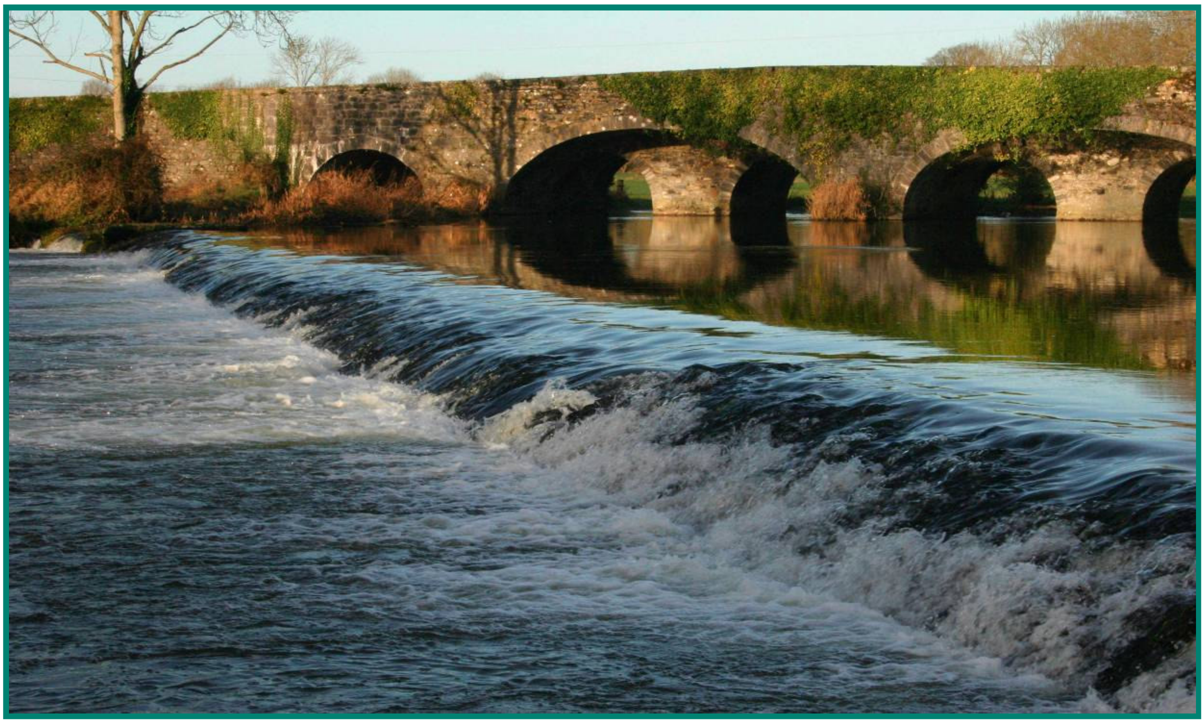
All Ireland Daubenton's Bat Waterway Monitoring Scheme 2006-2008



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All Ireland Daubenton's Bat Waterway Monitoring
Scheme 2006-2008

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

1. www.batconservationireland.org

2. stats@slangton.co.uk

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CONTENTS

EXECUTIVE SUMMARY

All bat populations are protected under Irish legislation. Under EU legislation Ireland is further required to maintain bat populations at favourable conservation status and to conduct monitoring programmes to assess bat population trends. Bat population trends provide an indication of ecosystem health.

The Daubenton's bat is easy to see when foraging because it feeds close to water, typically within 30cm of a smooth water surface. It can be found over rivers, streams, canals, pools and lakes. The characteristic nature of Daubenton's bats flying along a regular 'beat' over the surface of water makes it an easy species to record.

Using the monitoring methodology developed in Britain by BCT, the Daubenton's Bat Waterway Survey was introduced throughout the 32 counties of the Republic of Ireland and Northern Ireland in 2006. From 2006-2008, the project was managed by Bat Conservation Ireland and jointly funded by the National Parks & Wildlife Service (RoI), the Northern Ireland Environment Agency and Waterways Ireland.

It was initially proposed to sample at least 50 randomly selected waterways sites over the course of the 3 years of the scheme (2006-2008). In the first year of the scheme a total of 134 waterway sites were surveyed in 27 counties. Daubenton's bat 'passes' were recorded on 122 waterway sites (91%). During the repeated survey in 2007 a total of 199 waterway sites were surveyed in all 32 counties of the island. Daubenton's bat 'passes' were recorded on 171 waterway sites (86%). In 2008, 180 waterway sites were surveyed in all 32 counties. Daubenton's bat 'bat passes' were recorded on 156 waterway sites (87%). Overall, 286 waterway sites have been surveyed since 2006 and Daubenton's bat 'passes' were recorded on 254 waterway sites (89%).

Power analysis was carried out in 2006 and 2008 to determine the number of sample sites appropriate to monitor Red and Amber Alert targets. Results show that if between 150 and 200 sites are surveyed each year, it should be possible to detect Red Alerts in around 6 years and Amber Alerts in 10. Results of power analysis also show that a core of 67-75 sites surveyed twice annually and an additional 25-33 sites randomly surveyed each year are required to determine Amber Alerts after 15.4 years.

REML modelling shows that there is evidence for a decline in Daubenton's bat activity levels over the course of the survey from 2006 to 2008. A similar trend has been reported from the NBMP in the UK. However, this trend should be viewed with caution since only three years' of data have been compiled in Ireland to-date.

ACKNOWLEDGEMENTS

We would like to express our sincere thanks to all volunteers who contributed to the All-Ireland Daubenton's Bat Waterway Survey 2006-2008. Thanks to the individuals and groups that organised training courses and to those people who provided additional bat detectors for use by volunteers during the survey period.

Thanks also to

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- Staff of the Northern Ireland Environment Agency (formerly EHS), in particular, John Milburne.
- Staff of Waterways Ireland, in particular, Cormac McCarthy and Elizabeth Gabbett.
- Staff of Bat Conservation Trust UK, in particular, Jules Agate, Amy Coyte and Karen Haysom for their continuous support to BCIreland.
- Thanks to Meath County Council for funding the purchase of bat detectors for County Meath volunteers in 2006.

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INTRODUCTION

Bats constitute a large portion 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. 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 and the Iberian Peninsula to the Pacific Ocean and the northern islands of Japan (Altringham, 2003). It is widely distributed in Ireland and O'Sullivan (1994) reported it as the second most recorded species after common pipistrelle bat in 1988[1]. For a detailed description of the biology and ecology of this species, see Aughney and Roche (2006). The Daubenton's bat is easy to see when foraging because it flies very close to the water, typically within 30cm of the surface. It can be found over rivers, streams, canals, pools and lakes. 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). Aquatic insects make up most of its diet (e.g. Sullivan *et al.* 1993)

Why monitor Daubenton's bat?

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 as 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 EU Habitats Directive (92/43/EEC) and the Wildlife Acts (1976 and 2000) it is an offence to intentionally harm a bat or disturb its resting place.

The EU Habitats Directive lists all Irish bats species in Annex IV, while the lesser horseshoe bat *Rhinolophus hipposideros* is also listed in Annex II. Member states must maintain or, where necessary, restore 'favourable conservation status' of species listed in Annex II, IV and V. Conservation status is defined as 'the sum of the influences acting on the species concerned that may affect long-term distribution and abundance'. Article 11 of the Directive requires Member States to undertake surveillance of the conservation status of all the listed habitats and 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 is a signatory of the European Bats Agreement (EUROBATS). The

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[1] The common pipistrelle (*Pipistrellus pipistrellus*) was the only pipistrelle species known to exist in Ireland in 1988. Since then, three species of pipistrelle have been identified (*P. pipistrellus*, *P. pygmaeus* and *P. nathusii*).

development of strategies for monitoring bat populations is one of the stated objectives of the EUROBATS Conservation and Management Plan. Across Europe, bats are further protected under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention 1982), which, in relation to bats, aims 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).

Despite high levels of legal protection for all bats in Ireland, until 2003 there was no systematic monitoring of any species apart from the lesser horseshoe bat. This waterways scheme, together with the Car-based Bat Monitoring Scheme (Roche *et al.* 2009), the Brown long-eared bat Roost Monitoring Scheme (Aughney and Roche, 2008) and ongoing work at the new Centre for Irish Bat Research are helping to redress the imbalance and ensure countrywide monitoring of all Irish bat species.

Under the Habitats Directive, Member States are required to identify species declining at >1% per year. Such a decline would put a species into the "red" category. However, at this stage, assessing trends to this level of accuracy with the current dataset would not be statistically sound. It may be feasible to address this requirement in the future when more data has been gathered.

Other standard measurements of population trends are widely used. The British Trust for Ornithology (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.

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. More recently, however, the conservation status of all Irish bat species was considered to be good (NPWS 2008).

The EU Directive 2000/60/EC 'Establishing a Framework for Community Action in the Field of Water Policy' (Water Framework Directive) requires member states to actively expand the range of observations in future monitoring programmes of surface waters. One of the primary purposes of the Directive is to maintain the aquatic ecosystem as near as practical to its natural condition. The close association of bats with water makes them a suitable indicator group of water quality, insect biodiversity and the structure of associated waterside vegetation. A study in the UK focused on the potential use of Daubenton's bat as an indicator of water quality and riparian vegetation. The results demonstrated a positive correlation between this species of bat and water quality (Catto *et al.*, 2003). The Irish Daubenton's monitoring programme not only provides much-needed data on the status of the species' population but could also contribute to an index of aquatic habitat quality. This monitoring programme may also aid in recommendations for management of surface waters, especially riparian habitats of rivers and canals.

How to monitor Daubenton's bat

<u>Echolocation calls and bat detectors</u>

Daubenton's bats tend to use FM echolocation pulses ranging in a downward sweep on average from 79kHz to 33kHz in a typical foraging habitat. FM (Frequency Modulated) sounds are those that sweep down over a range of frequencies and are typically used by bats to determine fine detail in cluttered environments (Russ, 1999).

Heterodyne bat detectors tend to be tuneable, so the frequency to which the detector is set, is subtracted from the incoming frequency. Therefore if the detector is tuned to 50kHz and the incoming bat call is at 55kHz then the resultant output sound is at 5kHz (Elliott, 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. A Daubenton's bat 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 but when it feeds outside this area e.g. around trees, its echolocation calls become similar to other *Myotis* species such as Natterer's bat *M. nattereri*.

Sampling the activity of Daubenton's bats along waterways using a heterodyne bat detector is relatively straightforward. The echolocation call is loudest when the detector is tuned to 45kHz. However to distinguish from foraging pipistrelle bats the detector is tuned 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).

<u>Bat 'passes', a tool for surveying Daubenton's bats</u>

A 'bat pass' is a sequence of echolocation calls indicating a bat in transit (Fenton, 1970). 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 aims of this report

This is the first synthesis report for the waterways bat monitoring scheme. It brings together the data from 2006 to 2008 and

- examines volunteer participation and geographical coverage
- reviews total bat encounters, by year and by province
- looks at population trend data
- examines the results using Power analysis
- compares results using heterodyne and time expansion detectors
- examines the data in relation to water quality, waterway size and air temperature
- makes recommendations on the future of the survey.

METHODS

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

Surveyors were assigned a choice of 2 or 3 survey starting points. These points were located within 10km of the surveyor's preferred area and were selected from the EPA's National Rivers Monitoring Programme in the Republic of Ireland and the Water Quality Management Unit dataset under the NIEA, Northern Ireland.

Surveyors undertook a day visit (with landowner's permission) to assess if a site was suitable and safe to survey. At the chosen site, ten points approximately 100m apart were marked out along a 1km stretch. The surveyors then revisited the site on two evenings in August and started surveying 40 minutes after sunset. At each of the ten points, the surveyor recorded Daubenton's bat activity for four minutes using a heterodyne bat detector and torchlight (Walsh *et al.*, 2001).

Surveyors were instructed to undertake a survey during the first half of August: Survey 1 (1st August to 15th August) and, where possible, to complete a survey of their waterway on a second night (Survey 2 (16th August to 31st August).

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 bats but not seen skimming the water may be 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 also record a number of parameters including air temperature, weather data and waterway characteristics, such as width and smoothness. Volunteers are required to survey in pairs for safety reasons. One member of the team is designated as Surveyor 1 and uses the bat detector and torch while Surveyor 2 documents the numbers of 'passes' and other information required for the recording sheets. Information on the bat detection skills of Surveyor 1 and model 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.

Volunteer uptake and participation

Due to the paucity of bat workers in the Republic of Ireland and Northern Ireland, it was necessary to recruit new volunteers for this survey. BCIreland advertised the scheme widely. An on-line registration system was also set up on the BCIreland website to facilitate volunteer participation. Each training course consisted of a one hour Power Point presentation followed by an outdoor practical session to demonstrate the survey methodology. An information pack consisting of detailed description of the methodology was also provided for each volunteer team. BCIreland organised training courses throughout the Republic of Ireland and Northern Ireland in each year of the monitoring scheme (2006: 14 courses; 2007: 14 courses & 2008: 16 courses) and trained over 500 volunteers.

Statistical analysis

For statistical analysis a log-transformation was carried out on the data at the ten individual points within each survey; this effectively calculates a geometric mean number of passes for the survey and helps to reduce the influence of the very high counts sometimes recorded due to one or two bats repeatedly passing the observation point. To investigate potential relationships with explanatory variables, a REML model with random terms for sites and years within sites (REML rather than ordinary regression in order to allow for the two surveys at each site in each year: Survey 1 & Survey 2) was applied to the total of Daubenton's bat 'passes' plus 'Unsure' Daubenton's bat 'passes'. The maximum number of passes at any one spot was set to 48; this avoids problems with different observers recording different figures for continuous bat activity. A forward stepwise fitting procedure was undertaken; this was conducted manually in order to allow biological plausibility to influence the choice of terms. Correlations between explanatory variables were checked to avoid including highly correlated variables in the same model, and residuals were checked for approximate normality.

The final model contained terms for waterway site width, air temperature, identification skills of volunteers, start time, duration of survey and percentage of smooth surface of waterway. All of these terms were nominally significant at the 5% level, but these significance levels should be treated with caution because they do not allow for the stepwise process. To ease fitting and display, some continuous variables were grouped (e.g. temperature values grouped into five categories). Details of these six variables with significant influence on the mean number of bat passes recorded are displayed in Appendix I, Table 1a-f. Test statistics for other variables are presented in Appendix I, Table 2.

To assess trends, a Poisson Generalized Linear Model (GLM see Glossary) was applied to the data. Bootstrapping was undertaken at site level to calculate standard errors so that the analysis will not be invalidated by the distribution of the data or any temporal correlation in the data. This approach is similar to the approach used for assessing trend in Britain in the NBMP, and also for trends in bird populations. Recent work for the NBMP has suggested that precision may be improved, at the risk of some bias, by using a logistic regression model for the number of observation points with bats present. This approach will be evaluated in the future, but is not used in the current report.

Power Analysis uses, as its basis, information about how much sites vary from year to year. A very similar approach to the power analysis of the All Ireland Daubenton's Bat Waterway Survey was used with the Car-based Monitoring Scheme (2003-2008) (Roche *et al.,* 2009). This involves estimating the patterns of variability in the real data using REML analysis, and then simulating a large number of artificial datasets with added trend. GAM models (Fewster et al., 2000) are then fitted to the artificial datasets to see how frequently the trends are detected with different numbers of sites and years. More technical details are provided in Appendix II. As with the Car-based Monitoring Scheme (2003-2008), two standard levels of decline - Amber Alert, representing a 25% fall over 25 years (i.e. 1.14% per year), and Red Alert, representing a 50% fall over 25 years (i.e. 2.73% per year) - are used as the basis for the power analysis. In addition a simulation by doubling of the population over 25 years (i.e. 2.81% increase per year) was completed. All trends are simulated as constant percentage changes, but the analysis does not assume that this is known to be the case. The analysis is worked with 90% confidence limits (i.e. a one-sided significance test at P=0.05), and 80% power; which is the minimum acceptable, so results should be viewed as the absolute minimum numbers to achieve good results.

Detailed methodology is given in Appendix I and II.

Time Expansion Trials Methods

A study was undertaken to test whether the use of Tranquility Transect Time Expansion bat detectors could be used in addition to heterodyning method along a smaller number of sample sites (n=16). Two field assistants teamed up with 16 All-Ireland Daubenton's Bat Waterway Survey volunteer teams. While the volunteer teams were surveying for Daubenton's bat activity, the field assistants recorded, at each spot (n=160), bat activity for 4 minutes using a Tranquility Transect Time Expansion bat detector (this corresponded to the same 4 minutes surveyed by All-Ireland Daubenton's Bat Survey volunteers). Recordings were saved to a minidisc recorder for analysis. A repeat survey was undertaken for each waterway site.

Bridge surveys

During analysis of volunteer survey forms participating in the All-Ireland Daubenton's Bat Waterway Survey (2006-07) it was noted, in some instances, that a high level of bat activity was recorded adjacent to bridges. In 2008, BCIreland secured funding (60%) from The Heritage Council to undertake a survey a sample of eighty bridges covered under the monitoring programme to determine whether such bridges were roosting sites for bats.

The survey methodology followed that of Billington and Norman (1997). This methodology involved a grading system where the bridge examined was categorised as follows:

0 = no potential (no suitable crevices)

1 = crevices present may be of use to bats

2 = crevices ideal for bats but no evidence of usage

3 = evidence of bats (e.g. bats present, droppings etc.)

Evidence of bats is in the form of actual bats (visual or audible), bat droppings, urine staining, grease marks (oily secretions from glands) and claw marks. In addition, the presence of bat fly pupae (bat parasite) also indicated that bat usage of a crevice has occurred in the recent past. To complete this grading, each bridge was inspected. A high-powered, narrow beamed torch was used to inspect crevices, holes, cracks and joints beneath bridge arches and abutments, within culverts and within any external structures that may offer a roosting site for bats. Where necessary, an endoscope was employed for deep crevices not accessible using a torch. Where a bat was recorded in a structure but not identified to species level, a dusk detector survey was undertaken to confirm species identification. For a small number of bridges, a dusk survey was undertaken to determine the number of bats roosting within the bridge. In some cases, due to high water levels, arches of some bridges were not fully accessible and therefore assessment was aided by photographs.

All bridges were surveyed at least once and, where possible, a follow-up survey was completed. The data recording sheet used by Masterson *et al.* (2008) was adopted for this survey. A data recording sheet was completed for each bridge surveyed and this gathered descriptive information on the bridge structure, adjacent habitats, bat usage and importance for bats. In addition, the grid reference was noted for all surveyed bridges.

RESULTS

Descriptive Statistics

Volunteer participation from 2006 to 2008

A total of 131 volunteer teams surveyed 134 waterway sites in 2006. 189 volunteer teams surveyed 199 waterway sites in 2007 and 170 volunteer teams surveyed 180 waterway sites in 2008. The level of skills and bat detector experience of volunteer teams are presented in Table 1.

Table 1: Level of bat detector skill and level of bat detector experience of volunteer teams that participated in the All Ireland Daubenton's Bat Waterway Survey 2006-2008.

	2006 (n=134)	2007 (n=199)	2008 (n=180)
Level of skills			
Poor	12 teams (9%)	18 teams (9%)	18 teams (10%)
Okay	77 teams (57%)	99 teams (50%)	74 teams (41%)
Good	33 teams (25%)	62 teams (31%)	64 teams (36%)
Very Good	12 teams (9%)	19 teams (9.5%)	22 teams (12%)
Not Noted	3 teams (2%)	1 team (0.5%)	2 teams (1%)
Bat detector experience			
<1 year	28 teams (21%)	46 teams (23%)	26 teams (14%)
1 year	45 teams (34%)	47 teams (24%)	32 teams (18%)
2-3 years	25 teams (18%)	53 teams (26.5%)	57 teams (32%)
>3 years	36 teams (27%)	51 teams (25.5%)	63 teams (35%)
Not Noted	0 team (0%)	2 teams (1%)	2 teams (1%)

Over the duration of the three years of the scheme, a total of 268 volunteer teams registered with BCIreland and participated in the monitoring scheme. However, 132 volunteer teams (49%) only participated in the monitoring scheme for one year while 67 volunteer teams (25%) surveyed waterway sites for each of the three years of the monitoring scheme (See Figure 1).

The majority of volunteer teams are members of the general public (n=200) and the remainder are members of staff of funding partners (n=62) or BCIreland/local bat group members (n=31). The annual turn-over of volunteers is highest in the members of the public category where 57% participated for one year only.

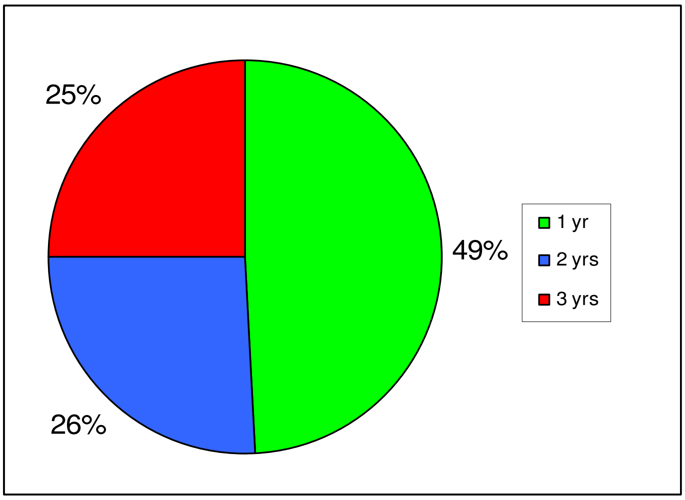


Figure 1: Volunteer participation in the All-Ireland Daubenton's Bat Waterways Survey for the duration of the scheme (2006-2008)

A total of 14 bat detector models were used by volunteers over the duration of the monitoring scheme. The most common detector types were the Bat Box III and the Magenta Mark III, two affordable heterodyne bat detector models (approximately €185 and €125 respectively).

