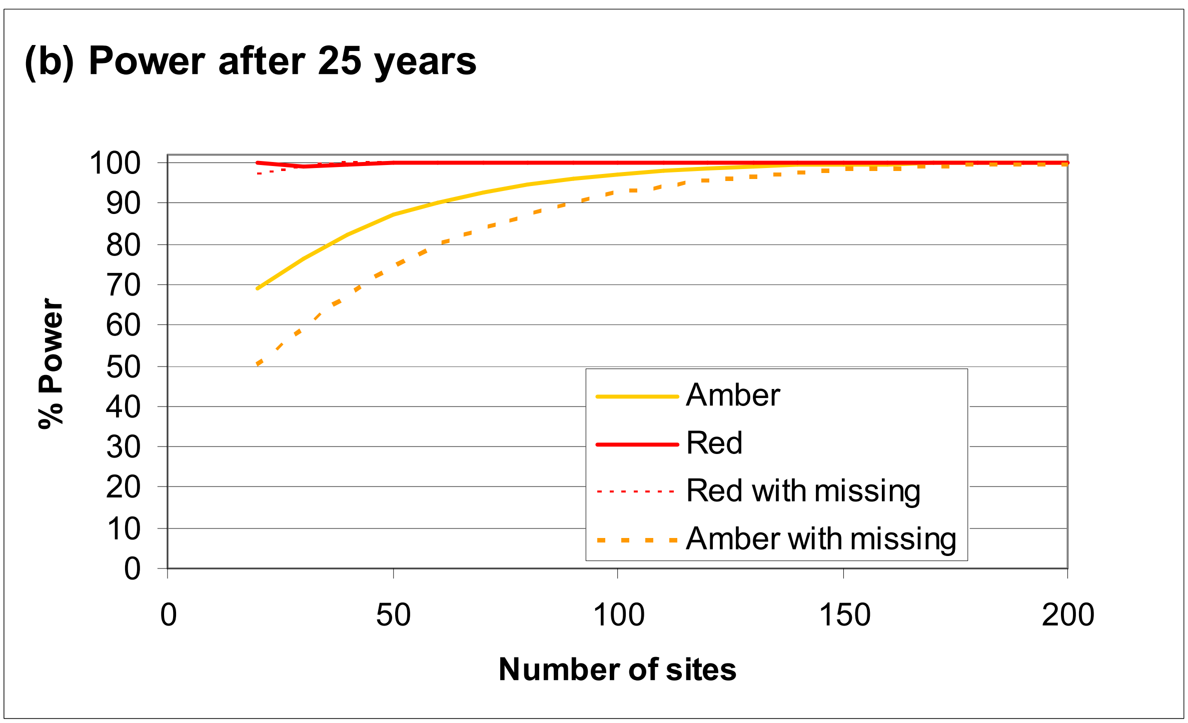
3.7 Power Analysis – detecting Amber and Red Alerts for the Daubenton's bat

The exact methodology used to derive Power Statistics is presented in Appendix D. Power Analysis uses, as its basis, information about how much sites vary from year to year. Since only one year of data is currently available, equivalent data from BCT's NBMP was used. For highly variable data, such as that collated in the monitoring scheme, negative binomial distribution was used. GAM analysis was then undertaken.

Power analysis results indicate that after 10 years it is possible to detect red alert declines of the Daubenton's bat with 90% power[1] with about 80 sites if surveyed twice every year or 150 sites with 40% missing values (i.e. 40% of the sites are not continuously surveyed from year to year). At 25 years, red alerts can easily be detected with a very small number of sites surveyed twice (<50 sites). At 25 years, amber alerts can be detected with 90% power with about 60 sites surveyed each year (twice) or around 90 sites with 40% missing values. Details of these figures are provided in Figure 6a and 6b.

[1] Power refers to the estimated percentage of simulations in which the decline is statistically significant. Red alerts refers to a 50% decline over 25 years (i.e. 2.73% decline a year), whilst Amber alerts is a 25% decline over 25 years (i.e. 1.14% per year).

Figure 6; Results of power analysis over periods of (a) 10 years and (b) 25 years. Power refers to the estimated percentage of simulations in which the decline is statistically significant. 'Red' refers to a 50% decline over 25 years, (i.e. 2.73% decline a year), whilst 'amber' is a 25% decline over 25 years (i.e. 1.14% per year).



4. DISCUSSION

The first year of the survey was a considerable success with a much higher number of volunteers participating in the monitoring scheme than expected. The Daubenton's Bat Waterway Survey methodology is considered as an ideal method to introduce inexperienced volunteers to bat surveying and this has been shown to be true by the degree of interest in the scheme.

Daubenton's bat was recorded on the majority of waterway sites surveyed in 2006, thus confirming that this species is widely distributed across linear waterways in the Republic of Ireland and Northern Ireland (e.g. O'Sullivan, 1994).

Although, bat 'passes' cannot be directly related the number of bats active on a given waterway site, bat 'passes' represent a measure of relative bat activity and an index of relative abundance (Walsh *et al,* 1995). Therefore, in measuring population trends, bat 'passes' provide a population index. The province of Connaught had the highest mean number of Daubenton's bat 'passes' per survey in 2006 in comparison to mean values for the three other provinces. While grid reference eastings and northings were included as variables in REML analysis and found to be not significant at a 95% level, the higher activity levels in Connaught may be related to higher rainfall levels in this part of the island. The Car-based Bat Monitoring Scheme for Ireland has reported that soprano pipistrelles are generally more active in survey squares to the west of the island (Roche *et al,* 2007). Ecological studies indicate that the soprano pipistrelle selects riparian habitats for foraging (e.g. Oakely and Jones 1998; Russ and Montgomery 2002; Vaughan, *et al*. 1997). Russ and Montgomery (2002) also reported that Daubenton's bats have the narrowest range of habitats actively selecting rivers and canals and avoiding those with little or no vegetation. Aquatic insects make up most of the diet of both Daubenton's bats (Sullivan *et al* 1993) and soprano pipistrelle bats. However, there is great variation in the mean number of Daubenton's bat 'passes' recorded for the waterway sites located within Connaught. Further investigation is required to determine whether Daubenton's bats have a higher level of activity in the west of Ireland.

