# Irish Bat Monitoring Programme

Proposals and Recommendations for a

## Pilot Daubenton's Bat Waterway Survey

## Final Report

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# Irish Bat Monitoring Programme

## Proposals and Recommendations for a **Pilot Daubenton's Bat Waterway Survey**

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## EXECUTIVE SUMMARY

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

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

The Daubenton's bat is easy to see when foraging because it opportunistically feeds close to water especially over smooth water surface. It can be found foraging over rivers, streams, canals, pools and lakes. It forages very close to the water, typically within 30cm of the surface.

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

A min-pilot of The Daubenton's Bat Waterway Survey was undertaken in August 2005. Five waterways were surveyed using heterodyne bat detectors. In addition, broadband technology was employed at one waterway. Daubenton's 'bat passes' were recorded at three waterways. A total of six species were recorded by broadband detectors at one waterway.

It is proposed to introduce The Daubenton's Bat Waterway Survey throughout the 32 counties of the Republic of Ireland and Northern Ireland in 2006. It is proposed to sample 50 randomly selected waterways sites. Surveyors will be provided with 'Grid Referenced Water Quality Sampling Sites' and asked to map a 1km transect. Volunteers will then survey Daubenton's bat activity at ten spots (approximately 100m apart) for four minutes using a heterodyne bat detector on two nights in August 2006. Results, maps and description of 'spots' using a standardised method will be returned to BCIreland for analysis.

Statistical analyses of Power will be carried out on data collected to determine that the number of sample sites is appropriate to monitor Red and Amber Alert targets.

# Chapter 1: Daubenton's Bat *Myotis daubentonii*, a species profile

## 1.1 DISTRIBUTION AND BIOLOGY

Daubenton's bat belongs to the Family Vespertilionidae and has a widespread distribution along a narrow band across Europe and Asia from Ireland, Britain, France, Iberian Peninsula to the Pacific Ocean and the northern islands of Japan (Altringham, 2003). It is widely distributed in Ireland and O'Sullivan (1994) reported it as the second most recorded species after common pipistrelle bat in 1988 (Only the common pipistrelle bat was known to exist in Ireland in 1988. Since then, three species of pipistrelle have been identified in Ireland).

Factors affecting the population of Daubenton's bat include a reduction in water quality of surface waters and loss of riparian vegetation including mature trees that can be used as roosts. Factors that reduce roosts, both summer and hibernation, will also impact on this species (Walsh *et al.,* 2001). In Ireland, bridge maintenance involving the spraying of liquid concrete into crevices under the arches of bridges is a major contributor to roost destruction (Smiddy, 1991, O'Sullivan, 1995 and Shiel, 1999).

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

It is a medium-sized bat with a mass of 7-15g, a wingspan of 240-275mm and a forearm length of 33-42mm. In general, it has brown dorsal fur with pale buff ventral fur. The ears are relatively small with a short blunt tragus. Characteristic features include a long calcar (the cartilage projection from the foot to the tail along the edge of the tail membrane) and large feet (Altringham, 2003).

### *1.1.1 Daubenton's bat in summer roosts*

Daubenton's bat is often called the water bat due to its preference for hunting close to water (Fairley, 2001). As a consequence this species rarely roosts far from waterbodies. Daubenton's bats are known to form maternity colonies in hollow trees, bridges and stone buildings. The most frequently used roosting sites are considered to be in stonework of bridges over water. A survey of 165 stone masonry bridges in Counties Sligo and Leitrim by Shiel (1999) resulted in 98 being considered suitable for roosting bats (i.e. suitable crevices were present in stone work). Of these, 66 bridges (67%) had roosting bats and of the 252 bats identified, 72% were Daubenton's bats. In relation to tree roosts, Boonman (2000) reported that Daubenton's bats prefer natural tree cavities of deciduous trees including oak and beech.