Waterway sites surveyed in 2006-2008

A total of 134 waterway sites were surveyed in 27 counties in 2006. In 2007, 199 waterway sites were surveyed in all 32 counties. In 2008, 180 waterway sites were surveyed in all 32 counties. In total, 286 waterway sites have been surveyed since 2006 (See appendices for complete list of waterway sites surveyed). Forty-five waterway sites were located in Northern Ireland while 241 waterway sites were located in the Republic of Ireland. A total of 156 rivers, 11 canals and one estuarine channel (North Slobs) were surveyed. Forty-eight waterways had more than one surveyed waterway site (e.g. 11 waterway sites along the length of the Royal Canal).

The greatest number of waterway sites surveyed over the three years were located in the province of Leinster (n=128) while the highest number of waterway sites per county was found in County Cork (n=20) (See Figure 2).

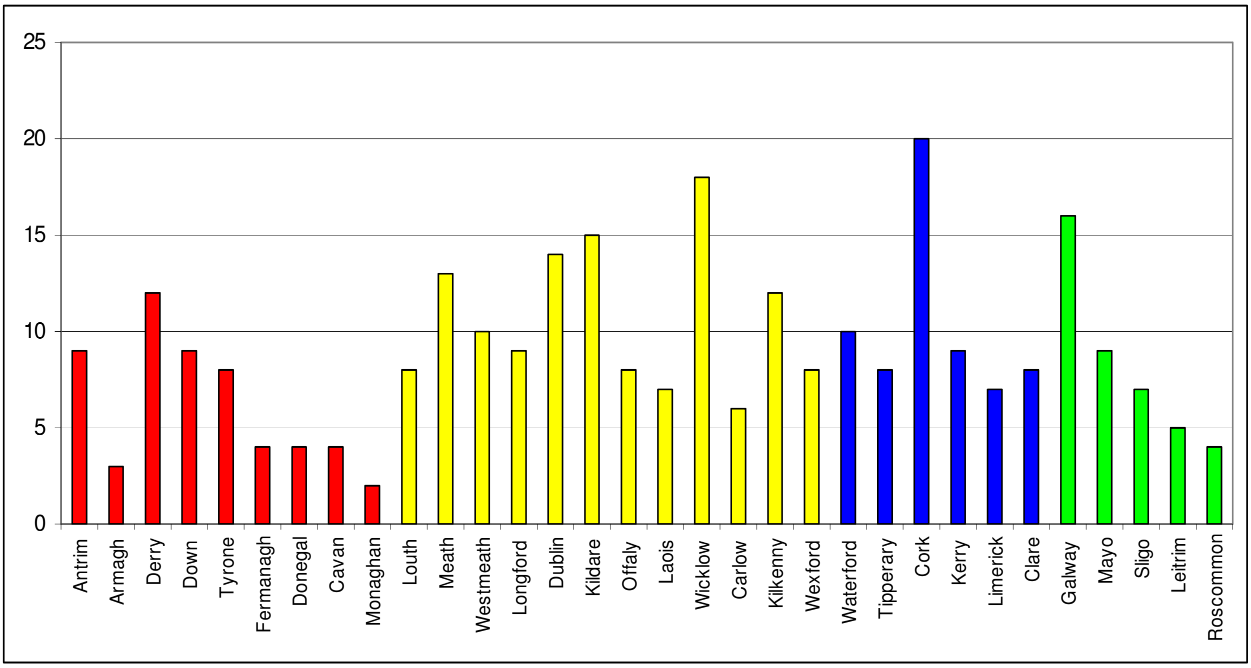


Figure 2: Number of waterway sites surveyed (n=286) in each county surveyed (n=32) over the duration of the monitoring scheme (2006-2008). ■ Ulster (n=55) ■ Leinster (n=128) ■ Munster (n=62) ■ Connaught (n=41)

For each of the three years of the monitoring scheme, the highest number of waterway sites surveyed was consistently in Leinster. There was an increase in the number of sites surveyed in 2007 in each province. While the overall number of sites surveyed in 2008 decreased from 2007, there was an increase in the number of sites surveyed in the province of Ulster (See Figure 3).

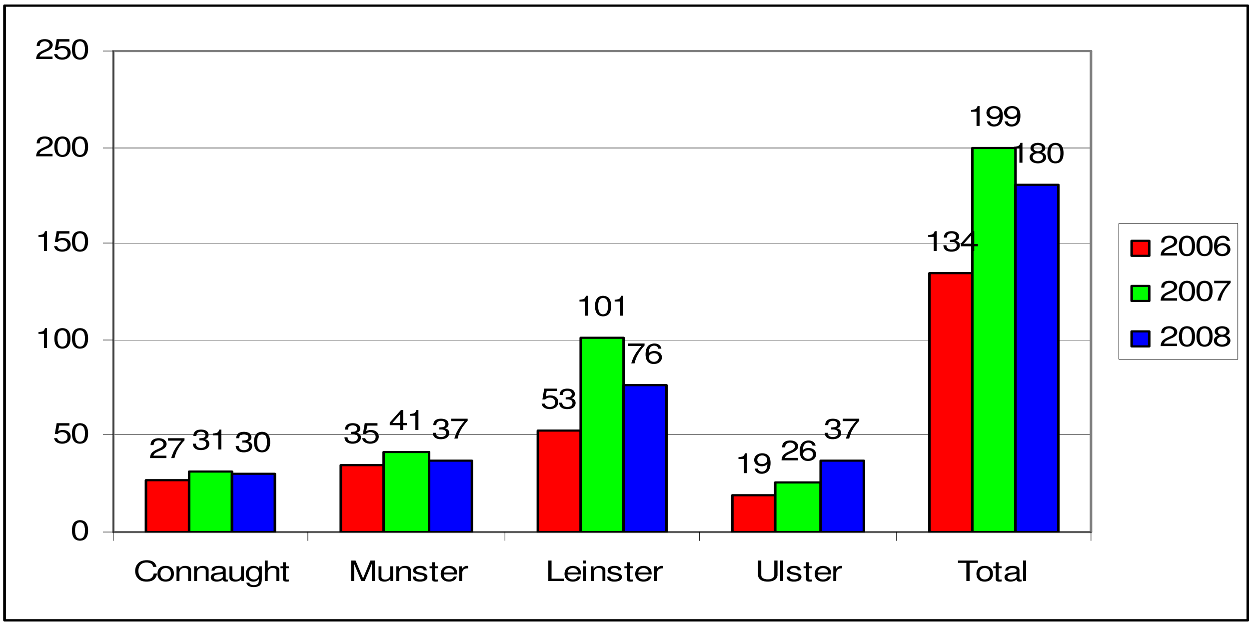


Figure 3: Number of waterway sites surveyed (n=286) in each province over the duration of the monitoring scheme (2006-2008).

Of the 286 waterway sites surveyed, 134 waterway sites (47%) were surveyed in one year only while 74 waterway sites (26%) were surveyed in two of the three years of the scheme and the remaining 78 waterway sites (27%) were surveyed in each of the three years of the monitoring scheme Figure 4 provides a further breakdown of number of waterways surveyed over the duration of the monitoring scheme. See Figure 5 for location of waterway sites as depicted on a map of the island. A breakdown of waterways surveyed for each county and province over the duration of the monitoring scheme is presented in Figures 6-9.

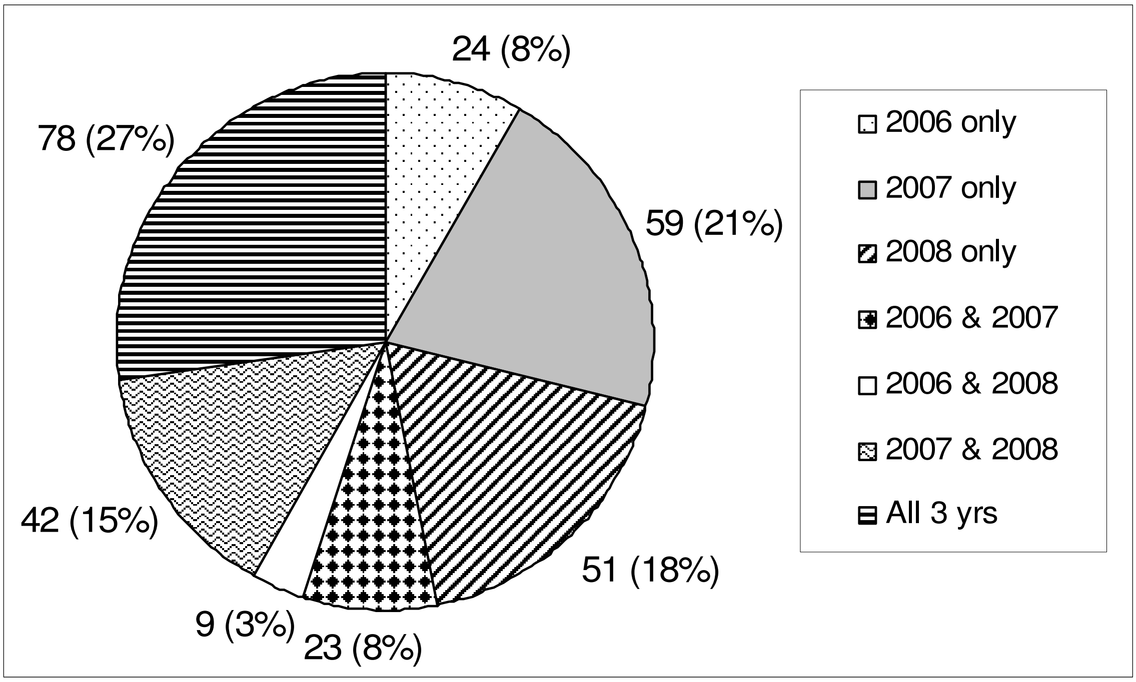


Figure 4: Number of waterway sites surveyed (n=286) during the monitoring scheme (2006-2008) by year.

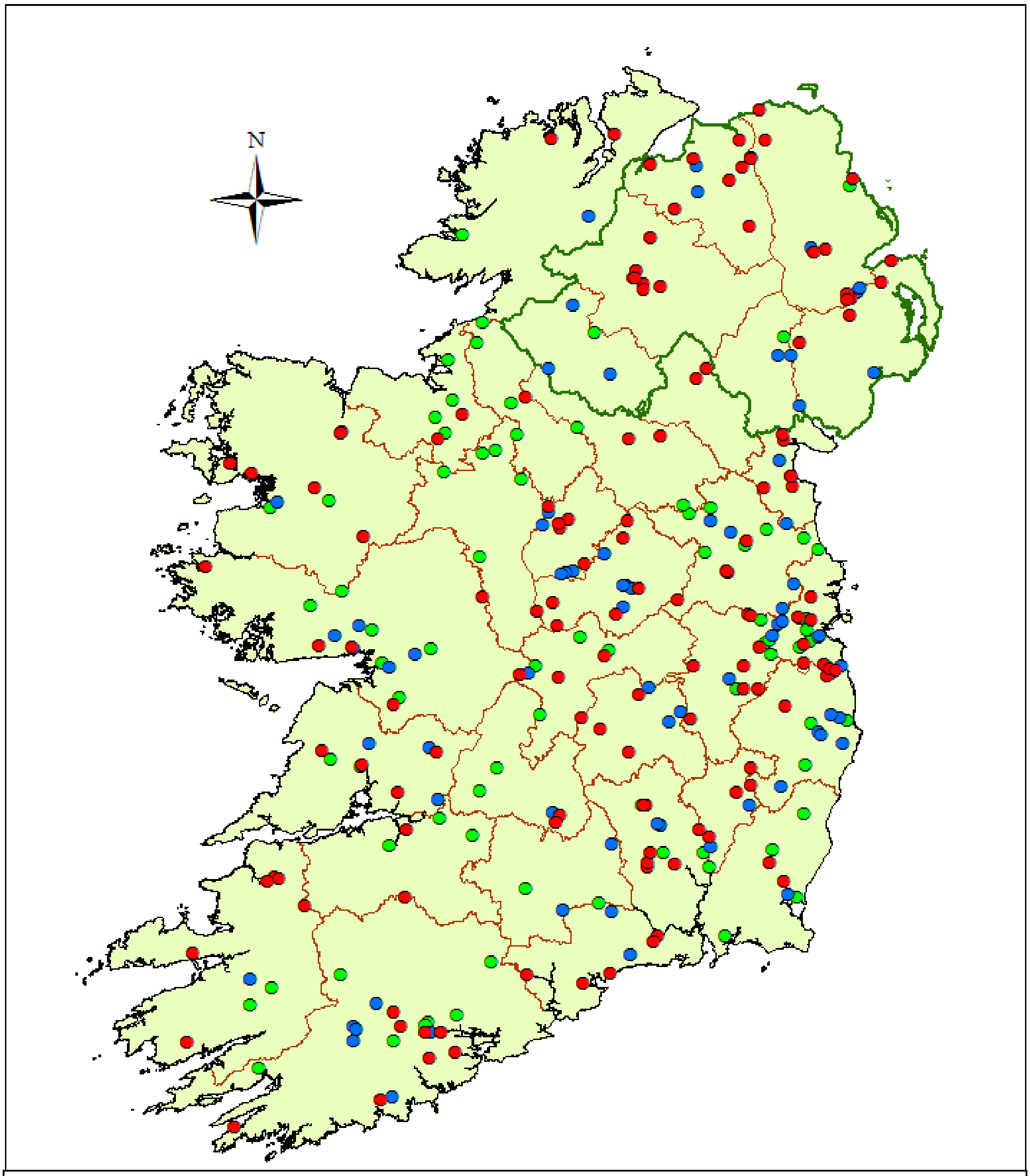


Figure 5: Location of all waterway sites surveyed in 2006, 2007 and 2008 under the All Ireland Daubenton's Bat Waterway Survey.

- Waterway sites surveyed in one year only (n=134)
- Waterway sites surveyed in 2 of the 3 years (n=74)
- Waterway sites surveyed in all 3 years (n=78)

Scale: 1:200,000 *GIS Arc View 9.2*

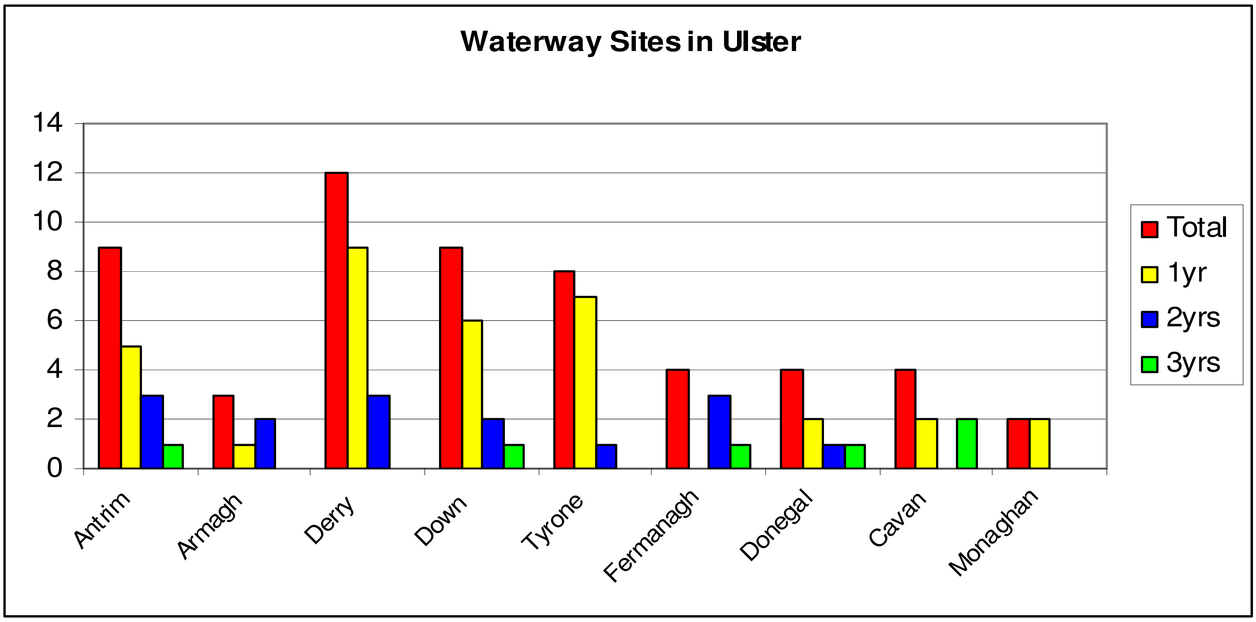


Figure 6: Waterway sites surveyed in 2006-2008 for each county in Ulster. Ulster: Total (n=55); 1yr (n=34); 2yrs (n=15) & 3yrs (n=6)

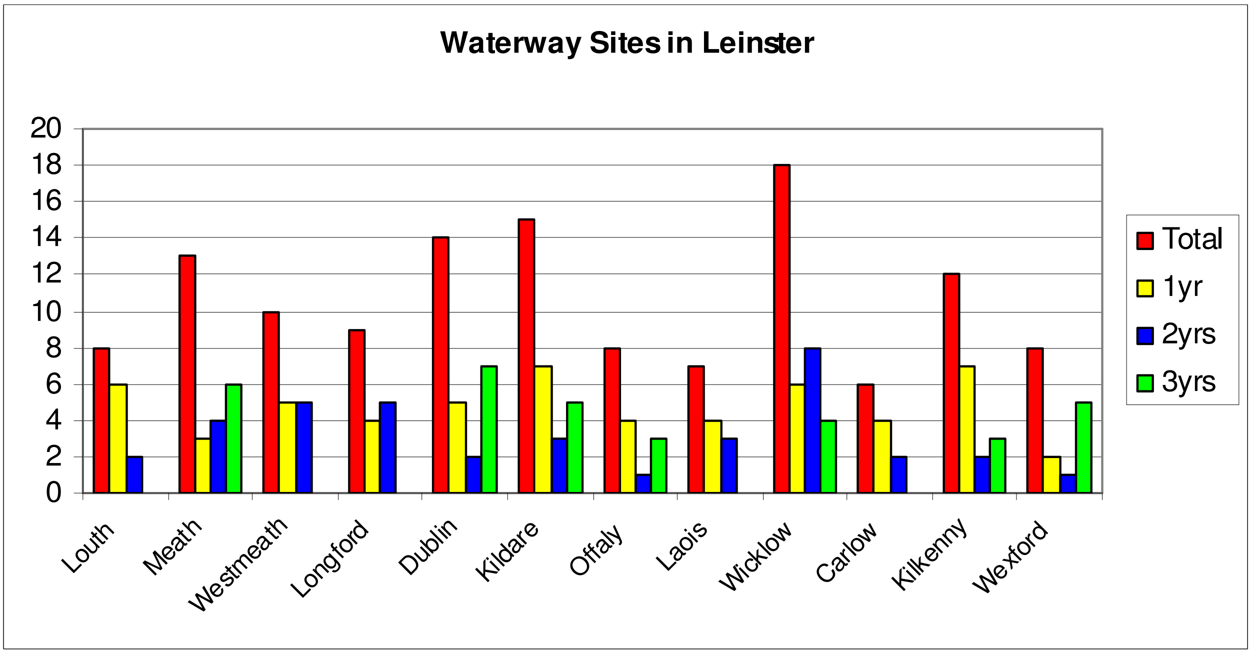


Figure 7: Waterway sites surveyed in 2006-2008 for each county in Leinster. Leinster: Total (n=128); 1yr (n=57); 2yrs (n=38) & 3yrs (n=33)

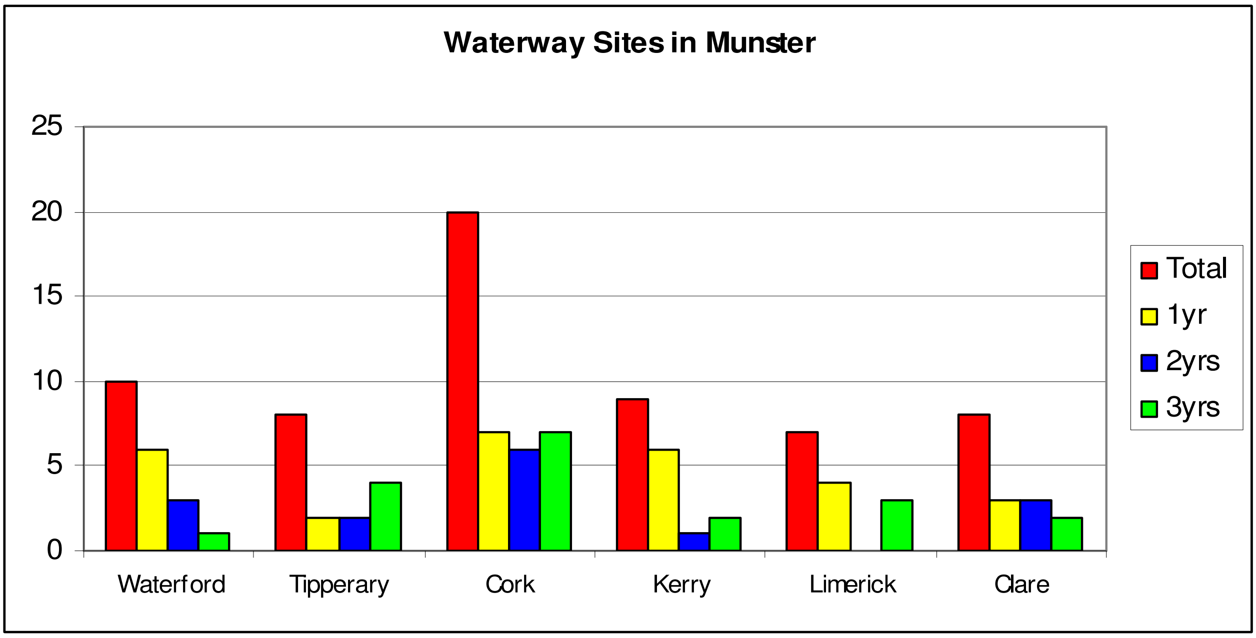


Figure 8: Waterway sites surveyed in 2006-2008 for each county in Munster. Munster: Total (n=62); 1yr (n=28); 2yrs (n=15) & 3yrs (n=19)