Results from REML analysis suggest that the width of waterways surveyed, air temperature recorded at the start of the surveys, rain during surveying and the identification skills of volunteers have a significant impact on the mean number of bat 'passes' recorded in 2006. While width was not strictly significant at the conventional $P<0.05$ level, it was retained as an important variable because results from the BCT's NBMP have also found this variable to be a significant influence on mean number of bat 'passes'. The results from the All-Ireland study suggest that there is a steady increase in bat 'passes' recorded with width of waterway. However, a high proportion of waterways surveyed in 2006 are in the >2-5m and >5-10m classes with few waterways in the narrowest and largest categories. In the NBMP, there are a proportionately larger number of surveys in the narrow and larger classes making it easier to demonstrate the significant influence of middle range classes of river width.

The majority of the surveys were undertaken in dry weather conditions. While the number of surveys undertaken in the less dry categories were very small, significantly more bat 'passes' were recorded during dry weather conditions. Poor climatic conditions may discourage bats from feeding on a particular night or from feeding in typical habitats. Daubenton's bats will feed in woodland and other sheltered habitats during bad weather (Vaughan *et al,* 1997). Further analysis over the coming years of surveying will be investigated to see if this relationship persists.

Air temperature was also found to have a significant influence on the number of bat 'passes' recorded with fewer 'passes' recorded at low temperatures (<12^{o}C). A similar trend is demonstrated by the NBMP. The relative abundance of bat activity correlated with higher air temperatures may be related to the level of insect activity at waterways surveyed. Future analysis of data from this survey will be compared with temperature data collated from regional weather stations to determine whether this relation persists.

Volunteers with greater experience recorded a higher number of bat 'passes'. Therefore as volunteers gain greater experience, the number of 'Unsure' bat 'passes' should decrease. Again further analysis over the coming years of surveying will be investigated to see if this relationship persists.

The proportion of 'Unsure' Daubenton's bats 'passes' recorded in 2006 are high. The NBMP demonstrated that volunteers participating in a monitoring scheme for the first time generally record a higher number of 'Unsures' in their first year compared to subsequent years. In relation to the All-Ireland data, over 50% of the volunteers stated that they had one year or less of survey experience using bat detectors and this, therefore, may account for the high number of 'Unsures'. Statistical analysis indicated that volunteers rating their skills as low recorded a significantly higher proportion of the total number of 'Unsures' recorded in 2006. This is not surprising but it would have been anticipated that the higher proportion of 'Unsures' might be due to inexperienced people recording other *Myotis* species as 'Unsures'. However, the fact that the less skilled users recorded fewer passes in total may suggest that this is not the case and that these 'Unsures' may in fact be Daubenton's bat passes.

Results of Power analysis show that a core of 80 sites surveyed twice annually will be enough to determine red alerts after ten years. However, to determine amber alerts, over 200 sites would be required to be surveyed twice annually. At 25 years, red alerts can easily be detected with less than 30 sites surveyed twice while amber alerts can be detected with about 60 sites surveyed twice each year. Recommendations about the future of the survey are made in Section 5.

5. RECOMMENDATIONS

Recommendation 1 Continue to survey Daubenton's bats using current methodology and strive to survey additional waterways in five counties currently not monitored in the Republic of Ireland and Northern Ireland.

Recommendation 2 Continue to sample sites selected from water quality datasets currently monitored by the EPA (Republic of Ireland) and EHS (Northern Ireland).

Recommendation 3 Continue to provide volunteers with three potential ten-figure 'Grid Referenced Water Quality Sampling Sites' within a 10 km radius of their address.

Recommendation 4 All volunteers should be provided with maps, recording sheets etc. of their chosen site. 1km route selection should end or start with 'Grid Reference' allocated to volunteers. Maps marked with 1km route should be submitted with results. Master copies should be deposited with BCIreland and stored for future reference.

Recommendation 5 The All-Ireland Daubenton's Bat Waterway Survey should take place in the month of August.

Recommendation 6 A minimum of 80 core sites should be randomly selected from the current dataset and this set is required to be surveyed twice in the month of August. The same set of 80 core sites is required to be surveyed each year for the duration of the monitoring scheme.

Recommendation 7 The start time should remain as 40 minutes after sunset, as stated in the BCT's current methodology.

Recommendation 8 Participating surveyors can be volunteers or professionals and training should be provided prior to surveying. Provide additional training material for volunteers to access e.g. web-based video footage and audio tracks of Daubenton's bat foraging and echolocations calls.

Recommendation 9 Recruitment should begin early in 2007. Training programmes should be prioritised in counties where no volunteers participated in 2006 and in counties where no training course was organised in 2006.

Recommendation 10 Continue to invest in a pool of heterodyne bat detectors (purchase one model type) for use by volunteers who do not own one.

Recommendation 11 A professional statistician should continue to carryout analysis and should have experience in relation to interpretation of bat data.

Recommendation 12 A pilot will be undertaken to test whether the use of Tranquility Transect Time Expansion bat detectors in the month of August 2007 could be used in addition to heterodyning method along a smaller number of sample sites (n=10). This would maximise the use of already available equipment and provide potential information on a greater range of species utilising waterways.