Maternity roosts tend to be comprised of female bats, the majority of which are pregnant at the time of establishment of the colony each year. Some non-breeding females and males may also be present. The majority of Daubenton's roosts known in Ireland consist of small groups of 10 individuals or less (Smiddy, 1991, O'Sullivan, 1994 and Shiel, 1999). The small size of these colonies may be more due to the size of cavity (particularly in stone bridges) available to roosting bats than due to their preference for small colonies. Larger roosts have been documented in buildings where space is available. Up to 200 individuals have been occasionally recorded (Fairley, 2001). A colony can often use a number of maternity roosts over the season resulting in frequent movement and fragmentation of the main colony between roosts (Altringham, 2003). To further complicate the matter, day and night roosts separate from the main maternity roosts are often used.

Maternity colonies are usually established in mid to late spring with the birth of young generally in June to mid-July. In general, the colony disperses in late summer once the young are weaned and are on the wing. Males tend to roost separately from the females and generally in small groups.

### *1.1.2 Emergence behaviour in Daubenton's bats during summer months*

The time at which bats emerge to feed is generally related to sunset, with influences from climatic conditions (e.g. cloudier nights are darker and therefore emergence tends to be earlier) and surrounding roost conditions (e.g. connecting treelines that provide shelter for commuting bats tends to allow bats to emerge earlier). Emergence times differ between species but Daubenton's bats have been recorded emerging only when it is fully dark rather than at dusk (Walsh *et al,* 2001) which can range from 30 to 120 minutes after sunset (Swift and Racey, 1983; Warren *et al,* 2000; Altringham, 2003). Daubenton's bats have also been reported to follow the most sheltered route to and from roosting sites to foraging areas, even if that means longer travelling time (Limpens and Kapteyn, 1991). This combined with a later emergence from a roost means that it can be 2 hours after sundown or later by the time this bat species arrives at a foraging site.

### *1.1.3 Feeding behaviour of Daubenton's bats during summer months*

Daubenton's bat is easy to see when foraging because it opportunistically feeds close to water especially over smooth water surface. It can be found foraging over rivers, streams, canals, pools and lakes. It forages very close to the water, typically within 30cm of the surface. Here it either trawls for insects from the surface of the water by gaffing them with its large feet or the tail membrane or takes them directly out of the air (aerial hawking) (Jones and Rayner, 1988). Daubenton's bats can be observed flying continuously back and forth along a regular flight path. Aquatic insects make up most of their diet. Sullivan *et al* (1993) reported that analysis of Daubenton's bat droppings collected from a roost in Waterford, were composed of mainly Trichopteran (Caddis-fly) and Dipteran (particularly Chironomidae (non-biting midge) & Ceratopgonidae (biting midge)) remains.

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. This bat species needs to feed in areas with high insect density to satisfy their energy requirements. Feeding times can vary from 2-4 hours from emergence time depending on the density of insect prey available in favoured habitats. Key foraging sites tend to be typically within 3 km of the main maternity roost (Altringham, 2003). Foraging activity is generally concentrated just after emergence with feeding tailing-off during night. However, it is not unusual for Daubenton's bats to feed at consistent level throughout the night before returning to roost before dawn.

While Daubenton's bats will commute along linear landscape features to key foraging sites it will rarely be observed foraging en-route (Limpens and Kapteyen, 1991). Not all bats feed every night as poor climatic conditions may discourage bats from feeding on a particular night. However, it has been documented that Daubenton's bats will feed in woodland and other sheltered habitats when light levels are high (Nyholm, 1965; Vaughan *et al,* 1997) or in poor climatic conditions or at the beginning of the summer when aquatic populations may not have fully emerged. Russ and Montgomery (2002) reported that *Myotis* bats had the narrowest range of habitats used of all Irish species investigated with Daubenton's bats selecting rivers and canals and avoiding those with little or no vegetation edge.

### *1.1.4 Echolocation calls and foraging style of Daubenton's bats*

Exploitation of insect prey populations and orientation during the darkened hours means that bats rely on vocalisation or echolocation when commuting and foraging. Bats generate ultrasounds in the larynx and emit these sounds either through the mouth or the nostril. These high frequency sounds are returned as echoes, from which the bat builds a sound picture of its immediate surroundings (Elliott, 1998). Neural circuits used for echolocation allows bats to detect the velocity of the prey item with an accuracy of 1 cm/sec and the distance of the target prey with an accuracy of 1mm (Kalko and Braun, 1991).