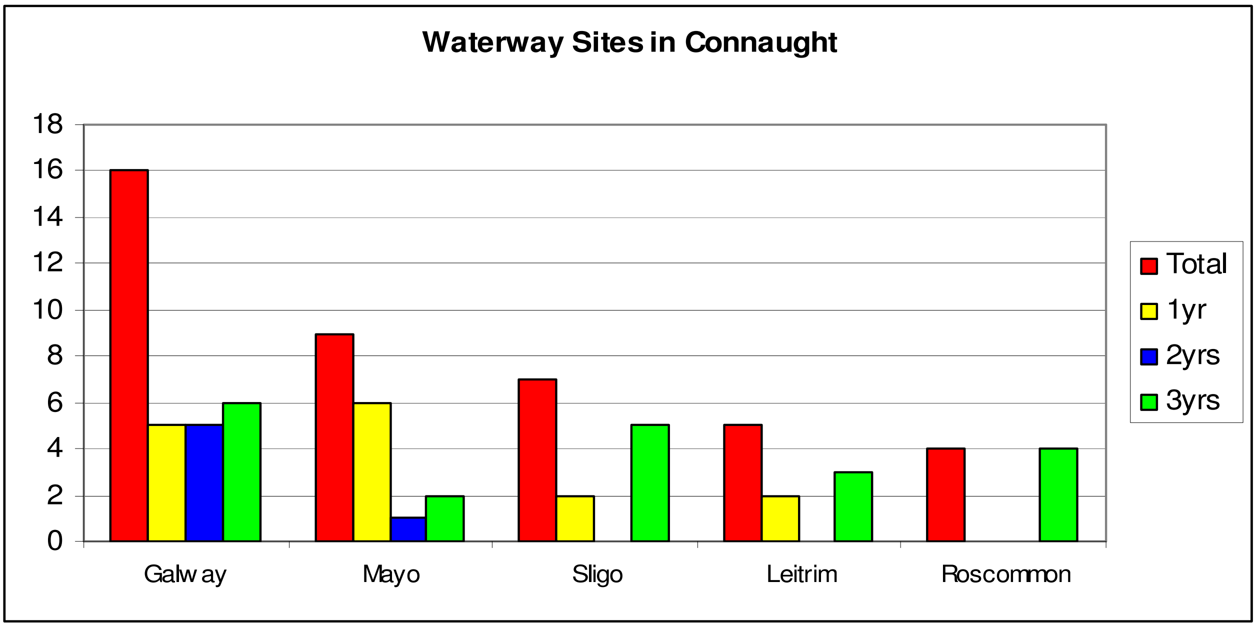


Figure 9: Waterway sites surveyed in 2006-2008 for each county in Connaught. Connaught: Total (n=41); 1yr (n=15); 2yrs (n=6) & 3yrs (n=20)

Number of completed surveys in 2006-2008

A total of 256 completed surveys from the 134 waterway sites were returned to BCIreland in 2006. A total of 384 completed surveys from the 199 waterway sites were returned in 2007 while a total of 311 completed surveys on 180 waterway sites were completed in 2008. Overall, 951 surveys were completed in the three years of the monitoring scheme amounting to 634 hours of monitoring time (40 minutes per survey). 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*). In 2006-2008 462 surveys were completed in Survey 1 and 489 surveys were completed in Survey 2 (See Figure 10). Waterway sites with repeated surveys (i.e. surveys completed in both sample periods S1 & S2) provide more robust data for monitoring. In 2006-2008, a total of 440 repeated surveys were completed (See Figure 11).

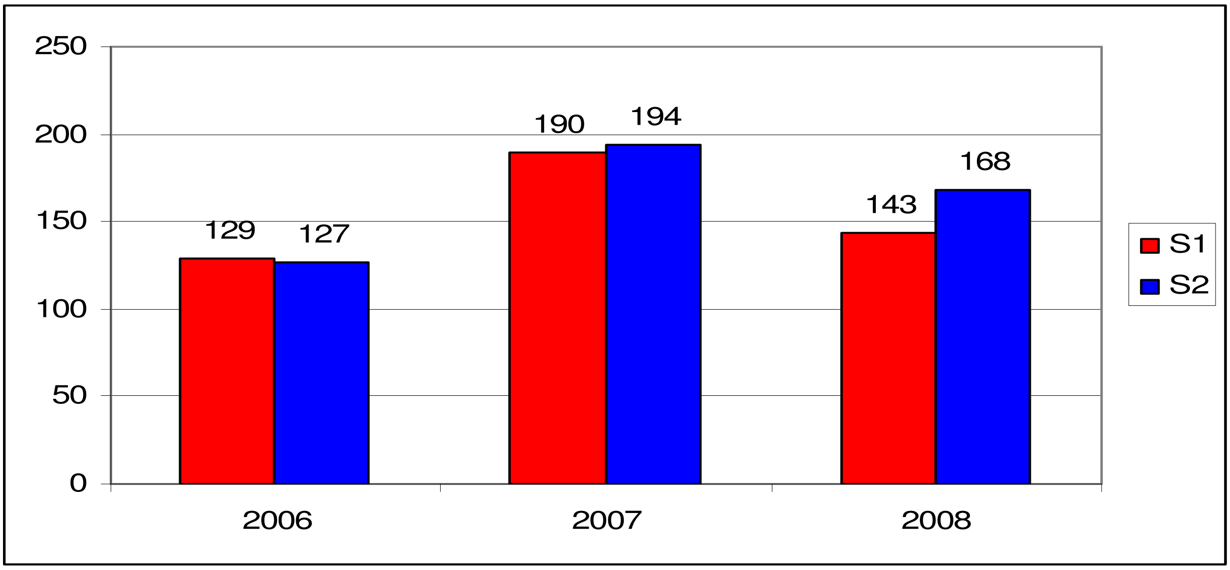


Figure 10: Number of completed surveys undertaken in 2006-2008 – S1 (n=462) & S2 (n=489).

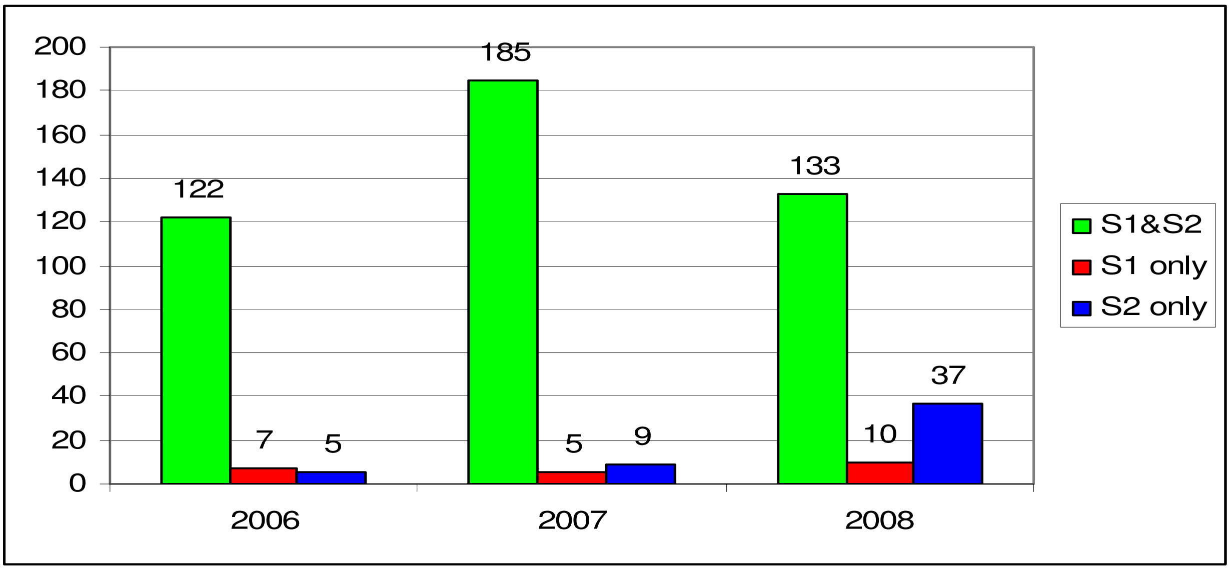


Figure 11: Number of repeated surveys undertaken in 2006-2008 - S1&S2 (n=440), S1 only (n=22) & S2 only (n=51).

Number of bat 'passes' recorded in 2006-2008

During the three years of monitoring, Daubenton's bat 'passes' were recorded on 253 waterway sites (89%) (See Figure 13) while Unsure Daubenton's bat 'passes' were recorded on 229 waterway sites (80%). Overall, bats were recorded (i.e. Daubenton's bat 'passes' and/or 'Unsure' Daubenton's bat 'passes') on a total of 267 waterway sites (93%) with only 19 waterway sites (7%) with no bats.. See Table 2 for a breakdown of results per year. The types of bat passes recorded in each year are depicted in Figure 12. The percentage of waterway sites with Daubenton's bat 'passes' and 'Unsure' Daubenton's bat 'passes' was greatest in 2006 (87.5% and 78.9% respectively).

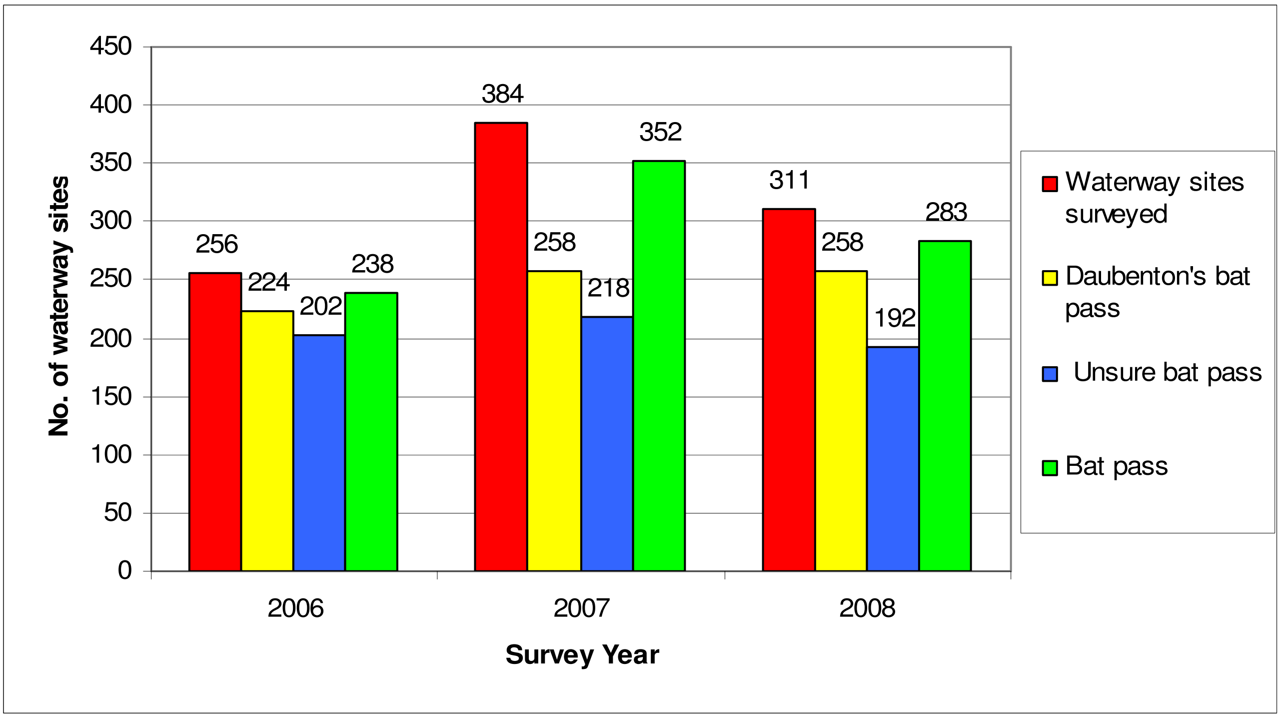


Figure 12: Number of completed surveys with Daubenton's 'bat passes' and Unsure Daubenton's 'bat passes' in 2006-2008.

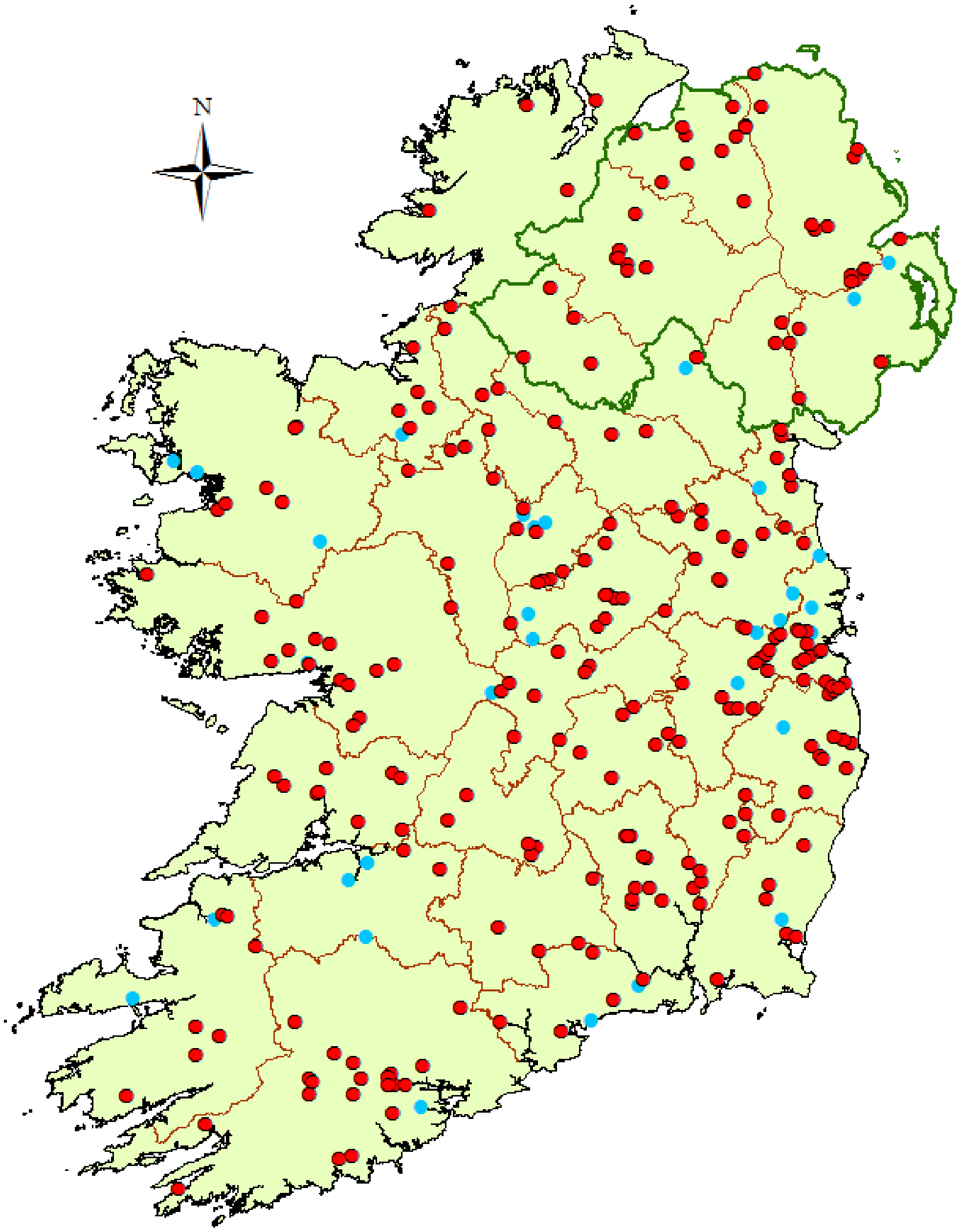


Figure 13: Location of all waterway sites surveyed in 2006, 2007 and 2008 for the All Ireland Daubenton's Bat Waterway Survey illustrating waterway sites where Daubenton's bat 'passes' were recorded (Total number of waterway sites surveyed n=286).

● Daubenton's bat 'passes' recorded (n=254)

● No Daubenton's bat 'passes' recorded (n=32)

Scale: 1:200,000 *GIS Arc View 9.2*

Table 2: Details of completed surveys where bat 'passes' were recorded in 2006, 2007 & 2008.

Province	N completed surveys	Daubenton's 'passes'	Unsure 'passes'	Daubenton's 'passes' only	Unsure 'passes' only	Bats recorded	No bats
	ALL SITES SURVEYED 2006						
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**
	ALL SITES SURVEYED 2007						
Connaught	60	51	39	18	7	58	2
Leinster	194	162	138	37	13	175	18
Munster	79	60	46	24	11	71	9
Ulster	51	45	36	13	4	49	2
Total	**384**	**318**	**259**	**92**	**35**	**353**	**31**
	ALL SITES SURVEYED 2008						
Connaught	49	44	27	20	3	47	2
Leinster	135	102	80	36	14	116	19
Munster	67	57	44	17	4	61	6
Ulster	61	55	41	18	4	59	2
Total	**312**	**258**	**192**	**91**	**25**	**283**	**29**
	ALL SITES SURVEYED 2006-2008						
Connaught	160	139	102	49	13	152	8
Leinster	431	349	306	80	37	386	44
Munster	212	179	139	55	16	195	18
Ulster	149	133	106	35	8	141	8
Total	**952**	**800**	**653**	**219**	**74**	**874**	**78**

At each of the 10 points of each completed survey volunteers recorded Daubenton's bat activity for 4 minutes generating 40 minutes of data per completed survey. In total, 949 (ten points per survey) completed surveys with 39,736 Daubenton's bat 'passes' and 10,570 'Unsure' Daubenton's bat 'passes' were submitted for statistical analysis. The mean number of Daubenton's bat 'passes' was 41.9 per survey and mean number of 'Unsure' Daubenton's bat 'passes' was 11.1 per survey. Details are presented in Table 3 according to each of the four provinces. Connaught has the highest mean number of Daubenton's bat 'passes' and bat 'passes' per survey for each of the three years (Table 3 & Figure 14). All provinces, except Ulster, recorded lower mean numbers than in 2008.

From 2006 to 2008, the proportion of waterways sites where Daubenton's bat 'passes' were recorded decreased from 91% in 2006 to 87% in 2008 (See Figure 14). The proportion of 'Unsure' Daubenton's bat 'passes' showed a decreasing trend from 85% in 2006 to 67% in 2008. The decrease in 'Unsure' Daubenton's is likely to reflect increasing experience on the part of surveyors.

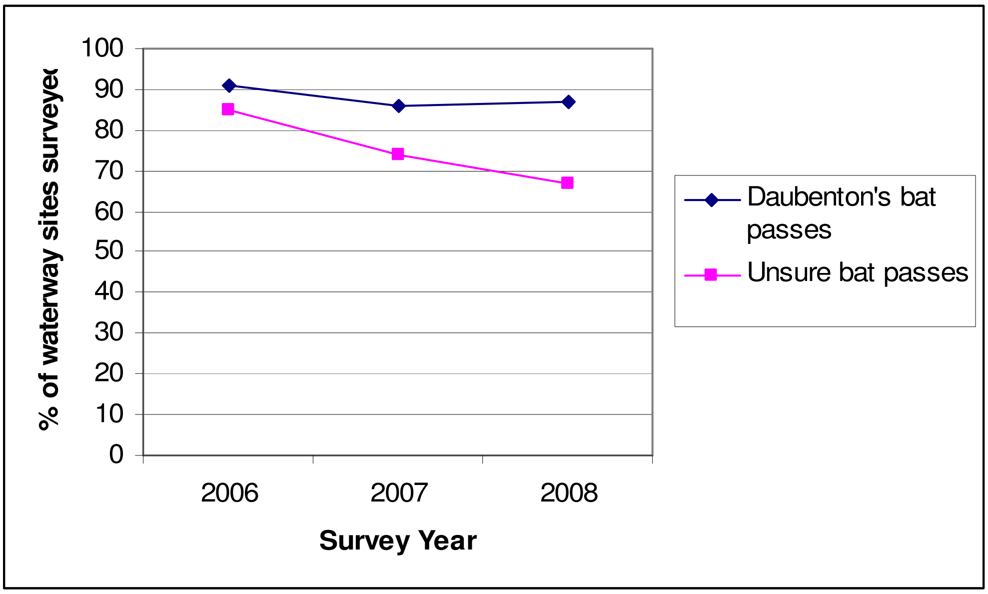


Figure 14: Percentage of waterway sites with Daubenton's 'bat passes' and 'Unsure' Daubenton's bat 'passes' in 2006-2008.

Table 3: Basic statistics: number of sites surveyed, mean, maximum numbers of bat 'passes' and percentage of sites with bats, shown by year and province. The final column refers to surveys with Daubenton's and 'Unsure' Daubenton's bat 'passes'. All values are per completed survey of 10 spot counts.