Recommendation 13 Contact EPA in relation to participating in survey, accessing water quality database and as a possible additional source of funding. In addition, contact Waterways Ireland for their continued participation in the survey.

Recommendation 14 Analysis of a potential relation between water quality and the presence of Daubenton's bat on surveyed waterways and the number of bat 'passes' will be investigated when sufficient data has been accumulated.

Recommendation 15 The use of Global Positioning Systems would provide accurate grid references for transects at each of the ten survey spots and their use should be considered. BCIreland will aim to accurately plot the ten survey spots of the core waterway sites in 2007.

Recommendation 16 Record other wildlife encountered during survey.

Recommendation 17 Provide participants with copies of annual reports and invite them to an annual workshop to discuss survey progress.

Recommendation 18 Continue to provide annual training courses as a means to recruit new volunteers.

Recommendation 19 Continue the collation of information of all different heterodyne bat detectors being used should be carried out and review whether weighting factors should be incorporated into trend estimation models to account for sensitivity differences.

GLOSSARY

Frequency Division
A system used to convert ultrasound to audible sound in real time. It has an unrestricted ultrasonic frequency range and therefore is appropriate for identifying the echolocation calls from many species across a range of frequencies. Recordings from this system can be used to produce sonograms allowing species identification post-survey.

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).

Heterodyne
A system used to convert ultrasound to audible sound in real time. This system has a restricted range making it possible only to detecting species echolocating at a particular dialled frequency. It produces calls with tonal qualities aiding identification. However, recorded calls are not suitable for sonogram analysis. This type of bat detector is widely used by surveyors.

National River Site Coding System
The coding system is hierarchical combining the river code and a station code. The river code is comprised of the Hydrometric Areas number, two-digit 01 to 40, an alpha code and two-digit identifier e.g. 34C01 representing the Castlebar River in the Moy Catchment which is the Hydrometric Area 34. The station code are four-digit codes e.g. 0100, 0200, etc., assigned initially in 0100 steps in order to avoid having to renumber sites by allowing up to 99 new sampling sites to be added between initial stations.

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=0.1 for a two sided test).

Time Expansion
A system used to convert ultrasound to audible sound through slowing down the original sound. It has an unrestricted ultrasonic frequency range and therefore is appropriate for identifying the echolocation calls from many species across a range of frequencies. Recordings from this system can be used to produce sonograms allowing species identification post-survey.

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APPENDIX A
FIELD INSTRUCTIONS MANUAL/METHODOLOGY TESTED IN AUGUST 2006

All Ireland
Daubenton's Bat
Waterway Survey
Survey Form

Grid reference of site:	Surveyors names:
Water way name:	Address:
Site name:	
Is the site a SAC:	
Is the site a NHA/SSSI:	Tel no.:
Bat detector used:	Email:
My length of field experience with a bat detector is: (please circle one) Less than 1 yr / 2-3 yrs / >3 yrs	
My bat identification skills are: (please circle one) Poor / OK / Good / Very good	

Survey 1 (1st -15th August)				Survey 2 (16th – 30th August)			
Date:				Date:			
Start Time:		Finish Time:		Start Time:		Finish Time:	
Temp (°C):		Wind (circle one)	Calm Light Breezy	Temp (°C):		Wind (circle one)	Calm Light Breezy
Cloud (circle one)	Clear (0–1/3) Patchy(1/3-2/3) Full (3/3)	Rain (circle one)	Dry Drizzle Light rain	Cloud (circle one)	Clear (0–1/3) Patchy(1/3-2/3) Full (3/3)	Rain (circle one)	Dry Drizzle Light rain

Number of Bat Passes			Number of Bat Passes		
Spot	Daubenton's bat	Unsure Daubenton's bat	Spot	Daubenton's bat	Unsure Daubenton's bat
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		

Waterway Characteristics

What % of waterway is sheltered by trees or overhanging vegetation?
None ☐ up to 50% ☐ greater than 50% ☐

How much of the waterway surface that is calm/smooth?
None ☐ up to 50% ☐ greater than 50% ☐

Approximate width of majority of waterway _________m
Number of spots with a clear view of the water _________

Thank You for your very valuable contribution to this monitoring programme.

Please return your completed forms to:
Dr Tina Aughney,
BCIreland, Ulex House,
Drumheel, Lisduff, Virginia,
County Cavan, Ireland.

All Ireland Daubenton's Bat Waterway Survey

INSTRUCTION MANUAL

Welcome Note

Thank you for volunteering to take part in the All Ireland Daubenton's Bat Waterway Survey. This project funded by the NPWS, Department of the Environment, Heritage and Local Government, Environmental Heritage Service, Department of Environment Northern Ireland and Waterways Ireland and is managed by Bat Conservation Ireland. The survey methodology to be used by this programme is currently in use in the UK as part of the UK's National Bat Monitoring Programme for Daubenton's bats managed by Bat Conservation Trust, UK.

We hope that you enjoy your participation in this survey whilst making a positive contribution to conservation.

Daubenton's Bats: Field Survey Method

The aim of this survey is to walk a route along a 1km stretch of river/canal. The activity of Daubenton's bats is recorded at 10 stopping points along the route on two evenings between the 1st and 30th August.

1. Methods

a. When to survey

Two separate evening counts should be made, one in each of the following survey periods: 1st-15th Aug and 16th-30th Aug with at least five days between each survey.

b. Equipment

- tuneable bat detector
- thermometer (outdoor)
- stopwatch
- recording sheets/notebook
- pencil/clip board
- rough map
- torch
- head torch

c. Volunteer Pack

- health and safety guidelines
- spot descriptions form
- landowner form
- landowner letter
- survey form
- sunset timetable
- OS map (copy)

d. Selecting a route

Bat Conservation Ireland will assign each volunteer 2/3 potential survey sites. The sites allocated will have a 10-figure grid reference which will correspond to a stretch of waterway monitored by the EPA/EHS Water Quality Monitoring Programmes. Please select the most accessible, convenient and safe one to survey ensuring to write the grid reference on the Field Survey Form.