Echolocation calls are comprised of two broad components: Constant Frequency (CF: single note of long duration) and Frequency Modulation (FM: sweeping down over a range of frequencies). An echolocation call can be described as a single pulse but in reality bats produce these pulses continuously as they build up a picture of their moving environment. The characteristic echolocation call of a particular species is often defined by its use of CF and FM components. Bats foraging primarily in cluttered environment (e.g. woodland) usually put more emphasis on FM components of their echolocation calls while those bats foraging in more open habitats will have a greater emphasis on CF components of the call (Russ, 1999). Bats flying in cluttered environments require fine detail to orientate therefore a series of rapid FM calls sweeping through a range of frequencies are produced. While FM calls are quiet, so do not travel far, they do provide the fine detail to distinguish small insects in clutter. Daubenton's bats tend to use FM echolocation pulses ranging in a downward sweep on average from 79 to 33 kHz in a typical foraging habitat.

Echolocation calls are related to the foraging habitat, the shape of the wings and time of emergence (Russ, 1999). Manoeuvrable bats, such as Daubenton's bats, have broad wings and tend to emerge late in the evening. While flying over water surface may not be considered as a cluttered environment in the true sense, the reflective properties of water combined with speed of the bat, means that for the Daubenton's bat and information it requires a water surface can be considered as a cluttered environment. Warren *et al* (2000) reported that Daubenton's bats actively selected against foraging over rapids (white water and heavy ripples) or cluttered water (projecting rocks and ripples) for several possible reasons e.g. more insects are found over smooth water or as a trawling species, obstacles such as rocks would make prey detection by echolocation more difficult or ultrasound noise generated by rapids may also interfere with echolocation analysis.

Flight speed is important to bats when intercepting prey items. The characteristic speed of a particular species is determined chiefly by flight morphology but an individual bat can also select a speed in response to its potential prey item, food availability and the nature of the habitats that it is flying within (Jones and Rayner, 1988). Daubenton's bats typically fly along a straight flight path before turning sharply at the end of the flight path in preparation for another flight run. Echolocation call properties are intimately linked with the foraging and flight style of a particular species.

### *1.1.5 Species identification and bat detectors*

The human ear is sensitive to sound frequencies from approximately 40Hz to 20,000Hz (20kHz). As a result, the echolocation calls of bats tend to be outside the human hearing range. Bat detectors convert the echolocation calls of bats into sounds that are audible to humans (Elliott, 1998). It is therefore possible to detect the presence of bats, assess the level of activity in an area and potentially identify the species by such instruments. There are a number of methods of converting the echolocation call into sound that humans can hear. The most commonly used method and therefore bat detector type is the heterodyne bat detector. Other frequently used methods are Frequency Division and Time Expansion.

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

To discriminate fully between many species, a combination of visual observations in relation to habitat type, bat flight pattern and detector noise output is used. When in its preferred foraging habitat a bat species has a characteristic echolocation call. Daubenton's bats echolocation call on a heterodyne bat detector can be described as a rapid series of clicks, often likened to the sound of a machine gun. The pulse repetition rate is very fast and very regular and loudest at 45kHz (Russ, 1999). The Daubenton's bat has a characteristic echolocation call when typically foraging over water 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 straight forward. The echolocation call is loudest when the detector is tuned to 45kHz. However to distinguish from foraging pipistrelle bats it is recommended to tune the detector to 35kHz. At this frequency, the pipistrelle bat echolocation calls lose much of its tonal qualities but the dry 'clicks' characteristic of Daubenton's bats are still clearly audible (Russ, 1999).

Models of heterodyne bat detectors differ in their tuning, bandwidth and sensitivity and therefore the use of different models by bat workers introduces bias in bat surveys. The sensitivity of different heterodyne bat detector models may be the most significant varying factor needed to be aware of during large-scale monitoring programmes. A detector that is twice as sensitive as another model will therefore record twice the number of bats. Improvements in bat detector technology will also mean the newer models will increase in sensitivity. Standardisation of model usage is generally not a viable option for large scale monitoring programmes with a large number of volunteers. However it is possible to calculate the sensitivity of models and thus weight the data collected accordingly and factor out potential bias (Walsh *et al,* 2001).