Connaught						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats
2006	53	66.3	21.1	87.4	77.2	92.5
2007	62	54.1	10.5	64.6	60.8	96.8
2008	49	44.0	6.5	50.5	45.9	95.9
All years	164	55.0	12.7	67.7	61.6	95.1
Leinster						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats
2006	102	43.9	27.2	71.2	51.1	94.1
2007	195	37.6	6.9	44.4	43.6	89.7
2008	135	33.4	5.6	39.0	38.0	85.9
All years	432	37.7	11.2	49.0	43.6	89.6
Munster						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats
2006	62	46.2	14.0	60.2	57.3	95.1
2007	78	48.8	7.1	56.0	52.2	89.7
2008	66	40.0	7.5	47.6	43.5	90.9
All years	206	45.2	9.3	54.5	50.9	91.7
Ulster						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats
2006	35	32.1	16.9	49.0	48.4	88.6
2007	51	29.8	8.7	38.5	37.6	96.1
2008	61	39.8	9.9	49.7	48.7	96.7
All years	147	34.5	11.1	45.7	44.8	94.6

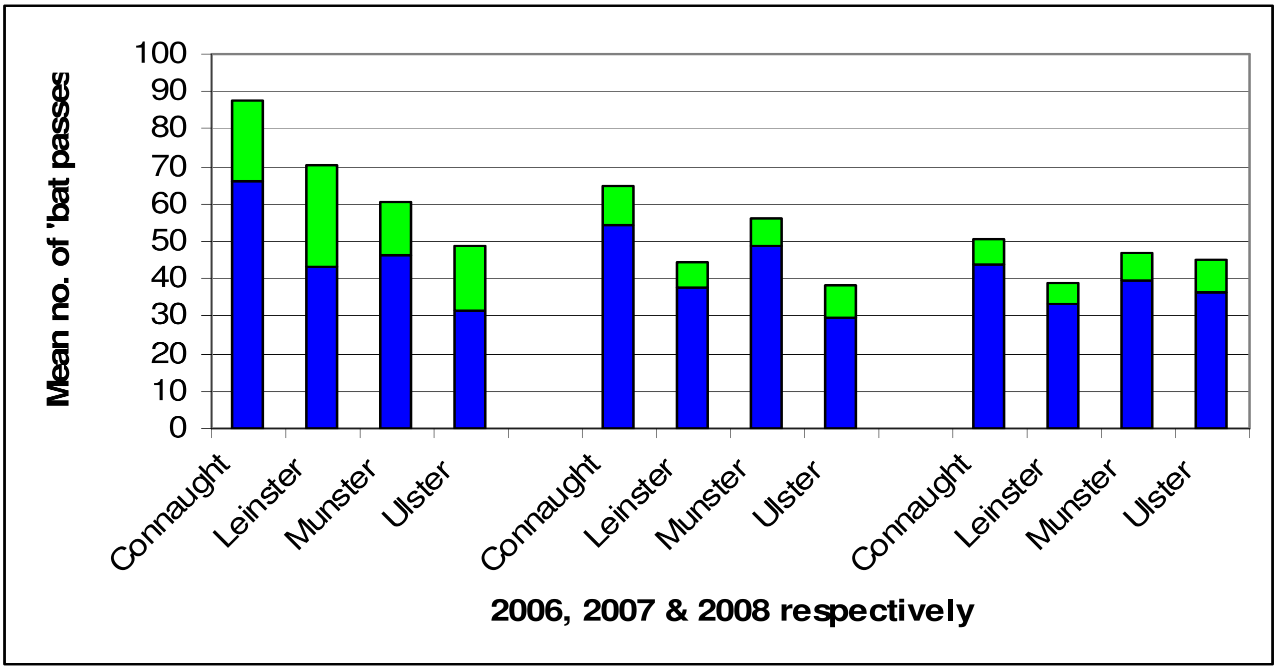
Contd. Table 3: Basic statistics: number of sites surveyed, mean, maximum numbers of bat 'passes' and percentage of sites with bats, shown by year and province. The final column refers to surveys with Daubenton's and 'Unsure' Daubenton's bat 'passes'. All values are per completed survey of 10 spot counts.

All Ireland						
Year	n completed surveys	mean sure	mean unsure	all	All (max 48 per spot)	% surveys with bats
2006	252	47.6	21.3	68.8	57.8	93.2
2007	386	41.5	7.7	49.2	47.3	91.7
2008	311	37.7	7.0	44.7	42.5	90.7
All years	949	41.9	11.1	52.9	48.5	91.8

With skewed data, means can be misleading as they are easily distorted by a few very large values. Therefore the percentiles are shown in Table 4 (e.g. if the data are arranged in ascending order, the 25th percentile is the value 25% along the line). Note that 2008 values are only lower than 2007 for the highest percentiles, suggesting that the lower means in Table 3 for 2007 may be the result of a decline in recorded 'bat passes' amongst the sites with the most counts. It cannot be entirely ruled out that this result is an artefact due to better recording of high counts as surveyors gain experience over the course of the monitoring scheme.

Table 4: Percentiles of the distribution of total counts (Daubenton's and 'Unsure' Daubenton's bat 'passes') in 2006-2008.

Percentile	minimum	5th	10th	25th	50th/median	75th	90th	95th	maximum
2006	0	0	2	7	34	80	138	202	1568
2007	0	0	1	9	30	68	112	164	377
2008	0	0	1	9	30	61	105	139	391



Daubenton's bat 'passes' 'Unsure' Daubenton's bat 'passes'

Figure 15: Mean number of bat 'passes' recorded during completed surveys in 2006-2008 (ten survey spots/completed survey, 4 minutes/spot, total 40 minutes sample time/completed survey).

Water Quality of Waterway Sites Surveyed

Waterway sites surveyed in 2006-2008 were assigned, where possible, from the EPA Water Quality dataset and the NIEA Water Quality dataset. A preliminary assessment of the water quality of waterway sites surveyed from those sites located in the Republic of Ireland was undertaken. The most recent information available for water quality was taken from www.epa.ie in relation to the 2003-2005 water quality data. The EPA routinely assesses the water quality of rivers across the country. The biological river quality (Q or biotic index) classification system is summarised as follows:

Q Value	Q5	Q4	Q3	Q2	Q1
Quality	Good	Fair	Doubtful	Poor	Bad

Intermediate indices of Q1-2, Q2-3, Q3-4 and Q4-5 are also used and denote transitional conditions. The scheme mainly reflects the impacts of biodegradable organic wastes on waterways. Biotic indices are related to the four Water Quality Classes (Unpolluted, Slightly Polluted, Moderately Polluted and Seriously Polluted).

Biotic Index	Q5, Q4-5 & Q4	Q3-4	Q3 & Q2-3	Q2, Q1-2 & Q1
Quality Status	Unpolluted	Slightly Polluted	Moderately Polluted	Seriously Polluted

Of the 241 waterway sites surveyed in the Republic of Ireland, 169 waterway sites were sampled by the EPA in the period 2003-2005. From this dataset, the following summary statistics were computed. Of the 92 waterway sites classified as 'Unpolluted', Daubenton's bat 'passes' were recorded on 91% of the waterway sites while 87% of waterway sites classified as 'Slightly Polluted' had recorded Daubenton's bat 'passes'. However to undertake a more intensive study, BCIreland has applied for 2006-2008 water quality data sets from the EPA and NIEA to investigation of the potential use of Daubenton's bats as water quality indicators.

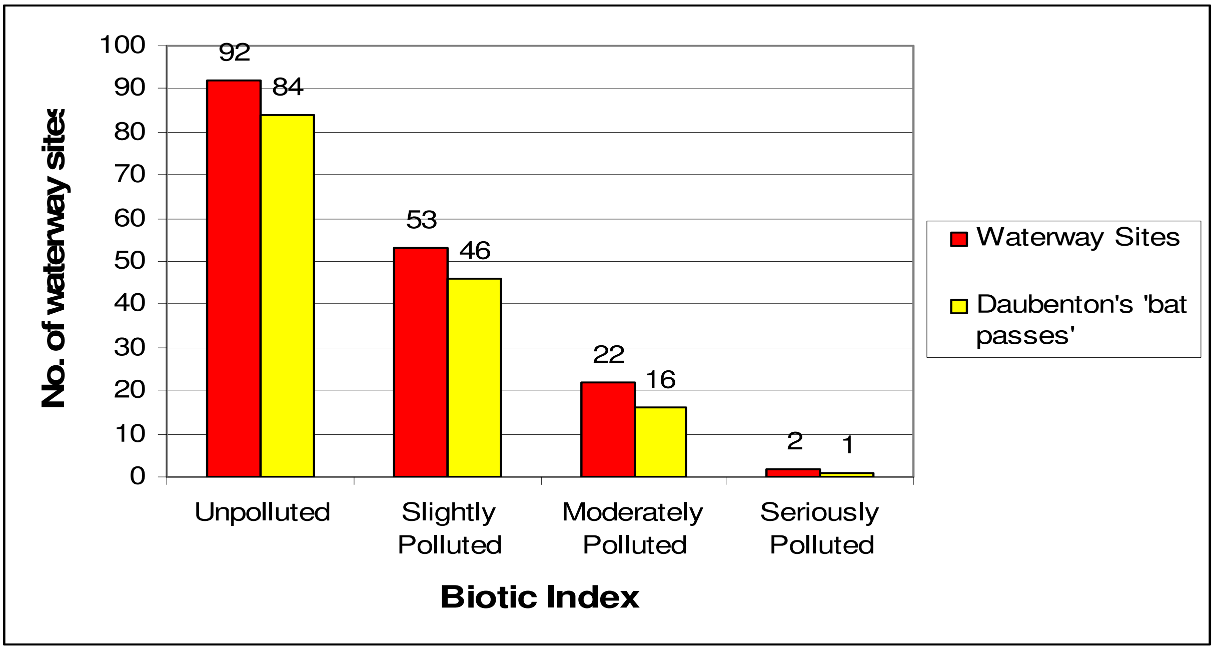


Figure 16: The number of waterway sites classified by Quality Status with Daubenton's bat 'passes'

Statistical Analysis of Results

To investigate potential relationships with explanatory variables, a REML model with random terms for sites and years within sites (was applied to the total of Daubenton's bat 'passes' plus 'Unsure' Daubenton's bat 'passes'. Waterway width values, as estimated by volunteers, were categorised into five groups (from <2m to > 20m). The majority of waterway sites were entered into the 5m-10m group. This parameter was found to be highly significant (χ^2 = 19.96 with 1 d.f., P<0.001, fitting as linear on the log-scale) and is therefore an important influence on the number of bat 'passes' recorded by volunteers. The graph in Figure 17, plotted on the log scale suggests that there is an increase in bat 'passes' with waterway width. .

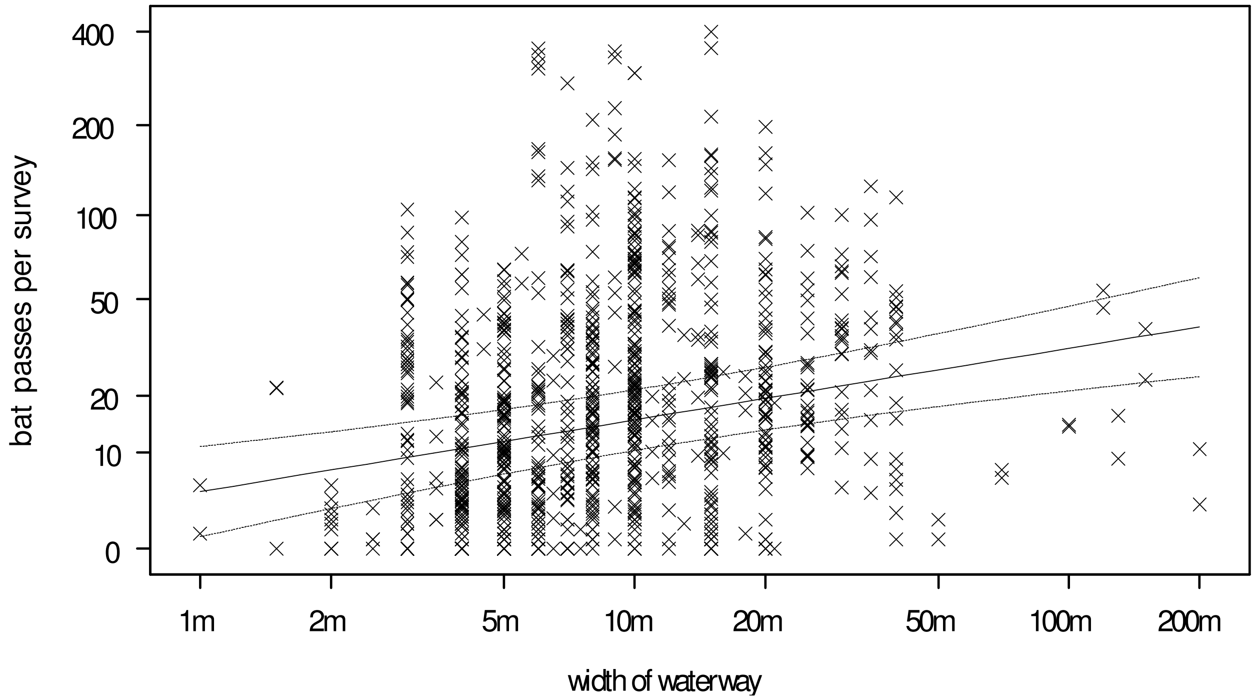


Figure 17: Back-transformed mean number of bat 'passes' recorded according to width of waterway sites surveyed. Upper and lower lines show 95% confidence limits for the estimated slope, adjusting for other terms in the model. (χ2 = 19.96 with 1 d.f., P<0.001, fitted as linear on the log scale)

Air temperature was recorded by volunteers at the start of the survey night. The values recorded were grouped into five categories (e.g. <12°C; 12.1-14.0°C, etc.). Temperature is significant at the 5% level, with an upward trend in the adjusted values on the log scale (χ^2 = 5.01 with 1 d.f., P=0.025). However, there is considerable variation about the fitted line (Figure 18). Mean number of bat 'passes' were highest for the category 14.1-16°C (Mean no. of bat passes = 58.9 for this temperature category).

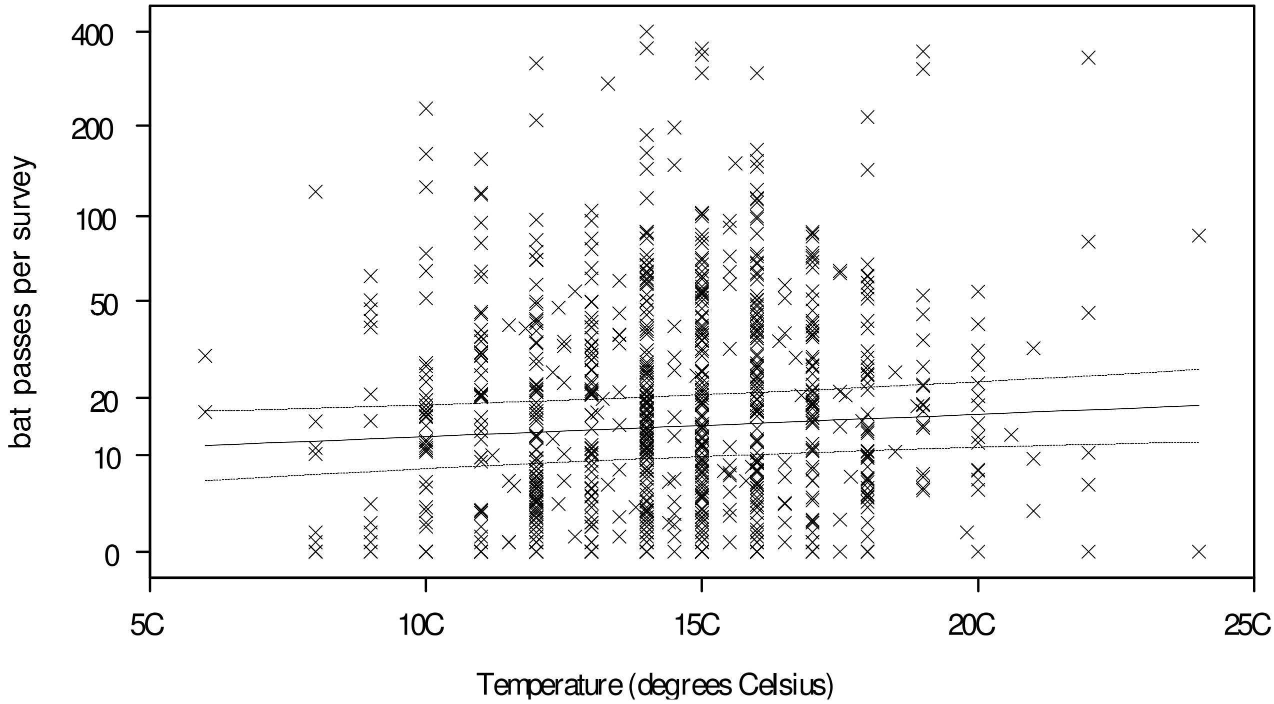


Figure 18: Back-transformed mean number of bat 'passes' recorded tabulated by temperature. Upper and lower lines show 95% confidence limits for the estimated slope, adjusting for other terms in the model. ($\chi 2$ = 5.01 with 1 d.f., P=0.025, fitted as a linear term)

Identification skills of volunteers has a significance influence on the number of bat 'passes' recorded (χ^2 = 13.70 with 3 d.f., P=0.003). Results indicate a contrast between 'poor' and 'okay' identification skills on one hand, and 'good' and 'very good' identification skills on the other hand with the second group recording a higher mean number of bat passes.

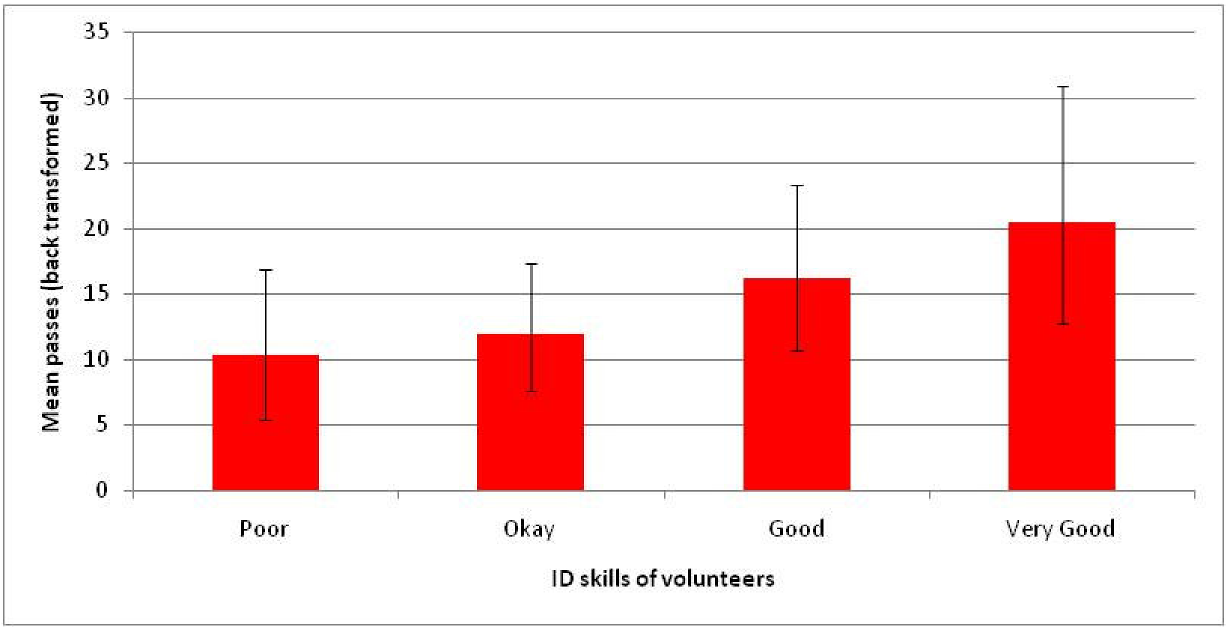


Figure 19: Back-transformed mean number of bat 'passes' recorded tabulated by Identification skills of volunteers. Bars show 95% confidence limits, adjusting for other terms in the model. (χ^2 = 13.70 with 3 d.f., P=0.003)

As the proportion of 'Unsure' Daubenton's bat 'passes' was high in 2006, 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'. However, the number of 'Unsures' recorded by volunteers has decreased dramatically in 2007 and 2008 to around 16% as identification skills of volunteers increased. This is comparable with the early years of the NBMP Waterway Survey, and only slightly above the proportion of 'Unsures' now recorded after over ten years of the NBMP Waterway Survey.