- Select a stretch of river or canal on an OS map. Identify a potential route of over 1km in length using the 10-digit reference point as one of the ten spots of the selected route.

- Visit the selected stretch of river/canal during the daytime and select an accessible site where it is safe and convenient to survey. Your chosen waterbody should be >2m in width.

- Select a start point that is convenient for both reaching the bank and standing to record bats. Clearly mark this as your first spot on the map.
- From this starting point walk along the river/canal, pacing out rough 100m intervals as you go. After each 100m, select the nearest point at which you can see the water-surface (Always ensure that there is at least 80m between each spot). Make

a descriptive note of the survey spots for future reference on the Spot Description Form. Repeat this until you have a total of ten points or survey spots.

NB: Do not chose survey spots that you think will be good for bats as this will bias the results, just stick to points that allow you to access the bank and to record bats conveniently and safely.

- During your daytime walk of the route, describe a feature/landmark for each spot to help you to identify it on your return night-time visit. These features most of permanent/long-term features where possible. If the site is featureless, you may to pace it out to permanent features nearby.

- You may have to make detours where the river bank becomes inaccessible or unsafe. This may mean that your route ends up longer than 1km, but this does not matter.

- Mark and number each spot on your map. Ensure that you make three copies of this map (Field copy, original to be filed by yourself and a third copy to be submitted with recording sheets to BCIreland).

- Record access gates and suitable parking areas, if relevant.

e. Landowner permission

Enclosed is a letter to be presented to the landowner and a form for the landowner to give you consent to enter his/her property. It is important that you gain permission in advance for any landowners or custodians if you are entering private property or sites with restricted access. If you are surveying such sites, please record landowner details and which section of your route that they apply to on the form provided.

f. Field methodology

Position yourself at the starting point at 40 minutes after sunset (please refer to your sunset timetable using the nearest town/city quoted on sheet).

- Just prior to starting time, record the following: Time, Temperature and Weather conditions (as indicated on recording sheet).

- At each survey spot, tune your detector to <u>35 kHz</u> and simultaneously use a torch to scan the water to check whether Daubenton’s bats can be seen skimming the water-surface. Do not use your torch continuously as this will discourage Daubenton’s bats from travelling in vicinity of your spot.

- Daubenton’s bat calls sound like a rapid click akin to machine-gun fire or marbles being dropped on a tile floor. They can be confused with Natterer’s bats, which sound similar (although weaker and more like a rapid crackling). Typically, Natterer’s bats fly erratically above the level of Daubenton’s bats and tend not to trawl the water-surface.

- Stand still and count the number of Daubenton’s bat passes for a total of <u>4 minutes</u>. Record the number of passes on the survey form or in a notebook.

- If you hear a bat that you think sounds like Daubenton’s, but you did not see it skimming over the water-surface, record it as an ‘Unsure Daubenton’s Bat’. Ignore bat passes of other species.

- At the last point, record your finish time. If you are forced to abandon the survey early, note down the location, time and reason for stopping.

2. Survey Tips

   a. Use fresh batteries for detector
   b. A bat pass is a continuous stream of echolocation calls indicating a bat flying past. If constant activity is heard estimate the number of times a bat flies past.
   c. Detectors are directional. For Daubenton's bats always hold the detector at 90^{o}, pointing it across the surface of the water.

Holding bat detector at 90^{O} angle

Suitable spot with good view of waterway

3. Health & Safety Guidelines

Precautions to avoid injury
• Identify potential hazards in daytime and avoid during night • No distracting work should be carried out while walking, and good illumination should be carried at night for use when walking on uneven ground and/or in unknown areas. • Use headtorch and pocket notepad, where possible, to keep hands free • Check mobile phone coverage during daylight hours
• Working alone should be avoided and no work should be undertaken where there is any significant risk, such as sites with a reputation for incidents, (e.g. where there may be a risk of personal assault). • Be aware of the location of the nearest house or phone so that help can be called if required. Carry a mobile phone.
• Clean any cuts etc imme ect reception blind spots.diately with clean water and cover adequately. • Anti-tetanus treatments should be up to date (these normally last ten years). • Avoid contact with water, particularly if contaminated with rats/cattle urine. Wash hands thoroughly and always before eating. If flu-like symptoms develop, inform doctor of possible exposure to Weils disease.
• When working in grassland areas where deer are present, wear long trousers and long socks. Check exposed skin for ticks. If a tick is found and flu-like symptoms develop – inform doctor
• Non-swimmers should be accompanied when walking by water • Do not cross rivers unless by bridge • Avoid work when risk of flooding and be aware of tides • Keep at safe distance from water edge
• Check weather forecast beforehand. • Ensure that waterproof and/or warm clothing is carried; hazards can increase significantly in heavy rain, strong winds and thunderstorms, especially at night. • Avoid/terminate all outdoor activity in inclement weather.

4. What to Return

- Complete Forms: Survey Form, Spot Description Form
- Map with 1km route and 10 survey spots marked on

Please return your completed forms/maps to: Dr Tina Aughney, BCIreland, Ulex House, Drumheel, Lisduff, Virginia, Co. Cavan, Ireland.

Many thanks for helping with this important pilot study. We would also like to thank the NPWS, EHS, The Heritage Council and Waterways Ireland for their valuable contribution to the All Ireland Bat Monitoring Programme. Survey methodology is based on that devised by The Bat Conservation Trust, UK.