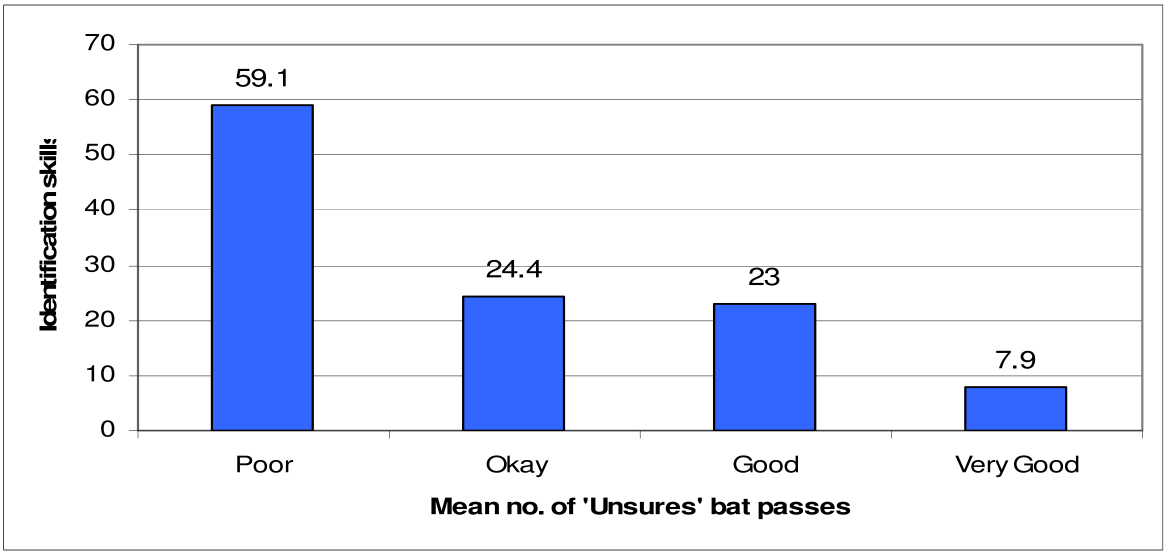


Figure 20: Percentage of bat 'passes' recorded by volunteers as 'Unsure' Daubenton's bat 'passes' by level of identification skills in 2006. (χ^2 = 22.23 with 3 d.f., P=0.001)

Volunteers are requested to start surveying 40 minutes after sundown. Statistical analysis in 2008 with three years of data has shown that when volunteers start surveying (i.e. the number of minutes after sundown) (Appendix I, Table 1d) is highly significant when fitted as a linear term (χ^2 = 8.56 with 1 d.f., P=0.003, fitting as linear on the log-scale). Although interpretation is made more difficult because there are relatively few observations more than a few minutes from the intended time of 40 minutes, the results do indicate that starting too early reduces the number of bat passes recorded overall for the duration of the survey. This result is not surprising since counts tend to be lower at the first few spots and volunteers starting before the recommended time tend to recorded fewer bat 'passes'.

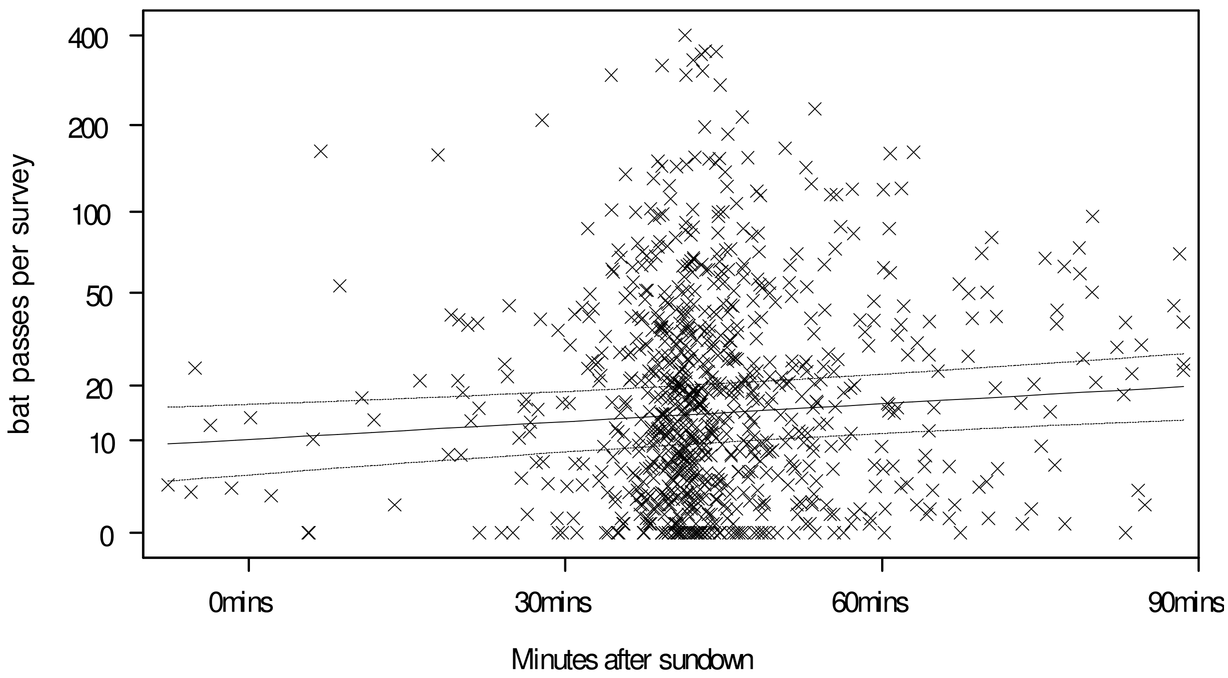


Figure 21: Back-transformed mean number of bat 'passes' recorded tabulated by starting time of survey (i.e. Minutes after sundown). Upper and lower lines show 95% confidence limits for the estimated slope, adjusting for other terms in the model. ($\chi 2$ = 8.56 with 1 d.f., P=0.003, fitting as linear on the log-scale).

Surveyors are requested to note the time they start the survey and the time they complete the survey. While volunteers record bat activity for 40 minutes, there is additional time noted for travel between survey spots. Consequently, the duration of the survey is dependent on a number of factors including the ease of travel between survey spots. Time taken (Appendix 1, Table 1e) remains a significant influence on the mean number of bat 'passes' recorded. Significantly fewer bat passes were recorded for surveys completed in less than 60 minutes (i.e. 40 minutes survey plus time taken to travel between survey spots).

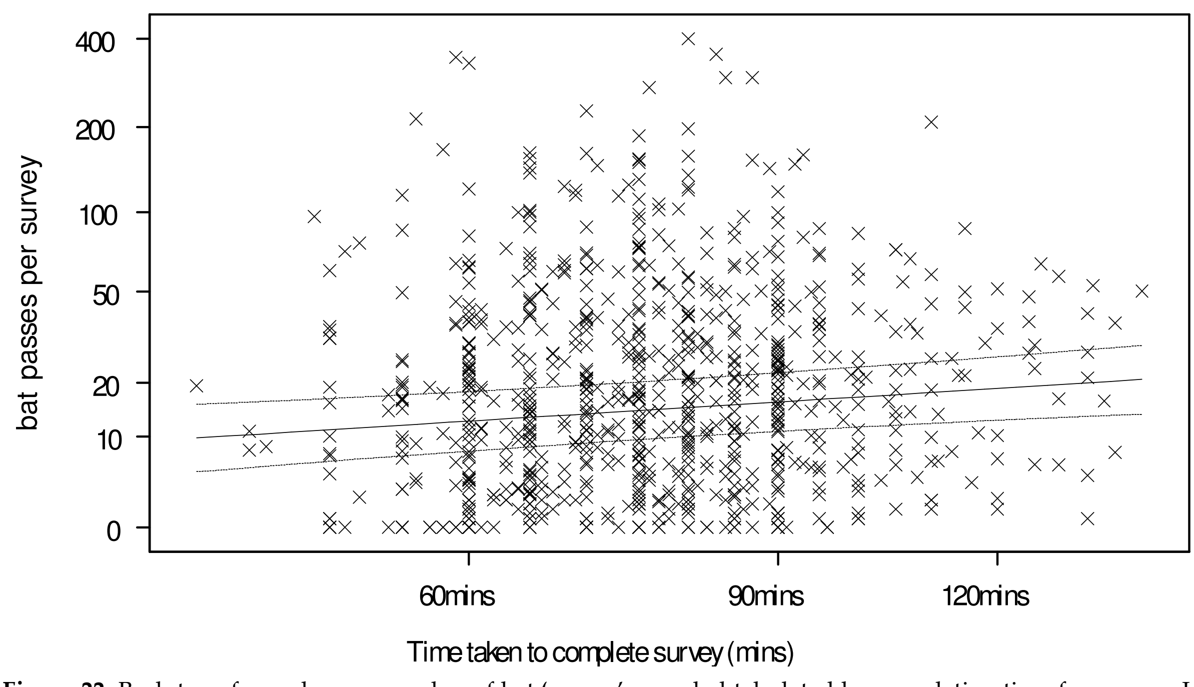


Figure 22: Back-transformed mean number of bat 'passes' recorded tabulated by completion time for survey. Upper and lower lines show 95% confidence limits for the estimated slope, adjusting for other terms in the model. ($\chi 2$ = 10.11 with 1 d.f., P=0.001, fitting as linear on the log-scale).

Volunteers are asked to estimate the amount of smooth surface on waterways surveyed. The assessment of the percentage calm surface is significant, (Appendix 1, Table 1e) (χ^2 = 9.37 with 3 d.f., P=0.025) with a greater number of bat passes recorded on waterways with more than 50% smooth surface.

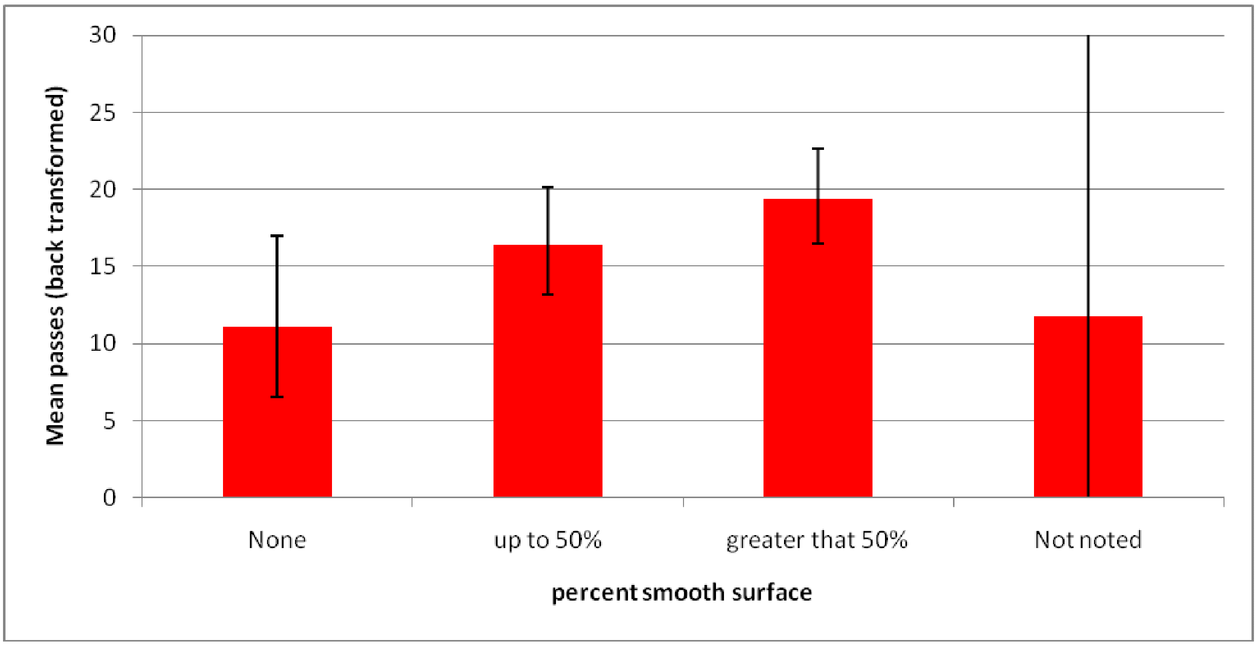


Figure 23: Back-transformed mean number of bat 'passes' recorded tabulated by the percentage of smooth surface of waterway sites. Bars are 95% confidence limits, adjusting for other terms in the model (χ^2 = 9.37 with 3 d.f., P=0.025).

The 'Rain' parameter is comprised of four categories with the majority of surveys undertaken during dry weather. This relationship was highly significant in 2007 (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). However this was not the case when the data from all three years was taken into account in 2008. With all three years together, there was no significant relationship between dry weather and bat 'passes'.

Other variables tested and found to be non-significant include detector model, volunteer experience, easting and northings. Details of all other variables tested are listed in Appendix 1, Table 2.

2007 Daubenton's Survey, a comparison of BCIreland data with NBMP data

A total of 542 surveys were completed in the UK in 2007 compared to 384 in Ireland providing an overall dataset of 926 surveys. The mean number of passes is slightly higher in Britain, but the proportion of surveys with bats is higher in Ireland (Republic of Ireland and Northern Ireland). The proportion of 'Unsure' Daubenton's bat 'passes' is higher in Ireland, again this is not unexpected since it was only the second year of the monitoring scheme and there were many first time surveyors participating again in 2007. To investigate the relationship between the log-transformed numbers of passes and other variables, a REML model was fitted (REML rather than ordinary regression in order to allow for the two surveys at each site) to the total of Daubenton's bat 'passes' plus 'Unsure' Daubenton's bat 'passes'. The final model contains terms for the variables river width, longitude and latitude.

River width is highly significant (χ^2 = 85.25 with 4 d.f., P<0.001), with more bat 'passes' in wider rivers (as is the case with both datasets). There is no sign that this relationship differs between Britain and Ireland (interaction χ^2 = 1.02 with 1 d.f., P=0.312, fitting width as linear on the log scale). Longitude is also highly significant (χ^2 = 14.77 with 1 d.f., P<0.001), with more bat 'passes' in the West of both Ireland and Britain. Latitude has a complex pattern which is represented by a cubic polynomial (χ^2 = 10.67, 11.12, 16.97 with 1 d.f. for linear, quadratic and cubic components, all P=0.001 or better), but basically there are less bat 'passes' recorded as one travels to the north. Interestingly there is no indication that these patterns differ between Britain and Ireland, perhaps suggesting that they are driven by climate, rather than other geographic patterns. ID skills are not significant after allowing for width and the geographic variables (χ^2 = 7.30 with 4 d.f., P=0.121), partially because skill levels are to some extent confounded with the geographic patterns. The difference between mean numbers in Britain and Ireland is not quite statistically significant (χ^2 = with 1 d.f., P=0.063), and even this suggestion of a difference vanishes once river width is allowed for (χ^2 = 0.81 with 1 d.f., P=0.368) and could possibly be explained by the fact that there are a greater number of wider rivers surveyed in Britain, thus accounting for the higher average number of Daubenton's bat 'passes' recorded there.

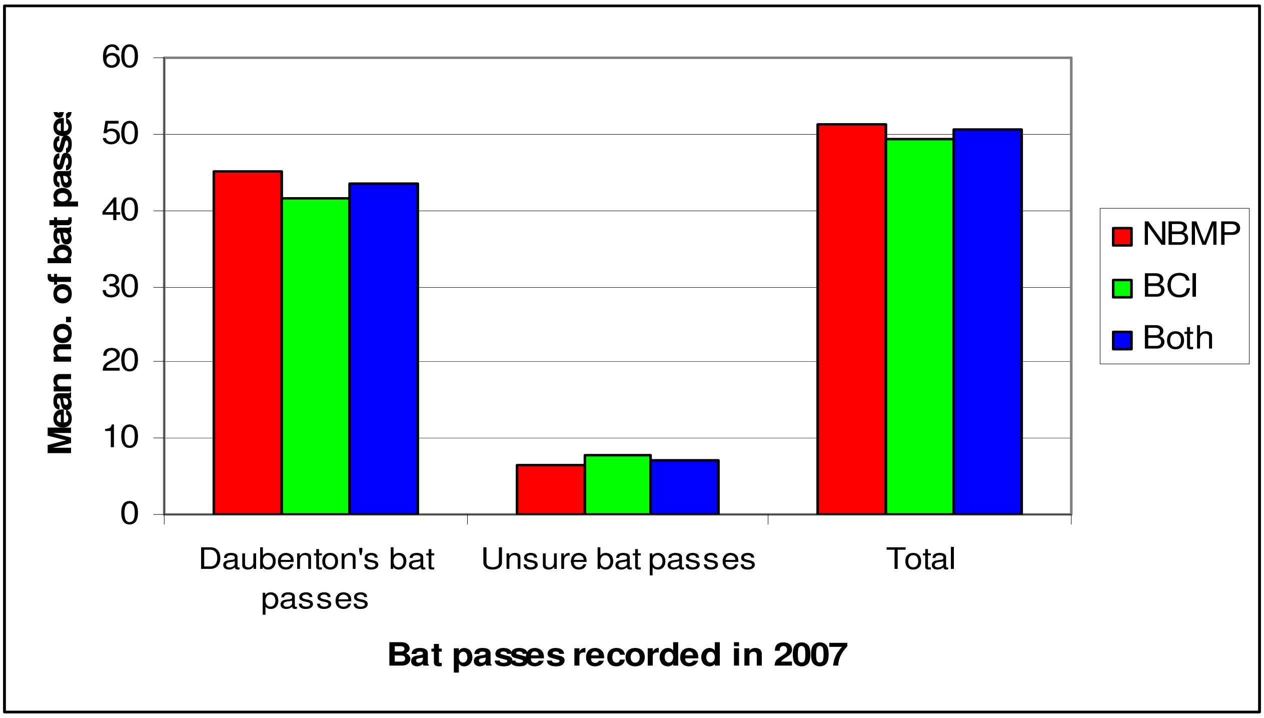


Figure 24: Mean number of bat passes recorded by volunteers participating in the BCT NBMP and BCIreland Daubenton's Bat Waterway Surveys in 2007.

Poisson Generalized Linear Model (GLM)

Whilst the REML model of log-transformed numbers of passes is appropriate for assessing the impact of explanatory variables, it produces biased estimates of population change. Hence, to assess trends, a Poisson Generalized Linear Model (GLM see Glossary) was applied to the data. Analysis undertaken for the 2006 & 2007 (Appendix III) data, using covariates, did not seem to improve precision, probably due to the numbers of missing values (i.e. waterway sites only surveyed once per year or only surveyed in either 2006 or 2007). However, analysis of the three years of data is more convincing in relation to the trends being expressed.

Figure 25 shows the results using a number of different response variables. The first graph shows the analysis of Daubenton's (sure) bat 'passes' and 'Unsure' Daubenton's bat 'passes'; there is a clear downward trend over the three years. Bootstrap 95% confidence limits for this linear decline run from -0.23 to -0.02; since the upper limit is less than zero, the decline is significant at $P<0.05$.

The second graph uses the data with the maximum number of bat 'passes' recorded at any one spot set to 48. The confidence limits are considerably shorter, showing that constraining the few very high estimates reduces the variability of the data and hence improves precision. Whilst the difference between 2006 and 2007 is less than in the previous graph, the reduction from 2007 to 2008 is greater. Once again the bootstrap limits suggest that there is a significant linear decline.

The third graph shows an analysis based on Daubenton's bat 'passes' only, which obviously gives lower estimates. As noted last year, the difference between 2006 and 2007 is small with this dataset. This is not surprising, since we know surveyors tend to record more 'Unsure' Daubenton's bat 'passes' in their first year. However, the evidence, whilst not conclusive, suggests that many of these 'Unsure' Daubenton's bat 'passes' would have been recorded as Daubenton's bat 'passes' once the observer had gained experience; it is therefore possible that this graph is misleading, and underestimates the 2006 value. As far as the 2007 to 2008 change is concerned, the message is the same as in the previous two graphs, with a big decline in numbers.

The final graph is the same as the one above it, except that covariates for ID skills and time after sunset are included in the model. The reason for just using these two covariates is firstly because covariates that always take the same value at a site (e.g. river width) are not useful in this analysis, and secondly because experience from the NBMP has indicated that only covariates with strong effects prove useful in practice.

To ensure that sites not visited each year did not have an undue impact on the results, the data with the number of passes limited to 48 at any spot was reanalysed including only sites monitored each year. Results were very similar to those based on the full dataset.

In summary, although there is, as is almost inevitable, some doubt as to what is happening in the first year of the survey, there is clear evidence for a decline in activity over the course of the survey from 2006 to 2008 in the recording of Daubenton's bats on waterway sites surveyed.

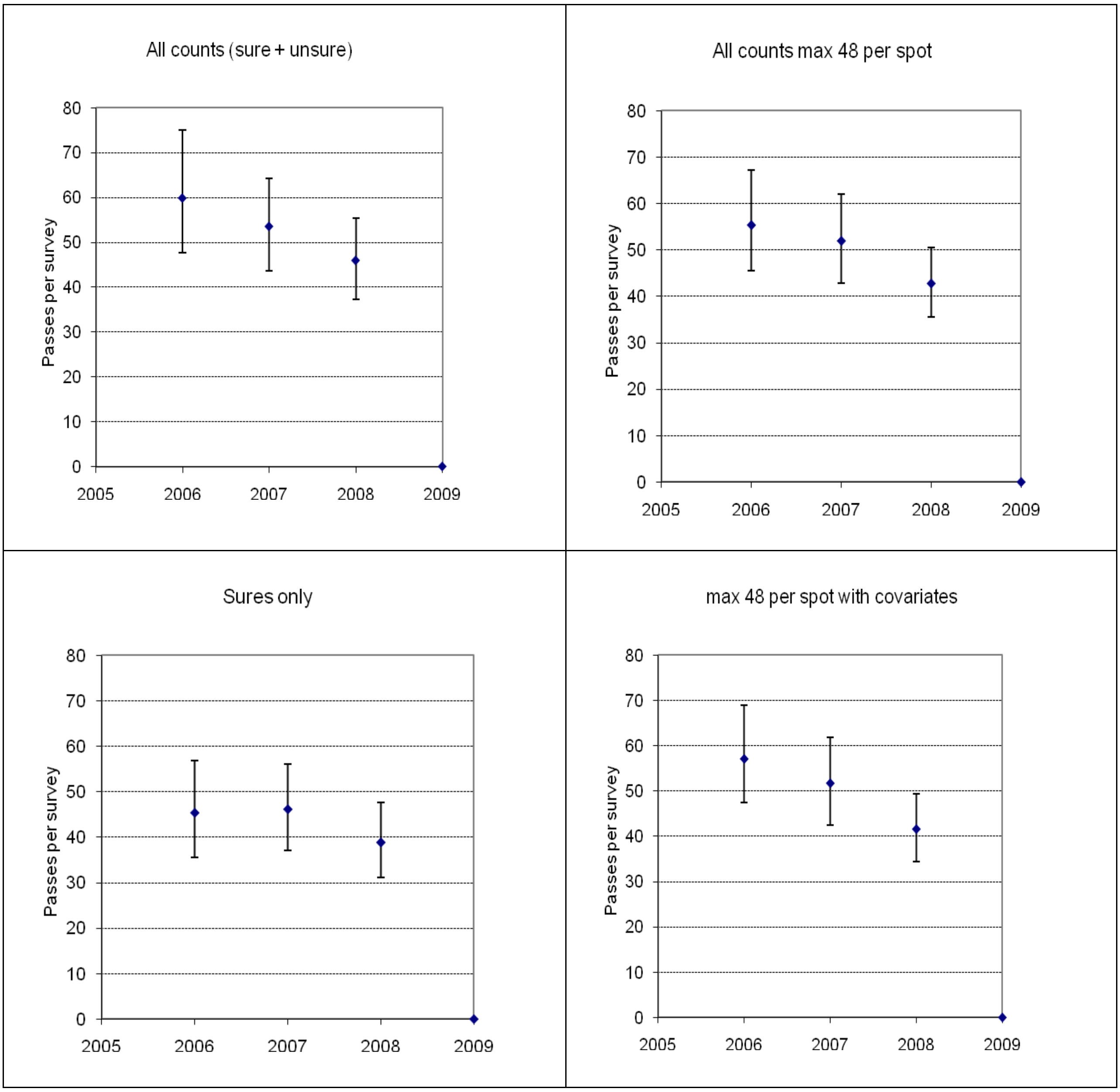


Figure 25: Results of the GLM model for total number of bat 'passes' (all passes – Daubenton's bat 'passes' = 'Sure' and 'Unsure' Daubenton's bat 'passes' = 'Unsure') recorded per survey. Bars are 95% bootstrapped confidence limits.

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

Power Analysis uses, as its basis, information about how much sites vary from year to year. Results of the power analysis are shown in Table 5 in terms of the average numbers of years to detect the specified changes 80% of the time (i.e. with 80% power). Note that these figures are subject to random error and hence will show some oddities, in particular, the number of years to detect an amber alert with 40 sites is less than that for 50, for example. Despite this, the overall trends are clear, with more years required with less sites. With between 150 and 200 sites each year it should be possible to detect red alerts in around 6 years and amber alerts in 10. In fact, the gain in power from increasing the number of sites above 100 is not that great; the main advantage of getting more sites is not an improvement in the precision for national estimates but rather the ability to give greater power for regional estimates (maybe at a country (Republic of Ireland and Northern Ireland separately) and province level, or a contrast between the west and the east, for example).

The figures for a doubling of the population are not dissimilar to those for halving it (i.e. red alert); this is not at all surprising giving the logarithmic nature of the models fitted.

Table 5: number of years (including the extra years needed at either end of the GAM curve) to achieve 80% power for various scenarios. Whilst the number of years must be an integer in reality results are shown here with one decimal place to aid comparisons. All simulations use two repeat surveys in each year with no missing values.

	Red Alert (50% decline over 25 years)		**Amber Alert (25% decline over 25 years)**		**Increase (doubling over 25 years)**	
Sites	**years**	**s.e**	**years**	**s.e**	**years**	**s.e**
30	9.0	0.5	19.7	1.0	10.9	1.5
40	8.7	0.6	17.5	0.7	10.0	1.6
50	8.0	0.5	18.5	1.2	9.2	1.5
75	7.2	0.4	14.1	0.8	8.1	1.5
100	6.8	0.4	12.2	0.4	8.2	1.5
150	6.2	0.7	10.8	0.4	6.7	0.9
200	6.0	0.6	9.6	0.3	5.7	0.6

The results in Table 5 are based on datasets without missing values so that, for example, the results for 100 sites are based on surveying the same 100 sites each year. While in reality, there is a high turnover of volunteers so a more realistic simulation is where only two thirds of the sites were visited each year. Therefore, a simulation with 100 sites in total and an amber alert trend, so that around 60-70 sites were visited each year after allowing for the random missing values. The time taken to detect the trend with 80% power was 15.4 years.

Time Expansion Trials

A study was undertaken to test whether the use of Tranquility Transect Time Expansion bat detectors could be used in addition to heterodyning method along a smaller number of sample sites (n=16). This would maximise the use of already available equipment and provide potential information on a greater range of species utilising waterways.

Each track (1 track/spot, 2 surveys/waterway site, n=320, a total of 21 hours and 20 minutes of recordings) was downloaded to Bat Sound™ V3.0 and calls were identified to species level where possible. Species that can be identified accurately by sonograms are pipistrelle species (*Pipistrellus pipistrellus, P. pygmaeus, P. nathusii*) and Leisler's bat (*Nyctalus leisleri*). Calls of *Myotis* bats were recorded but these are noted as *Myotis* spp. since they could belong to one of four similar species – Daubenton's bat *Myotis daubentoni*, whiskered bat *M. mystacinus*, Natterer's bat *M. nattereri* or the recently discovered Brandt's bat *M. brandtii*. Pipistrelle calls with a peak in echolocation between 48kHz and 52kHz were recorded as 'Pipistrelle unknown' because they could be either common or soprano pipistrelles.

Four species of bat were accurately identified (See Table 6): common (CP), soprano (SP) and Nathusius' pipistrelles (Nath) and Leisler's bats (Leis). In addition, recordings were made of the *Myotis* species group (My). Several 'Unknown pipistrelles' (Pip) (i.e. echolocation calls with a peak between 48-52kHz) were also recorded. All four species and the *Myotis* group were detected on two waterways sites (River Blackwater and the Royal Canal - Table 6) while only one species of bat was detected on two waterway sites (River Delvin and River Tolka – Table 6).

In summary, *Myotis* species were not recorded on two waterway sites (River Delvin and River Tolka) during Time Expansion Trials. This corresponded with results from these waterways reported by Daubenton's Volunteers. *Myotis* species were recorded by Daubenton's volunteers on all other waterways sites included in this trial and again this corresponded with sonogram recordings.

However, on analysis of individual survey spots, some misidentifications were recorded and this generally involved volunteers not recording Daubenton's bat 'passes' or 'Unsure' Daubenton's bat 'passes' where the Time Expansion Detector verified that Myotis bats were indeed present on the waterway.

Table 6: Details of the Presence/Absence of bat species detected at surveyed waterway sites in 2007 by time expansion detectors. common pipistrelle (CP), soprano pipistrelle (SP), Nathusius pipistrelles (Nath), Leisler's bats (Leis), *Myotis* species group (My) and 'Unknown pipistrelles' (Pip)

SITE NAME	SP	CP	NATH	PIP	LEIS	MY
All sites	✓	✓	✓	✓	✓	✓
River Blackwater	✓	✓	✓	✓	✓	✓
River Boyne	✓	✓		✓	✓	✓
Delvin River					✓	
River Tolka		✓				
Royal Canal	✓	✓	✓	✓	✓	✓
River Dodder (Castlekelly Br)	✓	✓		✓	✓	✓
River Dodder (New Br)	✓	✓		✓	✓	✓
River Dodder (Clonskeagh Br)	✓	✓		✓	✓	✓
River Dargle	✓			✓	✓	✓
Glencullen River (Knocksink Br)	✓	✓		✓		✓
Glencullen River (Glen/Dargle)	✓	✓		✓		✓
Unshin River (Riverstown)	✓	✓		✓	✓	✓
Duff River	✓	✓		✓		✓
Owenmore River	✓	✓		✓	✓	✓
Drumcliff River	✓			✓	✓	✓
Drowse River	✓	✓		✓	✓	✓

Bridge surveys

BCIreland surveyors surveyed 80 bridges in 15 counties across the country in 2008. The number of bridges surveyed per county is presented below. The highest number of bridges were surveyed in County Cork (n-15) followed by County Tipperary (n=9) and County Meath (n=9). During monitoring under the All Ireland Daubenton's Bat Waterway Survey, Daubenton's bat 'passes' were recorded at the majority of the bridges surveyed.

The array of bridges surveyed ranged from single arched stone bridges to multiple arched stone bridges to concrete culverts and to concrete expansion bridges. As is often the case, many of the original stone bridges have been modernised with concrete (i.e. concrete extensions or additional supports) to facilitate modern vehicular movement on roadways. Fifteen of the bridges surveyed were concrete bridges while all remaining bridges were originally constructed from sandstone or limestone. Twelve percent of these bridges had evidence of bats while 31% of bridges surveyed were considered suitable for roosting bats (i.e. crevices present within bridge structure suitable for roosting bats) (Aughney, 2008).

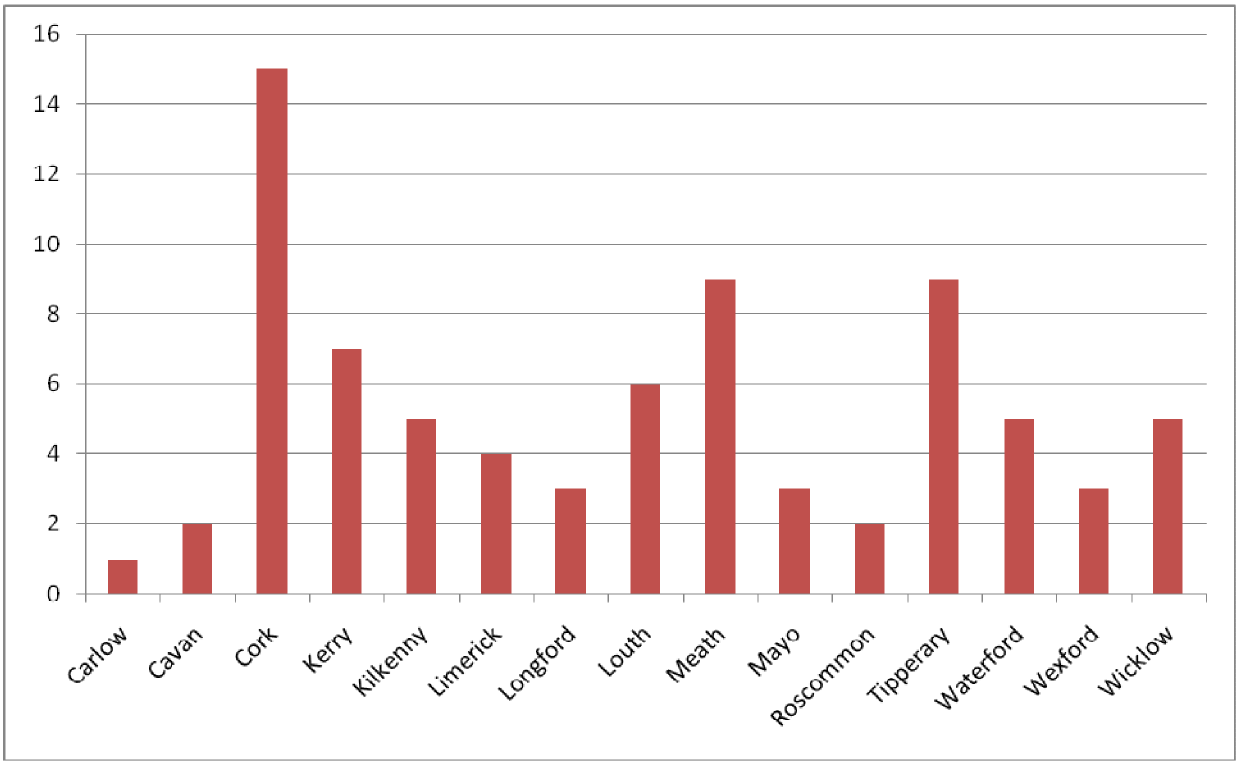


Figure 26: Number of bridges surveyed according to county location (n=80).

DISCUSSION

Volunteer uptake

The first three years of the survey were very successful with a much higher number of volunteers participating in the monitoring scheme than expected. The approach taken by BCIreland, co-ordinating local training courses with local authority Heritage or Biodiversity Officers, and/or liaising with local bat groups, worked very well in attracting members of the public to become involved. Making initial contact with local Heritage Officers and Biodiversity Officers about hosting training courses and encouraging 'pride' in their counties' bat biodiversity was key to the large up-take of volunteers from the general public. Heritage Officers and Biodiversity Officers were, thus, charged with media advertisement in their local county which worked exceptionally well.

The Daubenton's Bat Waterway Survey methodology is an ideal method to introduce inexperienced volunteers to bat surveying. However, there is a high turnover of volunteers participating in the scheme with only 49% of volunteers participating in all three years. To ensure that the datasets are robust enough to detect Red and Amber Alert declines (or equivalent increases) it is of great importance that the same set of 75 -100 waterways sites are surveyed twice each year (Hereafter known as 'core' waterway sites). In addition, robustness of the datasets are also increased if the 'core waterway sites' are surveyed by the same volunteer teams. Therefore, BCIreland must aim to ensure that these criteria are met.

Support for volunteers is essential to keeping volunteers from year-to-year. At present, the resource material available to volunteers is limited to web-links with sonograms recordings and Volunteer Survey Packs. While at least 14 training courses were hosted each year, it is not possible to provide re-training for every volunteer each year. BCT provide on-line tutorials for members participating in monitoring in addition to an extensive audio library of heterodyne echolocation calls for the majority of the species present in the UK. BCIreland should follow this example and provide greater support for volunteers. BCIreland should also contact all volunteers that have participated to-date to collate their reasons for continuing or not continuing to survey and their recommendations on how to improve the scheme.

Feed back to volunteers is limited to email contact and summary articles in the BCIreland Newsletter as well as a copy of the annual report. At present, volunteers for the Car-based Monitoring Scheme receive an additional email detailing the bat species and number of individuals recorded within their own 30km square (Roche *et al.*, 2009). This email is received well by volunteers. While the number of 30km squares surveyed under this scheme is much less than the number of waterway sites surveyed, a similar feedback email could be provided on a county basis providing volunteers with information on how bat activity compares to other waterway sites in the same county.

In addition, NPWS and NIEA (formerly EHS) staff were given the opportunity to undertake survey work in their local area. Again, this resulted in a larger number of survey sites being completed than anticipated. Waterway sites surveyed by NPWS and NIEA staff tended to be surveyed more regularly than waterways sites surveyed by members of the general public due to fact that many staff members completed the surveys as part of their day-to-day work schedule. Liaising with staff of the two principal funding bodies should continue especially to ensure that 'core' waterway sites are surveyed from year to year with the aim of at least two 'core' sites per county being covered per year. This would ensure that at least 64 waterway sites are surveyed annually with BCIreland staff/committee members committing to surveying a minimum of 11 waterway sites annually bringing the total of 75 'core' waterway sites and meeting minimum statistical requirements for Power Analysis.

Daubenton's records

The Daubenton's bat was recorded on the majority of waterway sites surveyed, thus confirming that this species is widely distributed across linear waterways in the Republic of Ireland and Northern Ireland. Daubenton's bats were recorded in every county on the island from the most northern waterway sites in Donegal and Antrim to waterway sites located in south west Kerry and Cork and also on waterway sites on the western seaboard in Mayo and Connemara. A similar distribution of Daubenton's bats was recorded by the BCT NBMP where this species was recorded from northern Scotland to southern England (www.bats.org).

The collation of Daubenton's bat records for 256 waterway sites around the island has greatly increased our knowledge on the distribution of this species. These records provided evidence that this species is present in 193 10km squares on the island (1019 10km squares in total on the island). It is also interesting to note that while a very high percentage (89%) of waterway sites surveyed had Daubenton's bats foraging along their length, bats, in general, were recorded on an even higher percentage of waterway sites surveyed over the three years (ie. Both Daubenton's and 'Unsure' Daubenton's bat 'passes').

The All-Ireland Daubenton's Bat Waterway Survey, in general, has recorded a higher percentage of incidence of Daubenton's bats on surveyed waterway sites compared to the BCT's NBMP (www.bats.org). In 2008, 81% of waterways surveyed in the UK (283 waterway sites of the total 351 waterway sites surveyed) had recorded Daubenton's bats compared to 86% for the same survey period in the Republic of Ireland and Northern Ireland. The BCT demonstrated that Daubenton's bat activity was significantly related to insect biodiversity and good water quality while bat activity was highest at wide, tree-lined and slow flowing water-bodies (Catto *et al., 2003)*.

Daubenton's activity across the island

Although, bat 'passes' cannot be directly related to 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 all three years 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. 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 in relation to rainfall and water quality when additional years of monitoring is completed. Such an investigation should also be undertaken in relation to linear habitat located along the survey route. An additional form should be included in future Volunteer Survey Packs to gather additional information on habitats present along waterway sites, in particular information on the presence of trees/treelines.

Selection of foraging habitat is also considered to be influenced by roost availability and location. Higher Daubenton's bat activity has been recorded by Rydell *et al. (*1994) adjacent to bridges compared to open water on rivers with little or no linear tall vegetation (e.g. tree lines). There is limited information on current roosting sites used by Daubenton's bats in the Republic of Ireland and Northern Ireland. O'Sullivan (1994) recorded 213 Daubenton's roosts across the island during the Wildlife Service survey of 1985-1988. Bridges are considered to be important roosting sites for bats, in particular, the stone masonry bridges. Irish bat species have been recorded in such bridges in previous independent surveys (Shiel, 1999 and Masterson *et al.,* 2008). Such species include: Daubenton's bat, Natterer's bats (*Myotis nattereri)* brown long-eared bat (*Plecotus auritus),* whiskered bat (*Myotis mystacinus)* and common pipistrelle bat (*Pipistrellus pipistrellus)*. Smiddy (1991) was one of the first surveys undertaken on bat usage in bridges in Ireland. He recorded that 14% of bridges surveyed in County Cork and 11% of bridges surveyed in County Waterford had bat evidence. Shiel (1999) surveyed a number of bridges in Counties Leitrim and Sligo and found that 38% of structures had bats present. Keeley (2007) surveyed bridges in Counties Offaly and Laois and noted that 15% of structures had bat evidence. While Masterson *et al.* (2008) surveyed bridges (n=113) in the Sullane and Laney River Catchments, County Cork and reported that 11% of bridges had bat evidence.

Bridges located along a selection of All-Ireland Daubenton's Bat Waterway Survey sites were surveyed in 2008 (Aughney, 2008). Twelve percent of these bridges had evidence of bats (the majority of which were identified as Daubenton's bats). In future, information should be gathered by volunteer teams on the types of bridges located along survey routes. This may provide additional information to support future analysis of collected data. There maybe a higher insistence of stone masonry bridges in certain regions or on certain rivers on the island

Variables affecting activity

Results from REML analysis for three years of data suggest that six of the variables tested have a significant impact on the mean number of bat 'passes' recorded. These are the width of waterways surveyed, air temperature recorded at the start of the surveys, the identification skills of volunteers, start time in relation to minutes after sundown, time taken to complete survey and smoothness of the water surface.

Width of waterway was found to be highly significant suggesting an increase in bat 'passes' with waterway width. There is some suggestion in the untransformed means that the number of passes may peak at 20m, but numbers of surveys on such wide rivers were small and the effect is not statistically significant. This is similar to the BCT NBMP results, which also recorded higher counts at wider rivers. However, waterway sites surveyed in Ireland tend to be narrower compared to the waterway sites included in the BCT's dataset. This proportionately higher number of wider rivers in the UK may be a reflection of larger rivers found in the UK compared to rivers in Northern Ireland and the Republic of Ireland. Analysis using both the Irish (BCIreland 2007 results) and UK data (BCT 2007 results) has shown that, once river width is accounted for, there is no difference in total bat 'passes' between the two datasets and that this parameter is a significant influence on mean number of Daubenton's bat passes recorded on linear waterway sites in both countries. The fact that both methods followed for the datasets are exactly the same, provides a great opportunity to undertake future analysis and therefore, BCIreland should continue to liaise closely with the BCT in relation to this monitoring scheme.

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°C). Gourlay (2004) also found that ambient temperature significantly affected the activity of the Daubenton's bat. A similar trend was demonstrated in the UK and in the Irish Car based Monitoring Scheme (e.g. Roche *et al.*, 2007). The higher relative abundance of bat activity correlated with higher air temperatures may be related to the level of insect activity because aerial insect abundance increases with air temperatures (e.g. Taylor, 1963; Williams, 1940).

Poor climatic conditions may discourage bats from feeding on a particular night or from feeding in typical riverine habitats. The majority of Daubenton's 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 in relation to REML analysis of 2006 and 2007 datasets. However, this variable did not have a significant influence on bat activity levels when 2008 results were included. August 2008 was exceptionally wet (www.meteireann.ie) and high rainfall in that month may have accounted for the slightly depressed activity of this species compared with the previous year. Daubenton's bats will feed in alternative habitats such as woodland and other sheltered places during bad weather (Vaughan *et al.*, 1997).