Sunset Times, 2006

Date	Dublin	Donegal Town	Galway	Athlone	Killarney	Belfast
Aug 1	09.22 PM	09.35 PM	09.32 PM	09.28 PM	09.29 PM	09.25 PM
2	09.20 PM	09.33 PM	09.30 PM	09.27 PM	09.27 PM	09.23 PM
3	09.18 PM	09.31 PM	09.28 PM	09.25 PM	09.26 PM	09.21 PM
4	09.16 PM	09.29 PM	09.27 PM	09.23 PM	09.24 PM	09.19 PM
5	09.14 PM	09.27 PM	09.25 PM	09.21 PM	09.22 PM	09.17 PM
6	09.12 PM	09.25 PM	09.23 PM	09.19 PM	09.20 PM	09.15 PM
7	09.10 PM	09.23 PM	09.21 PM	09.17 PM	09.19 PM	09.13 PM
8	09.08 PM	09.21 PM	09.19 PM	09.15 PM	09.17 PM	09.11 PM
9	09.06 PM	09.19 PM	09.17 PM	09.13 PM	09.15 PM	09.09 PM
10	09.04 PM	09.17 PM	09.15 PM	09.11 PM	09.13 PM	09.07 PM
11	09.02 PM	09.15 PM	09.13 PM	09.09 PM	09.11 PM	09.05 PM
12	09.00 PM	09.12 PM	09.11 PM	09.07 PM	09.09 PM	09.02 PM
13	08.58 PM	09.10 PM	09.09 PM	09.05 PM	09.07 PM	09.00 PM
14	08.56 PM	09.08 PM	09.07 PM	09.03 PM	09.05 PM	08.58 PM
15	08.54 PM	09.06 PM	09.05 PM	09.01 PM	09.03 PM	08.56 PM
16	08.52 PM	09.04 PM	09.03 PM	08.59 PM	09.01 PM	08.54 PM
17	08.50 PM	09.02 PM	09.01 PM	08.57 PM	08.58 PM	08.51 PM
18	08.48 PM	09.00 PM	08.59 PM	08.55 PM	08.56 PM	08.49 PM
19	08.46 PM	08.58 PM	08.57 PM	08.53 PM	08.53 PM	08.47 PM
20	08.43 PM	08.56 PM	08.55 PM	08.51 PM	08.51 PM	08.44 PM
21	08.41 PM	08.53 PM	08.53 PM	08.48 PM	08.48 PM	08.42 PM
22	08.39 PM	08.51 PM	08.51 PM	08.45 PM	08.46 PM	08.40 PM
23	08.37 PM	08.48 PM	08.48 PM	08.43 PM	08.44 PM	08.37 PM
24	08.35 PM	08.46 PM	08.45 PM	08.41 PM	08.42 PM	08.35 PM
25	08.33 PM	08.44 PM	08.43 PM	08.39 PM	08.40 PM	08.33 PM
26	08.30 PM	08.42 PM	08.41 PM	08.37 PM	08.38 PM	08.30 PM
27	08.28 PM	08.40 PM	08.39 PM	08.34 PM	08.35 PM	08.28 PM
28	08.26 PM	08.38 PM	08.37 PM	08.32 PM	08.33 PM	08.25 PM
29	08.24 PM	08.35 PM	08.34 PM	08.30 PM	08.31 PM	08.23 PM
30	08.22 PM	08.33 PM	08.32 PM	08.28 PM	08.29 PM	08.21 PM
31	08.20 PM	08.31 PM	08.30 PM	08.26 PM	08.27 PM	08.18 PM

All Ireland Daubenton's Bat Waterway Survey Spot Description Form

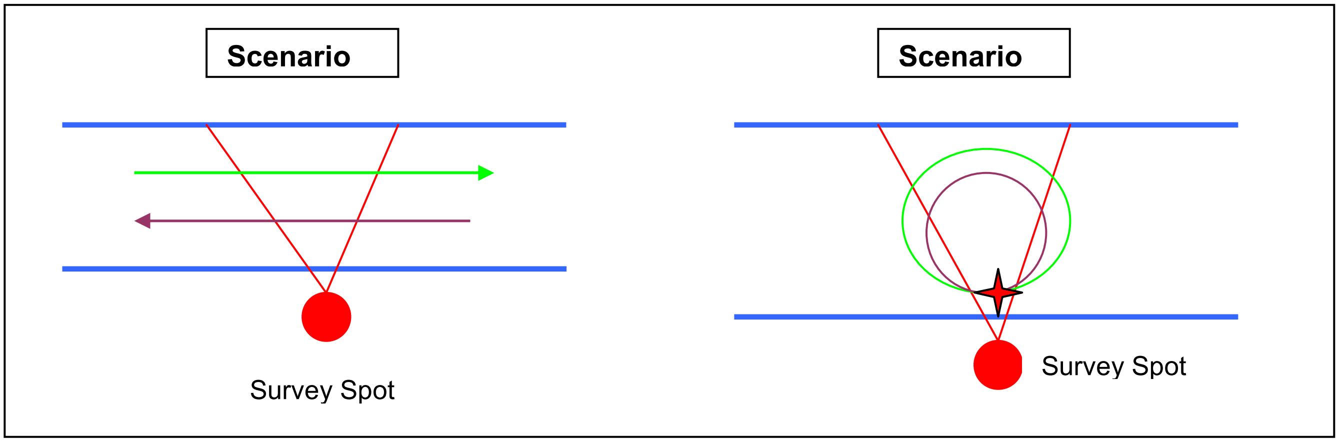
Please note your spot descriptions below. Try to use permanent features where possible; remember dead trees and such features are often removed. Please gain permission to enter land prior to survey.