In 2006, volunteers with greater experience recorded a higher number of bat 'passes'. While this variable did not have significant influence on the number of bat passes recorded in 2006-2008 dataset, the level of identification skills of volunteers did. Analysis of the three years of data indicate that there is a contrast between 'poor' and 'okay' identification skills on one hand and 'good' and 'very good' identification skills on the other hand with the second group recording a higher mean number of bat 'passes'. Good bat detector skills are essential to ensure that the data collected is accurate and robust for statistical analysis. It is therefore important to ensure that volunteer participation is consistent. It important to ensure the volunteers are well trained and confident and this could be achieved with more rigorous training courses and volunteer support provided through local bat groups as discussed above.

Time expansion trials also confirmed that volunteers, for the most part, correctly record Daubenton's bats when they are present. However there were some survey spots where the time expansion detector recorded *Myotis* species but the volunteers failed to record any type of bat 'pass' on the survey form. Therefore, training of volunteers has to ensure that by the end of the training session, volunteers are equipped to identify Daubenton's bats. It must also be emphasised to volunteers that detectors should only be used with new batteries to ensure that bats are detected and that the appropriate wattage of torches are used to aid bat visibility in the waterway. Greater web support is needed and such should include a library of bat echolocation calls for volunteers. If possible, video footage should also be included demonstrating a complete survey of one survey spot showing correct usage of bat detector and torch to aid the detection of Daubenton's bats.

The proportion of 'Unsure' Daubenton's bats 'passes' recorded in 2006 were high. The BCT's 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. Since 2006, the proportion of 'Unsure' recorded has decreased and this may be linked to the experience of volunteers that participate in the monitoring scheme for more than one year.

The time at which bats emerge to feed is generally related to sunset, with influences from climatic conditions and surrounding roost conditions. The difference in emergence time and activity may also be related to the predominant foraging technique and diet of the species (Jones and Rydell, 1994). The time bats emerge from a roost 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 time (Limpens and Kapteyn, 1991). This, combined with late 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. For the purposes of the present survey volunteers are requested to start surveying 40 minutes after sundown. Results showed that the start time for surveys (i.e. the number of minutes after sundown) is significantly positively correlated with Daubenton's activity, with later start times resulting in higher numbers of 'passes'. Although there are relatively few observations more than a few minutes before the intended time of 40 minutes, the results do indicate that starting too early reduces the number of bat 'passes' recorded overall for the duration of the survey. This result is not surprising given the bat's known emergence characteristics.

Surveyors are requested to note the time they start the survey and the time they complete the survey. Time taken remains a significant influence on the mean number of bat passes' recorded, with the biggest difference apparent for very short survey times of less than one hour. A significantly lower number of bat 'passes' was recorded for surveys completed in less than 60 minutes. In 2007, the more apparent pattern in the data was that higher counts were recorded on surveys completed over a longer time. Completing a survey in less than 60 minutes means that there is a possibility that volunteers are not remaining the full 4 minutes at each spot or that survey spots are not spaced at approximately 100m apart. It could also imply that surveyors are more likely to spend longer at a spot if they are getting lots of passes. Another factor worth mentioning maybe bankside habitat – heavily vegetated banks which might indicate better foraging habitat for bats could also require more "negotiating time" by the surveyors, whereas a relatively open bank side may be much easier and quicker to walk along. Therefore following the survey protocol strictly needs to be emphasised with volunteers and more detailed explanation of the methodology should be provided in training courses.

Volunteers are asked to estimate the amount of smooth surface on waterways surveyed. The assessment of the percentage calm surface is significant, with a greater number of bat passes recorded on waterways with greater than 50% smooth surface. Radio-tracking studies in Britain have shown that Daubenton's bats forage night after night over the same stretch of waterway. For example, most bats in one study (Altringham, 2003) had only 1-3 regular feeding sites which ranged from 30m to 100m long. Favoured sites were those over stretches of smooth water with tree cover on one or both banks of the waterway.

Water bodies offer bats high densities of insects especially since many have aquatic larval stages (Walsh and Harris, 1996). Daubenton's bats need areas with high insect density to satisfy their energy needs. The air directly above water is considered to be rich in insects and Rydell *et al.* (1999) have indeed documented that the insect density was highest at the lowest level of 0.5m above the water surface, the area in which Daubenton's bats typically concentrate their feeding (Jones, 1993). The echoes from small insects are faint and may be masked in areas where clutter from vegetation and ripples in the water

(Siemers *et al.*, 2001). Therefore, small insects are more detectable over smooth water. Rydell *et al.* (1999) compared Daubenton's bat activity over calm sections and over sections with ripples and found in a 5-minute period, activity was as much 20-40 times greater over the calm water sections.

Siemers *et al.* (2001; 2005) documented that smooth water surfaces also increase the detection of insects due to the acoustic mirror effect. Smooth water is considered to be an acoustically smooth background that reflects sound thereby facilitating the detection of prey items. Therefore the smooth surface of water increase search efficiency of echolocating bats and thus trawling bats such as Daubenton's bats have a preference for calm water.

A downward trend for Daubenton's

Certain factors, such as improving volunteer experience in bat detection should, it would seem, lead to an increase in observed bat passes over time. However, REML analysis shows that there is clear evidence for a decline in numbers over the course of the survey from 2006 to 2008 in the recording of Daubenton's bats on waterway sites surveyed.

Possible factors that may have resulted in this decline include poor weather in 2007 and 2008. The August of both years had high rainfall which can lead to Daubenton's using alternative foraging habitats. Considering the downward trend in the number of bat passes recorded over the duration of the monitoring scheme and the general poor weather noted in August 2007 and 2008, the effects of rainfall on Daubenton's activity needs to be further investigated. Other factors that may also prove important have not yet been included in the analysis, however, such as changes in water quality indices. The water quality of survey sites can have a profound impact on insect bio-diversity and biomass, and water pollution can reduce the quality of foraging sites for bats (Walsh and Harris, 1996). In addition, the overall trend of reduced insect biodiversity in Europe may also be a factor in reduced bat activity. Severe declines in insect populations have been documented including macro-moth species in Britain (Conrad *et al.*, 2006).

A similar trend has been reported from the NBMP in the UK where over 10 years of data has been collated to date. The UK trend shows numbers gradually rise, peaking around 2005, but fall back down again since then with low counts in 2008.

However, caution is required in relation to the Irish figures since only three years' of data have been compiled to date. Also the unusual wet weather encountered in August of 2007 and 2008 could have suppressed bat activity on waterway sites during surveys. Therefore, any conclusions on this trend cannot be made until further years of surveying are completed.

Power

Power Analysis shows that if the same 150 and 200 sites are surveyed each year, it should be possible to detect red alerts in around 6 years and amber alerts in 10. In fact, there is little gain in power from increasing the number of sites above 100, assuming each site is repeated year on year; the main advantage of surveying more sites is not an improvement in the precision for national estimates but rather the ability to give greater power for regional estimates. However, the number of waterways surveyed since 2006 has been greater than 100 per year but there have been fewer repeatedly surveyed sites (78 waterway sites surveyed in each of the three years). A core of 67-75 sites surveyed twice annually each year, along with an additional 25-33 sites, are required to provide data robust enough to determine amber alerts after 15.4 years.

As discussed above, it is essential that a system is put in place to ensure that 'core' sites are surveyed twice annually. Prior to the new field season, waterway sites surveyed for at least 2 of the 3 years of the scheme should be potentially selected as 'core' sites and volunteer teams should be contacted to determine their on-going participation in the scheme. An agreement with regional staff of funding partners should also be put forward to aim for at least 2 'core' sites per county to be surveyed. A selection of at least 100 'core' sites would provide greater assurance that the minimum of 75 'core' waterway sites are surveyed annually.

RECOMMENDATIONS

Recommendation 1	Continue to survey Daubenton's bats using current methodology. In particular, sites should continue to be surveyed twice in the month of August and start time should remain as 40 minutes after sunset
Recommendation 2	A minimum of 100 core sites, to include the 78 sites that have been surveyed every year so far, should be selected from the current dataset. These 100 core sites should be prioritised for survey each year.
Recommendation 3	Strive to survey additional waterways and where possible have a minimum of 5 survey sites per county with an aim of 50 survey sites surveyed per province over a three year period to allow regional differences to be investigated. New sites should be selected from water quality datasets currently monitored by the EPA (Republic of Ireland) and NIEA (Northern Ireland).
Recommendation 4	Continue to provide annual training courses as a means to recruit new volunteers and as a means to provide education on the conservation of bats in general. Where necessary to ensure continuity of survey, new volunteers should be deployed to cover core sites. Otherwise, continue to provide volunteers with three potential ten-figure 'Grid Referenced Water Quality Sampling Sites' within a 10 km radius of their address.
Recommendation 5	Provide excellent volunteer support including survey tutorials, online video and audio library, annual feedback and more rigorous training programmes.
Recommendation 6	The potential for regional staff of funding partners to survey a minimum of 2 waterway sites per county (i.e. 64 waterway sites in total) should be examined.
Recommendation 7	A professional statistician with experience of bat data interpretation should continue to carry out analysis of the data. Future statistical analysis should involve binomial analysis of collated data to determine its potential usefulness for assessing population trends.
Recommendation 8	Record additional information on survey forms in relation to habitat types present along survey sites.

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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).

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.

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.

APPENDIX I

Statistical Results: REML Model

Table 1: 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 ($\chi^2 = 19.96$ with 1 d.f., P<0.001, fitting as linear on the log-scale)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
2m or less	15	9.3	3.79	0.185	0.127
<=5m	283	31.4	2.44	0.346	0.056
<=10m	361	61.8	4.25	0.443	0.054
<=20m	181	70.8	10.72	0.446	0.057
>20m	95	55.8	4.90	0.565	0.068

(b) Temperature ($\chi^2 = 5.01$ with 1 d.f., P=0.025)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
<=12C	197	42.9	4.03	0.362	0.050
12.1-14	219	56.6	8.74	0.377	0.050
14.1-16	260	58.9	4.89	0.396	0.050
16.1-18	133	44.8	4.46	0.396	0.052
over 18C	49	54.5	11.62	0.455	0.058

(c) ID skills ($\chi^2 = 13.70$ with 3 d.f., P=0.003)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
Poor	87	41.4	6.16	0.308	0.062
Okay	461	42.2	2.42	0.341	0.049
Good	288	63.8	4.90	0.419	0.053
Very Good	103	81.8	17.84	0.484	0.065

(d) Minutes after sundown (χ^2 = 8.56 with 1 d.f., P=0.003 as a linear term)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
before 30 mins	51	38.9	7.09	0.367	0.058
30-40mins	203	50.4	4.29	0.382	0.051
40-50mins	411	59.4	5.59	0.386	0.050
50-70mins	142	47.8	4.65	0.416	0.051
70-90mins	36	45.9	6.10	0.454	0.058

(e) Time taken (χ^2 = 10.11 with 1 d.f., P=0.001, fitting as linear on the log-scale)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
<=60min	141	41.0	5.57	0.305	0.053
61-75min	276	53.9	3.73	0.395	0.051
76-90min	260	62.9	8.03	0.416	0.050
over 90min	134	48.4	3.66	0.399	0.052

(f) percent calm surface (χ^2 = 9.37 with 3 d.f., P=0.025)

		Raw data		Adjusted for other variables	
Group	surveys	mean count	s.e.	log	s.e.
None	43	30.4	9.90	0.325	0.054
up to 50%	247	45.5	3.70	0.422	0.029
greater that 50%	640	57.7	3.82	0.468	0.023
Not noted	10	38.5	13.92	0.337	0.175

Table 2: variables tested and found to be non-significant when added to final model.

Term	χ^2	d.f.	P
province	0.54	3	0.909
easting	0.01	1	0.916
northing	0.48	1	0.487
cloud	5.16	3	0.161
wind	1.31	3	0.727
rain	2.17	3	0.537
Day number in year	0.69	1	0.405
period	0.15	1	0.702
week	5.08	5	0.406
Tree shelter	2.06	3	0.559
clear	0.43	1	0.511
detector	17.74	14	0.219
experience	2.25	3	0.523

Figure 3a: 2007 Results of GLM model for total number of Daubenton's bat passes (all passes – 'Sure' and 'Unsure') recorded per survey. Bars are 95% bootstrapped confidence limits.

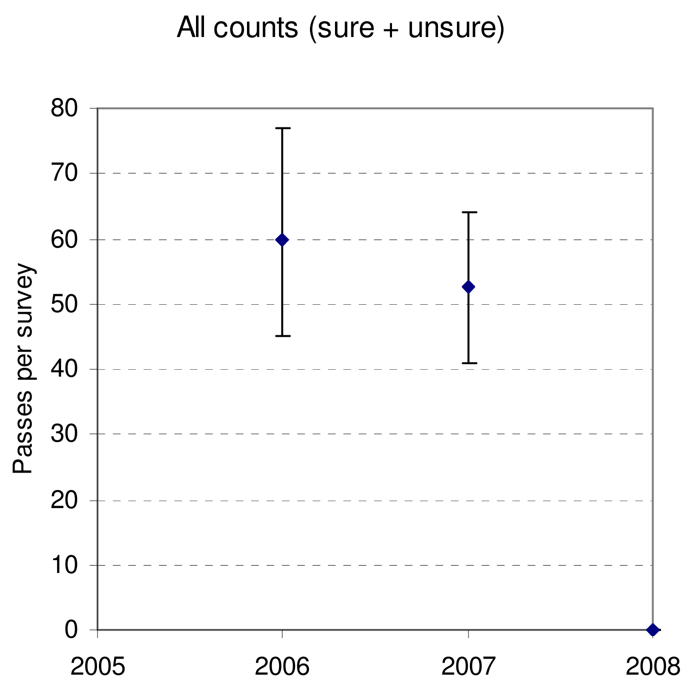


Figure 3b: 2007 Results of GLM model for total number of Daubenton's bat passes (all passes 'Sure' and 'Unsure' to a maximum of 48) recorded per survey. Bars are 95% bootstrapped confidence limits.

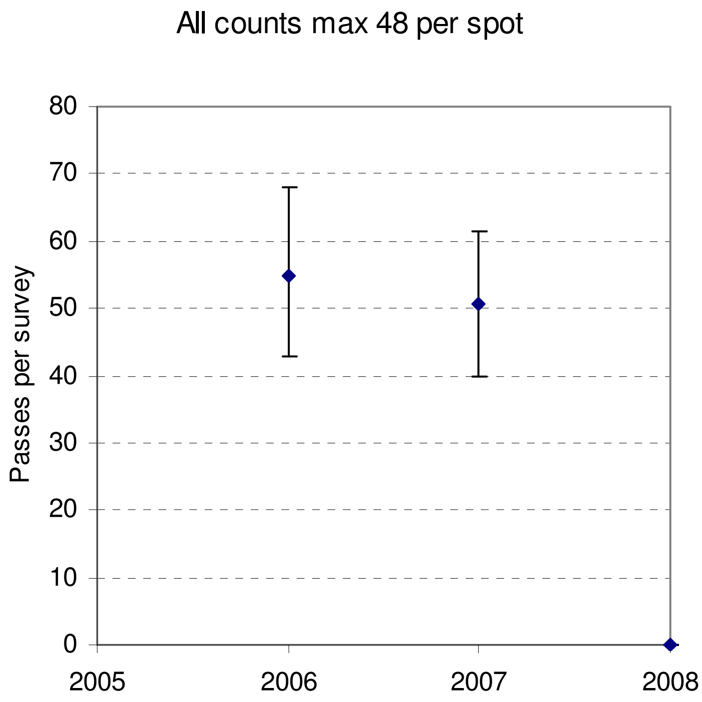
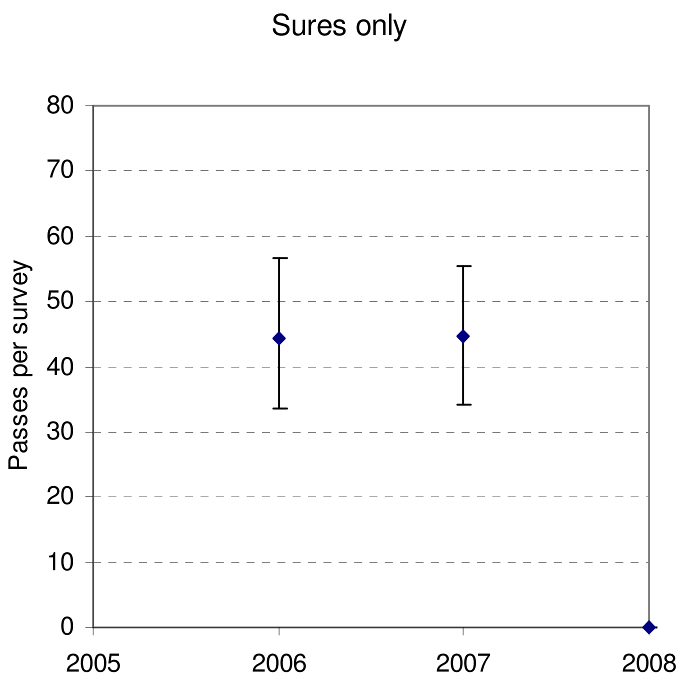


Figure 3c: 2007 Results of GLM model for total number of Daubenton's bat passes ('Sure' passes only) recorded per survey. Bars are 95% bootstrapped confidence limits.



APPENDIX II

Power Analysis Technical Details

The power analysis uses a simulation approach, rather than exact calculations; this is because the data is a poor approximation to any standard distribution, and because we are interested in the power using GAM curves, rather than simple linear trends. Simulations are based on the variance components from a REML model of suitably transformed bat counts per survey, estimating variances for sites, sites within years and replicate surveys within sites within years. Data are simulated using these variance estimates and back-transformed to the original scale after adding suitable year effects in order to produced the required long-term trend. Uncertainty in the estimates of variances can lead to erroneous estimates of power (Sims et al. 2007) and so each simulated dataset is based on variance estimates taken from a bootstrapped version of the original dataset, thus ensuring that the power results are effectively averaged over a range of plausible values of the variance estimates.

GAM models are then fitted to the simulated data, using bootstrapping to produce a one-tailed test for a decline at P = 0.05 (equivalent to P = 0.1 for a two sided test). Calculations are based on a GAM analysis of trend over time (rather than REML), although a REML model is used as the basis for the simulations. In order to find the number of years required to achieve 80% power for each number of sites, a sequential method (based on a modified up-and-down method, Morgan, 1992) is used to determine the number of years of data to include in each simulated dataset, ensuring that precise estimates are obtained with the minimum number of simulated datasets. The final estimate of power is then taken from a logistic regression of the probability of obtaining a significant decline against the number of years of data included in the simulation.

All GAM curves used the default degrees of freedom (0.3*nyears); this is the value suggested by Fewster et al. (2000) and seems to work well with NBMP data. Because GAM trends are estimated with less precision in the first and last years of a series, the second year is used as the base year in the simulations, and the trend is estimated up to the penultimate year

In the past we've used a log-normal transformation of the counts for bat field data, but this tended to produce a small number of implausibly large numbers of bat passes. The results presented here therefore use a transformation based on normal scores (see for example Armitage and Berry, 1987) which was more successful in mimicking the distribution of the real data.

Results should be treated with caution as they are dependent on many assumptions, some of which will only be approximately correct. In particular, the simulations assume that the same trend applies across all habitats, and more sites will be needed in the situation where the extent of the decline varies geographically or between different habitats. It is also assumed that all surveys are successfully completed; missing surveys will increase the number of sites needed to achieve the specified level of power.

APPENDIX III

Waterway sites surveyed under the All-Ireland Daubenton's Bat Waterway Survey 2006-2008

Table 1: County by county listing of waterways surveyed by the All-Ireland Daubenton's Bat Waterway Survey 2006-2008

(Shading = completed surveys; D = Daubenton's 'bat passes' recorded).

Site Code	Waterway	Site Name	Grid Ref	County	06	07	08
1001	River Boyne	Slane Bridge	N9640073610	Meath	D	D	D
1002	River Blackwater	O'Dalys bridge	N6530080320	Meath	D	D	D
1003	Borora River	Moynalty Bridge	N7352082560	Meath	D	D	D
1029	River Boyne	Ramparts	N8740067400	Meath	D	D	D
1030	Blackwater River	Donaghpatrick Bridge	N8194072310	Meath	D	D	
1031	Athboy River	Athboy Bridge	N7169064260	Meath	D	D	D
1038	Tolka River	Dunboyne-Loughsallagh Br	O0280041700	Meath			
1068	River Nanny	Dardistown Bridge	O1114070200	Meath	D	D	D
1132	River Blackwater	Mabe's Bridge	N7361077290	Meath	D		D
1204	River Boyne	2km d/s Blackwater confl.	N8852069110	Meath		D	
1251	Broadmeadow	Milltown Bridge	O0721051770	Meath			
1283	River Boyne	Trim Walkway	N8069056480	Meath			D
1284	River Boyne	Trim Castle	N8019056889	Meath			D
1005	Vartry River	Newrath Bridge	T2860096800	Wicklow	D	D	D
1006	Kings River	Ballinagree Bridge	O0364002380	Wicklow			
1007	Avonmore River	Ballard Bridge	T1442095670	Wicklow	D	D	D
1008	Glencullen River	Glencullen Bridge	T2190017900	Wicklow	D		
1009	Vartry River	Nun's Cross	T2560097900	Wicklow	D	D	
1010	River Ow	Roddenagh Bridge	T1170079200	Wicklow	D	D	
1012	Dargle River	Bray Bridge	T2640118895	Wicklow	D		D
1013	River Slaney	Seskin Bridge	S9770093900	Wicklow	D		D
1083	Avonmore River	Clara Vale Site 2	T1690092100	Wicklow		D	D
1090	Derry River	Tomnafinoge Wood	T0190070300	Wicklow		D	D
1227	River Dargle	Ballinagee Bridge	O2040014700	Wicklow		D	
1250	Grand Canal	Ponsonby Bridge	N9370026600	Wicklow		D	
1252	River Dargle	Tinehinch Bridge	O2212516160	Wicklow		D	D

1255	Varty River	Ashford Bridge	T2704797405	Wicklow		D	D
1274	Glencullen River	Knocksink Bridge	O2190017900	Wicklow		D	
1275	Avonmore River	Clara Vale	T1845591104	Wicklow		D	D
1285	Glencullen River	Glencullen/Dargle confluence	O2430017200	Wicklow		D	
1286	Vartry River	Annagolan Bridge	T2220099300	Wicklow		D	D
1011	Camlin River	The Mall Bridge	N0610075700	Longford		D	D
1023	Royal Canal	Aghnaskea Bridge	N0860080500	Longford			
1024	Inny River	Newcastle Bridge	N1830057000	Longford		D	D
1033	Camlin River	Carrigglass Bridge	N1650078000	Longford			
1034	Inny River	Ballymanhon Bridge	N1520056500	Longford		D	D
1044	Royal Canal	Farranyoogan	N1300074200	Longford		D	
1051	Royal Canal	Scally's Bridge	N2300060100	Longford		D	
1100	Inny River	Shrule Bridge	N1350055900	Longford		D	D
1232	Inny River	Coolnagon Bridge	N3870070000	Longford		D	
1004	Ward River	Bridge north of Killeek	O1453046397	Dublin			
1035	Delvin River	Gormanstown Bridge	O1707665774	Dublin			
1037	Tolka River	Cardiff Bridge	O1260037700	Dublin	D		
1039	Tolka River	Abbotstown Bridge	O0930038300	Dublin	D		
1040	River Dodder	Oldbawn Bridge	O0975026300	Dublin	D	D	
1041	River Dodder	Bridge on Spring Avenue	O1361028910	Dublin	D	D	D
1046	Royal Canal	Collins Bridge	O0280036750	Dublin	D		D
1047	Royal Canal	Granard Bridge, Castleknock	O0940038100	Dublin		D	
1048	Grand Canal	Kilmainham Section	O1280033200	Dublin	D	D	
1094	River Dodder	Newbridge Firhouse	O1145027750	Dublin		D	
1131	River Dodder	Milltown Bridge	O1698030410	Dublin	D		
1217	River Dodder	Castlekelly Bridge	O1110020260	Dublin		D	
1249	Tolka River	Violet Hill Drive, Finglas	O1430037400	Dublin			
1271	River Dodder	Clonskeagh Bridge	O1750030700	Dublin		D	D
1036	River Liffey	Leixlip Bridge	O0075035810	Kildare	D	D	
1042	Grand Canal	Henry Bridge	N9560028200	Kildare	D	D	
1116	Grand Canal	Spencer Bridge	N6680018900	Kidare			D

1125	Grand Canal	Limerick Bridge	N8730018700	Kildare			
1126	River Liffey	Kilcullen Bridge	N8424009730	Kildare	D	D	D
1127	River Liffey	Connell Ford	N8135013680	Kildare	D	D	
1128	Royal Canal	Deey Bridge	N9790037000	Kildare	D	D	D
1130	Royal Canal	Smullen Bridge	N9410037400	Kildare			
1142	Grand Canal	Milltown Bridge	S6550097500	Kildare	D		
1143	Grand Canal	Ayimer Bridge	N9730029500	Kildare	D	D	D
1165	River Liffey	Ballymore Eustace	T9262009790	Kildare	D		
1177	Grand Canal	Hazelhatch Bridge	N9880030700	Kildare	D		D
1203	Royal Canal	County Meath Bridge	N8860039600	Kildare			D
1240	Royal Canal	Chambers Bridge	N9000038800	Kildare			D
1256	River Liffey	New Bridge	N8704009850	Kildare		D	
1067	River Fane	Stephenstown Bridge	J0139001610	Louth		D	D
1211	Castletown River	Toberona	J0300009700	Louth		D	
1212	Kilcurry River	Bridge near Lurgankeel	J0272811980	Louth		D	
1214	River Dee	Bridge in Ardee	N9528590665	Louth			
1215	Dee River	Drumcar Bridge	O0660091170	Louth		D	
1220	Boyne Canal	Oldbridge	O0460076200	Louth		D	
1221	River Glyde	Castlebellingham	O0600095100	Louth		D	
1225	River Boyne	Beaulieu Bridge	N1250075900	Louth			
1071	Sow River	Poulsack Bridge	T0480027000	Wexford		D	D
1074	Tintern Abbey Str.	Tintern Abbey	S7940010000	Wexford	D	D	D
1077	River Sow	Kilmallock Bridge	T0327031910	Wexford			
1081	River Barrow	St Mullins	S7295037800	Wexford	D	D	D
1120	North Slob	Channel	T0827525539	Wexford	D	D	D
1159	River Bann	Margerry's Bridge	T1144159337	Wexford	D	D	D
1161	River Slaney	Scarawalsh Bridge	S9837545068	Wexford	D	D	
1254	River Slaney	Enniscorthy Bridge	S9742239898	Wexford			D
1076	River Shannon	Banagher Bridge	N0050015800	Offaly		D	D
1092	River Shannon	Lusmagh	M9666915225	Offaly			
1129	River Brosna	Ballycumber Bridge	N2120030600	Offaly	D	D	D

1172	Grand Canal	Srah Castle	N3290025200	Offaly	D	D	D
1174	Grand Canal	Griffith Bridge/ Shannon Harbour	N0330019100	Offaly	D	D	
1207	Clodiagh River	Muchlagh Bridge	N3100022800	Offaly		D	
1209	Brosna River	Mill Race Coola Mills	N4200050200	Offaly		D	
1210	Silver River	Wooden Bridge	N1270014300	Offaly		D	
1078	River Nore	Knockanore	S5469643591	Kilkenny	D	D	D
1079	River Nore	NE of Warrington	S5373654466	Kilkenny	D	D	
1080	River Nore	Threecastles Bridge	S4582162709	Kilkenny	D	D	D
1082	River Barrow	Graiguenamanagh Bridge	S7072443544	Kilkenny	D	D	D
1185	Dinin River	Dinin Bridge	S4789062850	Kilkenny		D	
1186	River Nore	Fennessys Mill	S5228754953	Kilkenny		D	D
1202	River Nore	Dysart	S5960039300	Kilkenny			D
1238	Glory River	Monachunna Townland	S4810038100	Kilkenny		D	
1239	Kings River	Ballycloven	S4853939873	Kilkenny		D	
1242	Mountain River	Ballycoppigan Bridge	S7343549860	Kilkenny		D	
1287	Kings River	Kells Bridge	S4941543690	Kilkenny		D	
1267	River Nore	Threecastles Bridge d/s	S4650062600	Kilkenny			D
1032	River Brosna	Ballnagore Bridge	N3560039600	Westmeath	D		
1086	Royal Canal	Bellmount Bridge	N3950051100	Westmeath		D	D
1088	River Brosna	Newell's Bridge	N3830042300	Westmeath		D	D
1093	Trib. of Boyne	Ballivor Road Bridge	N6030345270	Westmeath		D	
1140	River Shannon	Burgess Park, Athlone	N0410041000	Westmeath	D		
1173	Boor River	Kilbillaghan Townland	N1180034950	Westmeath			
1201	Lacey's Canal	Butler's Bridge	N4200050300	Westmeath			D
1234	Breensford River	Unknown	N1040044400	Westmeath			
1236	Inny River	Ballycorkey Bridge	N3120063900	Westmeath		D	D
1257	Royal Canal	Ballinea Brdige	N3850051100	Westmeath		D	D
1179	River Erkina	Footbridge 0.5km u/s Durrow	N4050077500	Laois		D	
1181	River Nore	Waterloo Bridge	S4110084000	Laois		D	
1182	Owenass River	Bridge Nth of Irishtown Hs	N4500007300	Laois		D	
1183	Delour River	Annagh Bridge	S2910093500	Laois		D	

1196	River Barrow	Portnahinch Bridge	N4910010100	Laois		D	D
1199	Vicarstown Canal	Vicarstown	N6150000500	Laois		D	D
1228	Stradbally River	Stradbally Bridge	S5720096300	Laois		D	D
1163	River Douglas	Cunnaberry Bridge	S8422067950	Carlow	D		
1184	River Barrow	Clashganey Lock	S7360945865	Carlow		D	D
1258	River Slaney	Kilcarry Bridge	S8940062500	Carlow		D	D
1197	River Dereen	Acaun Bridge	S9000077900	Carlow			D
1213	River Dereen	Ballykilduff Townland	S9000070900	Carlow			D
1259	River Barrow	Lower Ballyellen Lock	S6920053200	Carlow		D	
1014	Streamstown River	Interpretative Centre	M4820006100	Galway	D	D	D
1015	Clarinbridge River	Cow Park Commonage	M4123420005	Galway	D	D	D
1016	Black River	Moyne Bridge	M2500049000	Galway	D	D	D
1017	Lough Kip River	Dr. Chlaidhdi	M2221531223	Galway	D	D	
1018	Owenriff River	Glan Road Bridge	M1224443146	Galway	D	D	D
1019	River Corrib	Salmon Weir Bridge	M2959225666	Galway	D		D
1020	Kilcolgan River	Dunkellin Bridge	M4420218423	Galway	D		D
1021	Cregg River	Addergoole River	M3228334994	Galway	D	D	
1022	Clare River	Claregalway Bridge	M3717933228	Galway	D	D	D
1043	Rafford River	Ratty's Bridge	M5473423259	Galway	D	D	
1160	Rafford River	Rafford House	M6083726048	Galway	D	D	
1180	River Suck	Ballyforan Bridge	M8160046300	Galway			D
1195	Gort River	Castletown Mill	M4583303174	Galway		D	
1205	River Knock	Knockadrohid Bridge	M1587926695	Galway		D	
1262	Corrib River	Quincentennial Bridge	M2928726328	Galway			
1270	Dawros River	Derryinver Bridge	L7000059000	Galway			D
1045	River Rinn	Cloonart Bridge	N0830083200	Leitrim		D	
1115	Drowse River	Lennox's Bridge	G8180857254	Leitrim	D	D	D
1144	Diffagher River	Cloonemeohe Bridge	G9345124542	Leitrim	D	D	D
1145	River Shannon	Dowra Bridge	G9910026700	Leitrim	D		
1146	River Shannon	Mahanagh Bridge	G9557611687	Leitrim	D	D	D

1114	Owenmore River	Big Bridge	G6662412322	Sligo		D	D
1118	Owenmore River	Templehouse Bridge	G6250918568	Sligo	D	D	D
1119	Drumcliff River	Drumcliff Bridge	G6823242240	Sligo	D	D	D
1121	Duff River	Bridge at Drumacolla	G7960049100	Sligo	D	D	D
1152	River Unshin	Ballygrania Bridge	G6949725875	Sligo	D	D	D
1176	Clooneen River	Bridge nth of Kilavil	G6364110056	Sligo			
1194	Unshin River	Riverstown	G7399720147	Sligo		D	
1122	Boyle River	Knockvicar Bridge	G8728605541	Roscommon	D	D	D
1147	River Suck	Castlecoote Bridge	M8086362621	Roscommon	D	D	D
1157	Boyle Canal	Boyle Canal	G8200004300	Roscommon	D	D	D
1158	Lung River	Br u/s Lough Gara	M6614696681	Roscommon	D	D	D
1028	River Moy	Mount Falcon Fisheries S1	G2494413324	Mayo			D
1095	Cartron River	Carran	F8001100176	Mayo			
1098	River Moy	Mount Falcon Fisheries S2	G2484212404	Mayo			D
1124	Manulla River	Belcarra Walkway	M2010085400	Mayo	D		D
1150	Owenwee River	Belclare Bridge	L9599882163	Mayo	D	D	D
1171	Robe River	Crossboyne Bridge	M3386170962	Mayo			
1190	Owengarve River	Rosgalive Bridge	L8866096312	Mayo			
1191	Carrowbeg River	2nd br u/s lake, Westport Hs	L9940484624	Mayo		D	D
1198	Castlebar River	Castlebar Town	M1400090500	Mayo			D
1025	Inagh River	Inagh Bridge	R2082081290	Clare	D	D	D
1026	Inagh River	Moananagh Bridge	R1703084900	Clare	D		
1135	Errina-plassey Canal	Errina Bridge	R6400064800	Clare	D	D	
1137	Claureen River	Claureen Bridge	R3285978100	Clare	D	D	D
1138	River Fergus	Drehidnagower	R3301778654	Clare	D		
1166	River Fergus	Dromore Wood	R3592787828	Clare		D	D
1216	Scarrif River	Cooleen Bridge	R6030086000	Clare		D	D
1218	Scarrif River	1km u/s Scarrif Bridge	R6330084315	Clare			D
1027	Mulkear River	Bridge Nth of Coolruntha	R8060068700	Tipperary	D	D	D
1063	River Suir	Knocklofty Bridge	S1450020628	Tipperary		D	D

1064	River Suir	Thurles Bridge	S1295758635	Tipperary		D	
1069	Nenagh River	Tyone Bridge	R8770077900	Tipperary	D	D	D
1072	Suir River	Kilsheelan Bridge	S2862023234	Tipperary	D		
1073	Suir River	Cabragh Bridge	S1119956062	Tipperary	D		
1085	Clashawley River	Fethard	S3400020000	Tipperary		D	D
1089	River Aherlow	Cappa Old Bridge	R9935429318	Tipperary	D	D	D
1049	River Lee	Bannon Bridge	W6131671632	Cork	D		D
1050	Martin River	Bawnafinny Bridge	W5979075412	Cork	D	D	D
1052	River Owenboy	Priests Bridge	W6049161227	Cork	D		
1053	River Foherish	Carrigaphooca Bridge	W2963673766	Cork	D	D	
1054	Glashaboy River	Upper Glanmire Bridge	W7146478294	Cork	D	D	D
1055	Shournagh River	Tower Bridge	W5862074551	Cork	D	D	D
1056	Laney River	Carrigagulla Bridge	W3894683016	Cork	D	D	
1057	Bride River	Coolmucky Bridge	W4603767916	Cork	D	D	D
1058	River Lee	Drumcarra Bridge	W2955867786	Cork	D	D	
1059	River Sullane	Linnamilla Bridge	W3113972814	Cork	D	D	
1060	River Blackwater	Charles bridge	W2481194404	Cork	D	D	D
1061	Argideen River	Lisselane Bridge	W4050044400	Cork			D
1087	Dripsy River	Dripsey Bridge Lower	W4612279628	Cork	D		
1091	Glengarrif River	Footbridge NW of Glengarrif	V9178756970	Cork	D	D	D
1099	River Blackwater	Careyville	W8558399508	Cork	D	D	D
1101	Arigideen River	Kilmaloda Bridge	W4519545566	Cork	D	D	
1123	River Lee	Kennel's to Weir Stream	W5870071400	Cork		D	
1187	Owenboy River	Ballea Bridge	W7090063300	Cork			
1206	River Lee	Lee Fields	W6484371393	Cork			D
1208	Dripsey River	Dripsey Bridge	W4876073864	Cork			D
1062	Owenreagh River	Bridge u/s Upper Lake	V8842282104	Kerry	D	D	D
1065	River Feale	Racecourse Footbridge	Q9808433646	Kerry		D	
1066	Flesk	Flesk Bridge	V9672589468	Kerry	D	D	D
1096	River Feale	Finuge Bridge	Q9511132113	Kerry			
1097	River Sneem	Br u/s Ardsheelhane R confl.	V6891667568	Kerry	D		

1153	Feale River	Listowel Bridge	Q9952633292	Kerry			D
1226	Emlagh River	Bridge west of Emlagh townland	Q6480003300	Kerry			
1263	River Laune	1/2km below Beaufort Bridge	V8816692633	Kerry		D	D
1276	Blennerville Canal	Blennerville	V8164713313	Kerry			D
1075	Whelan's Br Stream	Whelan's Bridge	S5220009900	Waterford	D		
1084	Owennashad River	Br u/s Blackwater R. confl.	S0482098940	Waterford	D	D	D
1107	Whelan's Br River	Br West of Carrickduston	S5075007600	Waterford			
1117	River Suir	Suir Valley Railway	S3410347108	Waterford		D	D
1151	St. John's River	Kilbarry Walkway	S1000060000	Waterford			D
1162	Colligan River	Colligan Bridge	S2195897983	Waterford		D	
1167	River Blickey	Twomile Bridge	X2250091200	Waterford			D
1200	Dalligan River	Ballyvoyle	X3359794997	Waterford			
1233	River Bride	Tallow Bridge	W9980094400	Waterford		D	
1237	Mahon River	Aughshemus Bridge	S4160002600	Waterford			D
1103	Maigue River	Fort Bridge	R5060025700	Limerick			
1136	Greanagh River	Coolagh Bridge	R4434946357	Limerick			
1139	Barnakyle River	Bridge SE of Clarina	R5103853043	Limerick			
1154	Mulkear River	Annacotty Bridge	R6430057700	Limerick	D		D
1155	River Owenocarney	Annagore Bridge	R4768267717	Limerick	D		
1156	Bilboa River	Gortnagarde Bridge	R7800050500	Limerick	D	D	D
1178	Feale River	Mount Colums Creamery	R1000022000	Limerick			D
1102	River Lagan	Shaws Bridge	J3250069000	Antrim	D	D	
1108	Glenarm River	Glenarm Estate	D3012511916	Antrim	D	D	D
1229	Glenarm River	Glenarm Castle	D3100015100	Antrim			D
1231	River Lagan	Drum Bridge	J3060067100	Antrim		D	
1245	Sixmile Water	Loughshore Park	J8650014800	Antrim			D
1260	Sixmile Water	Millrace Trail	J1550085500	Antrim			D
1266	River Lagan	Stranmillsweir to Lagan Meadows	J3410070900	Antrim		D	D
1267	Sixmilewater	Castlefarm Bridge	J1440086800	Antrim		D	D
1280	River Faughan	Faughan Bridge u/s	D4930020600	Antrim			D

1070	Moyola River	Curran	H8920095500	Derry	D		
1104	Mascosquin River	Ree Bridge	C8981623667	Derry	D	D	
1105	River Roe	Dog Leap	C6790020300	Derry	D	D	
1106	River Roe	Dungiven Bridge	C6830009800	Derry	D	D	
1192	River Bush	Bush Golf Course	C9370042500	Derry			D
1241	River Bush	Conagher Bridge	C9574930521	Derry			D
1244	River Faughan	Park Bridge	C5910002400	Derry			D
1246	Lower Bann	The Cuts	C8560030300	Derry			D
1253	Aghadowney River	Agivey Bridge	C8980022900	Derry			D
1272	River Roe	Roe Road Bridge	C6680022900	Derry			D
1281	Aigivey River	Errigal Bridge	C8130014500	Derry			D
1290	Aigivey River	Moneycarrie Bridge	C8670019500	Derry			D
1109	Cusher River	Clare Glen Bridge	J0140043900	Armagh	D	D	
1223	Newry Canal	Victoria Lock	J0960023400	Armagh		D	D
1289	River Lagam	Wolfden's Bridge	J2847668805	Armagh			D
1110	Newry Canal	Moneypennys Lock	J0330051200	Down	D	D	D
1111	Bann (Newry) Canal	Scarva Heritage Centre	J0640043700	Down			
1112	Moneycarragh River	Moneylane	J3990036900	Down	D	D	
1113	River Ravernet	Legacurry Bridge	J2970060100	Down			
1224	The Quoile	Quoile Pondage	J4960047000	Down			D
1268	River Bann	Lawcencetown	J0990049200	Down		D	
1278	Crawsfordsburn River	Crawsfordsburn Country Park	J4670082000	Down		D	
1291	Lagan Canal	Ballyskeagh	J2850066500	Down			D
1292	Enler River	Dundonald	J4230073200	Down			
1133	River Blackwater	Nine Eyes Bridge	N6304083380	Cavan	D	D	D
1141	River Blackwater	Killryan Bridge	H2025014600	Cavan	D	D	
1248	Annalee River	Rathkenny Bridge	H5350011600	Cavan		D	
1273	Annalee River	Butler's Bridge	H4070010400	Cavan			D
1148	Owenea River	Owenea Bridge	G7369092110	Donegal	D	D	D
1149	River Deele	Milltown Bridge	C2450099613	Donegal	D		D

1164	River Crana	Castle Bridge	C3480432892	Donegal	D		
1277	Lackagh River	Lackagh Bridge	C0956930880	Donegal		D	
1168	Kesh River	Kesh	H1820064200	Fermanagh	D	D	
1169	River Erne	Enniskillen	H2700053000	Fermanagh	D	D	D
1170	Colebrook River	Ballindarragh Bridge	H3310036000	Fermanagh	D		D
1265	Sillees River	Glencunny Bridge	H0830038400	Fermanagh		D	D
1134	Monaghan Blackwater	New Mills, Cornahoe	H7189838769	Monaghan			D
1261	Ulster Canal	Monaghan Town	H6800034700	Monaghan			
1230	Camowen River	Lover's Retreat Picnic Site	H4680072900	Tyrone			D
1235	Fairywater	Poe's Bridge, d/s	H4250075000	Tyrone			D
1243	Camowen River	Bracky Bridge	H5350071400	Tyrone			D
1247	Glenelly River	Drumspar	H4960091300	Tyrone			D
1264	River Strule	Stone Bridge	H4370077600	Tyrone		D	D
1279	River Strule	Stone Bridge u/s	H4369577631	Tyrone			D
1282	Fairy Water	Omagh	H4290074900	Tyrone		D	
1288	Drumragh River	Lissan Bridge	H4660070100	Tyrone			D