Spot	Description	Landowners Name & Contact Details
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Access / Parking Notes

POINTS TO REMEMBER ON THE NIGHT OF THE SURVEY

1. Bat Passes



Counting the number of 'bat passes' at each of your 'Survey Spots' is as follows:

Scenario A: This represents the typical straight line flights of the Daubenton's bat. A 'bat pass' is counted each time an individual bat passes through your 'Survey Spot' (as represented by the red lines radiating from the 'Survey Spot'). Two 'bat passes' are presented here.

Scenario B: This represents a flight path by Daubenton's bats often seen on wide stretches of rivers. The looping (always within 30cm of the water surface) produces a continuous noise of echolocation calls on the bat detector (said to be constant activity). Therefore to count this as 'bat passes', pick a spot (as represented by the red star) and count everytime the individual bat passes this point as one 'bat pass'. Two 'bat passes' are presented here.

2. Flight Pattern

REMEMBER Daubenton's bats fly within 30cm of the water surface. This will allow you to differentiate this species from other bat species foraging in the area.

3. Echolocation call

REMEMBER to listen for those RAPID DRY CLICKS (fast repetition rate and constant rhythm) when tuned to ***35kHZ*** on your bat detector.

4. Start Time

Start 40 minutes after sunset.

5. Bat Detector and Torch

REMEMBER to gently scan your 'SURVEY SPOT' at a 45^{o} angle. This will allow you to hear the bats travelling towards you in time to turn on your torch on in order to see Daubenton's bats flying low and through your survey area. Only count bats passing within this area.

Holding bat detector at 90^{O} angle

Suitable spot with good view of waterway

APPENDIX B

Table 1: All-Ireland Daubenton's Bat Waterway Survey Training Courses

	Venue	Organised by:	No. of Volunteers
1	Lough Neagh Visitors Centre	EHS	13
2	Wicklow National Park	NPWS	18
3	Environmental Science Unit, NUIG	NUIG & Galway Bat Group	21
4	Meath Co. Co. Chamber Offices	Meath Co. Co.	13
5	Tennis Pavilion, Bushy Park	Dublin City Council	27
6	Killarney Education Centre	Kerry Bat Group	13
7	Zoology Department, UCC	Cork County Bat Group	26
8	Tipperary Institute, Clonmel	Tipperary IT	9
9	Wexford Wildfowl Reserve	NPWS	11
10	Sligo Co. Co. Chamber Offices	Sligo Co. Co.	19
11	Kilcullen Heritage Centre	Kildare Co. Co.	8
12	Waterways Ireland Scariff Offices	Waterways Ireland	9
13	Waterways Ireland Carrick-on-Shannon	Waterways Ireland	12
14	Castle Archdale, Co. Fermanagh	EHS	8
		Total	***207***

Table 2: County by County listing of waterways surveyed by the All-Ireland Daubenton's Bat Waterway Survey 2006

Ulster			
Waterway	**Site Name**	**Grid Ref**	**County**
River Logan	Logan Valley Regional Park	J3250069000	Antrim
Glenarm River	Glenarm Forest	D3012511916	Antrim
Newry Canal	Moneypennys	J0330051200	Armagh
Bann Canal	Scarva Heritage Canal	J0640043700	Armagh
Cusher River	Clare Bridge	J0140043900	Armagh
River Roe	Dog Leap	C6790020300	Derry
River Roe	Dungiven Bridge	C6830009800	Derry
Moyola River	Curran Bridge	H8920095500	Derry
Macosquin River	Ree Bridge	C8980023700	Derry
Moneycarragh	Moneylane Lock	J3990036900	Down
Ravernet River	Legacurry Bridge	J29700 60100	Down
Kesh River	Kesh	H1820064200	Fermanagh
River Erne	Enniskillen	H2700053000	Fermanagh
Colebrook River	Ballindarragh Bridge	H3310036000	Fermanagh
River Blackwater	Killryan Bridge	H2025014600	Cavan
River Blackwater	Nine Eyes Bridge	N6304083380	Cavan
Owenea River	Owenea Bridge	G7369092110	Donegal
River Deele	Milltown Bridge	H2450099613	Donegal
Crana River	Crana Park	C3480432892	Donegal
Leinster			
Waterway	**Site Name**	**Grid Ref**	**County**

River Boyne	Slane Bridge	N9640073610	Meath
River Blackwater	O'Dalys bridge	N6530080320	Meath
Borora River	Moynalty Bridge	N7352082560	Meath
River Boyne	Ramparts	N8740067400	Meath
Blackwater River	Donaghpatrick Bridge	N8194072310	Meath
Athboy River	Athboy Bridge	N7169064260	Meath
Tolka River	Dunboyne-Loughsallagh Br	O0280041700	Meath
River Nanny	Dardistown Bridge	O1114070200	Meath
River Blackwater	Maudlin Bridge	N7367077250	Meath
River Brosna	Ballynagore	N3560039600	Westmeath
River Shannon	Burgess Park, Athlone	N0410041000	Westmeath
Grand Canal	Hazelhatch Bridge	N9880030700	Dublin
Delvin River	Gormanstown Bridge	O1711065810	Dublin
Tolka River	Cardiff Bridge	O1260037700	Dublin
Tolka River	Abbotstown Bridge	O0930038300	Dublin
River Dodder	Oldbawn Bridge	O0975026300	Dublin
River Dodder	Bridge on Spring Avenue	O1361028910	Dublin
Royal Canal	Collins Bridge	O0280036750	Dublin
Royal Canal	Granard Bridge	O0840038100	Dublin
Grand Canal	Kilmainham Section	O1280033200	Dublin
River Dodder	Milltown Bridge	O1698030410	Dublin
River Liffey	Leixlip Bridge	O0075035810	Kildare
Grand Canal	Henry Bridge	N9560028200	Kildare
Grand Canal	Corbally Line	N8730018700	Kildare
River Liffey	Kilcullen Bridge	N8424009730	Kildare
River Liffey	Connell Ford	N8135013680	Kildare
Royal Canal	Deey Bridge	N9790037000	Kildare
Royal Canal	Smullen Bridge	N9410037400	Kildare
Grand Canal	Milltown Bridge	S6550097500	Kildare
Grand Canal	Ayimer Bridge	N9730029500	Kildare
River Liffey	Ballymore Eustace Bridge	N9262009790	Kildare
River Brosna	Ballycumber Bridge	N2120030600	Offaly
Grand Canal	Srah Castle	N3290025200	Offaly
Grand Canal	Griffith Bridge	N0330019100	Offaly
Vartry River	Newrath Bridge	T2860096800	Wicklow
Kings River	Ballinagree Bridge	O0364002380	Wicklow
Avonmore River	Ballard Bridge	T1442095670	Wicklow
Glencullen River	Glencullen Bridge	T2190017900	Wicklow
Vartry River	Nun's Cross	T2560097900	Wicklow
River Ow	Roddenagh Bridge	T1170079200	Wicklow
Dargle River	Bray Bridge	O2640118895	Wicklow
River Slaney	Seskin Bridge	S9770093900	Wicklow
Douglas River	Cunaberry Bridge	S8422067950	Carlow
River Nore	Knockanore	S5469643591	Kilkenny
River Nore	NE of Warrington	S5373654466	Kilkenny
River Nore	Threecastles Bridge	S4582162709	Kilkenny

River Barrow	Graiguenamanagh Bridge	S7072443544	Kilkenny
Tintern Abbey Stream	Tintern Abbey	S7940010000	Wexford
River Sow	Kilmallock Bridge	T0327031910	Wexford
River Barrow	St Mullins	S7295037800	Wexford
North Slob	Channel	T0827525539	Wexford
River Bann	Margerry's Bridge	T1144159337	Wexford
River Slaney	Scarawalsh Bridge	S9837545068	Wexford
Munster			
Waterway	**Site Name**	**Grid Ref**	**County**
Whelan's Br River	Whelan's Bridge	S5220009900	Waterford
Owennashad River	Br u/s Blackwater R. confl.	S0482098940	Waterford
Mulkear River	Bridge Nth of Coolruntha	R8060068700	Tipperary
Nenagh River	Tyone Bridge	R8770077900	Tipperary
Suir River	Kilsheelan Bridge	S2862023234	Tipperary
Suir River	Cabragh Bridge	S1119956062	Tipperary
River Aherlow	Cappa Old Bridge	R9935429318	Tipperary
River Lee	Bannon Bridge	W6131671632	Cork
Martin River	Bawnafinny Bridge	W5979075412	Cork
Owenboy	Priests Bar Bridge	W6049161227	Cork
River Foherish	Carrigaphooca Bridge	W2963673766	Cork
Glashatoy River	Upper Glanmire Bridge	W7146478294	Cork
Shournagh River	Tower Bridge	W5862074551	Cork
Landey	Carrigagulla Bridge	W3894683016	Cork
Bride River	Coolmucky Bridge	W4603767916	Cork
River Lee	Drumcarra Bridge	W2955867786	Cork
River Sullane	Linnamilla Bridge	W3113972814	Cork
River Blackwater	Charles Bridge	W2481194404	Cork
Dripsey River	Dripsey Bridge Lower	W4612279628	Cork
Glengarrif	Footbridge NW of Glengarrif	V9178756970	Cork
River Blackwater	Careyville	W8558399508	Cork
Arigideen River	Kilmaloda Bridge	W4519545566	Cork
Owenreagh River	Bridge u/s Upper Lake	V8842282104	Kerry
Flesk	Flesk Bridge	V9672589468	Kerry
Sneem River	Br u/s Ardsheelhane R. confl.	V6291667562	Kerry
Greanagh River	Coolah Bridge	R4434946357	Limerick
River Barnakyle	Old Forge Bridge	R5103853043	Limerick
Mulkear River	Annacotty Bridge	R6430057700	Limerick
Owenocarney River	Annagore Bridge	R4768267717	Limerick
Bilboa River	Newbridge	R7800050500	Limerick
Inagh River	Inagh Bridge	R2082081290	Clare
Errina-plassey Canal	Errina Bridge	R6400064800	Clare
Claureen River	Claureen Bridge	R3285978100	Clare
River Fergus	Drehidnagower	R3301778654	Clare
Inagh River	Moananagh Bridge	R1703084900	Clare
Connaght			

Waterway	Site Name	Grid Ref	County
Streamstown River	Interpretative Centre	M4820006100	Galway
Clarinbridge River	Cow Park Commonage	M4123420005	Galway
Black River	Moyne Bridge	M2500049000	Galway
Lough Kip River	Dr. Chlaidhdi	M2221531223	Galway
Owenriff River	Glan Road Bridge	M1224443146	Galway
River Corrib	Salmon Weir Bridge	M2959225666	Galway
Kilcolgan River	Dunkellin Bridge	M4420218432	Galway
Cregg River	Addergoole River	M3228334994	Galway
Clare River	Claregalway Bridge	M3717933228	Galway
Rafford River	Ratty's Bridge	M5473423259	Galway
Rafford River	Rafford House	M6083726048	Galway
Manulla River	Belcarra Walkway	M2010085400	Mayo
Owenwee River	Belclare Bridge	L9599882163	Mayo
River Robe	Crossboyne Bridge	M3386170962	Mayo
Owenmore River	Big Bridge	G6662412322	Sligo
Owenmore River	Templehouse Bridge	G6250918568	Sligo
Duff River	Bridge at Drumacolla	G7960049100	Sligo
River Unshin	Ballygrania Bridge	G6949725875	Sligo
Drumcliff River	500 u/s Drumcliff Bridge	G6823242240	Sligo
Drowse River	Lennox's Bridge	G8180857254	Leitrim
Diffagher River	Cloonemeohe Bridge	G9345124542	Leitrim
River Shannon	Dowra Bridge	G9910026700	Leitrim
River Shannon	Mahanagh Bridge	G9557611687	Leitrim
Boyle River	Knockvicar Bridge	G8728605541	Roscommon
River Suck	Castlecoote Bridge	M8086362621	Roscommon
Boyle Canal	Boyle Canal	G8200004300	Roscommon
Lung River	Br u/s Lough Gara	M6614696681	Roscommon

APPENDIX C – STATISTICAL ANALYSIS

Table 1: Mean number of bat 'passes' recorded by 131 completed surveys submitted for statistical analysis in January 2007

Province	N surveyed waterways	No. of waterways with Daubenton's bat 'passes'	No. of waterways with 'Unsure' bat 'passes'	No. of waterways with bat 'passes'	No. of waterways with no bat 'passes'
Connaght	49	68.6	22.4	91.0	91.8
Leinster	102	43.9	27.2	71.2	94.1
Munster	64	47.7	14.0	61.7	95.3
Ulster	35	32.1	16.9	49.0	88.6
All	250	47.9	21.4	69.3	93.1

Table 2: Effects of factors from the REML model.
Ordinary means and standard errors are shown for numbers of passes (sures and unsures), as well as predicted values on the log scale, after adjusting for the effects of other factors in the model. The number of surveys is for the raw means; adjusted means are sometimes based on fewer surveys due to missing values amongst the covariates.

(a) Width (χ^2 = 9.45 with 4 d.f., P=0.051)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
2m or less	5	2.6	1.29	0.029	0.213
<=5m	83	35.9	4.27	0.295	0.065
<=10m	105	76.3	10.01	0.425	0.068
<=20m	37	136.8	48.31	0.513	0.093
>20m	16	54.4	9.36	0.493	0.133

(b) Rain (χ^2 = 14.21 with 3 d.f., P=0.003)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
dry	213	74.1	10.03	0.501	0.060
drizzle	13	50.5	15.77	0.391	0.086
light rain	11	33.5	9.99	0.419	0.080
not noted	11	35.6	11.92	0.093	0.139

(c) Temperature (χ^2 = 10.72 with 4 d.f., P=0.030)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
<=12C	48	38.2	7.08	0.304	0.072
12.1-14	60	80.3	29.97	0.296	0.070
14.1-16	60	74.0	13.99	0.318	0.072
16.1-18	35	66.5	12.97	0.377	0.074
over 18C	22	86.6	23.89	0.460	0.079

(d) ID skills (χ^2 = 6.41 with 3 d.f., P=0.093)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
Poor	22	52.0	12.01	0.258	0.123
Okay	137	49.0	5.18	0.275	0.070
Good	60	89.2	15.98	0.461	0.089
Very Good	29	137.3	60.33	0.409	0.109

Table 3: Percentage of 'Unsure' Daubenton's bat 'passes' by identification skills.
The logit-transformed values are taken from a mixed logistic regression model (Generalised Linear Mixed Model, GLMM). The final column back-transforms these (values are close to the overall means as site is the only other factor in the model). Number of surveys includes number of surveys with Daubentnon's bat 'passes' and number of surveys with 'Unsure' Daubenton's bat 'passes'.

	surveys	**mean % unsure**	**logit**	**logit s.e.**	**adjusted**
Poor	38	59.1	0.241	0.457	56.0
Okay	254	24.4	-1.125	0.187	24.5
Good	112	23.0	-1.424	0.279	19.4
Very Good	54	7.9	-2.763	0.461	5.9

Table 4: Variables tested and found to be non-significant when added to final model**.**

Term	χ^2	**d.f.**	**P**
province	2.74	3	0.434
east	0.66	1	0.418
north	0.55	1	0.458
cloud	2.75	3	0.431
wind	4.60	3	0.204
day number in year	0.01	1	0.931
period	0.15	1	0.701
week	1.79	5	0.878
time taken	0.22	1	0.639
log-transformed time	0.46	1	0.500
treeshelter	4.38	3	0.223
smoothwater	2.46	3	0.483
clear	0.20	1	0.656
detector	10.16	10	0.426
experience	5.16	3	0.160

POWER ANALYSES

In order to carry out power analyses, the following steps were carried out:

1. A REML model was fitted to the log-transformed counts from data collated to estimate the amount of variability between sites and between repeat surveys at the same site.
2. 26 years of data was simulated with these variabilities. This also requires information about how much sites vary from year to year, which is not available from the one year of data, so the equivalent figure from NBMP was used. Similarly for year-to-year variation about any trend.
3. Simulated trend equivalent to a red alert (50% decline over 25 years, i.e. 2.73% decline a year), or to an amber alert (25% decline over 25 years, i.e. 1.14% per year) was added.
4. Then tested to see whether a statistically significant decline is produced from the simulated data, using a GAM model.
5. The whole process is repeated 100 times to work out the power (i.e. the percentage of simulations giving a significant result). To reduce the impact of chance variation, a smooth curve was fitted through the results, in order to estimate the relationship between power and number of sites.

Analyses with the full 26 years of data was carried out (i.e. a trend over a period of 25 years), and with just the first 11 years. For the red alert simulations, the impact of missing data by deleting 40% of the data at random was examined.