### *1.1.6 Bat passes and feeding buzzes, tools for surveying Daubenton's bats*

A 'bat pass' is a sequence of echolocation calls registered indicating a bat in transit (Fenton, 1970). The 'bat pass' is the unit generally measured when surveying for bats.

As the distance between a bat and insect prey shortens and the bat zones in for capture, the bat produce shorter echolocation calls at a faster rate to receive information on the insect. The calls become so rapid that it is no longer possible to distinguish between separate pulses. This is termed as 'feeding buzz' and it occurs when a bat has detected or caught an insect.

Therefore two different units of bat activity can be recorded, the first which is a sequence of at least two echolocation calls indicating a bat in transit, a 'bat pass' and the second is a 'feeding buzz', which indicates a feeding bat. However, all bats produce similar sounding 'feeding buzzes' so it is not used to distinguish species of bats. In addition, bat detectors can not differentiate between several passes by the same bat and single passes by several bats so the counts of bat passes represent an index of relative abundance and relative activity (Walsh *et al,* 1995). However, in measuring population trends, bat passes do provide a population index.

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. However, this may lead to the problem that bat passes recorded are not statistically independent and to the question of how many bat passes to record when activity is constant.

# Chapter 2: **Why monitor Daubenton's bat *Myotis daubentonii*?**

## 2.1 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. 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 Wildlife Act (1976) and Wildlife (Amendment) Act 2000 it is an offence to intentionally harm a bat or disturb its resting place.

The EU Directive (92/43/EEC) on the Conservation of Natural and Semi-natural Habitats and of Wild Flora and Fauna (The Habitats Directive) lists all Irish bats species, including Daubenton's bat, in Annex IV while the lesser horseshoe bat *Rhinolophus hipposideros* is listed in Annex II. Member states must maintain and restore 'favourable conservation status' of species listed in Annex II, IV and V. Favourable conservation status is defined as 'the sum of the influences acting on the species concerned that may affect long-term distribution and abundance'. Articles 11 of the Directive states that 'Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2 with particular regard to priority natural habitat types and priority 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). This agreement recognises that endangered migratory species can only be fully protected if their migratory range is protected. Under this agreement, strategies for monitoring bat populations of selected species are part of its Conservation and Management Plan. Across Europe, they are further protected under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention 1982), which, in relation to bats, exists to conserve all species and their habitats.

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

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

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

There are no precise definitions to decide at what population size a species becomes vulnerable to extinction or at what rate of population decline will result in extinction. Rates of change may be used as estimates such as those conservation alerts defined by The British Trust for Ornithology (BTO). The BTO has developed Alert Levels based on IUCN-developed criteria for measured population declines. Species are considered of high conservation priority (i.e. Red Alert) if their population declines by 50% or more over a 25-

year period. Species are considered of medium conservation priority (i.e. Amber Alert) if there is a decline of 25-49% over 25 years. A 50% and 25% decline over 25 years translates into an annual decline of 2.73% or 1.14% respectively. Thus if a 1.14% decline rate is observed in less than 25 years, then the species is given Amber Alert status. These Alerts are based on evidence of declines that have already occurred or can be predicted to occur based on statistically robust monitoring data that is sensitive enough to meet Alert Levels.

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

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

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

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. It is considered that 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 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). An Irish Daubenton's monitoring programme will not only provide much-needed data on the status of the species' population but could also contribute an index of aquatic habitat quality. The monitoring programme may also aid in recommendations for management of surface waters, especially riparian habitats of rivers and canals.

## 2.2 WHAT IS THE DAUBENTON'S BAT WATERWAY SURVEY UK?

The Daubenton's Bat Waterway Survey is the current monitoring protocol in operation for monitoring bats at waterways in the UK and is under the management of The Bat Conservation Trust (BCT). It was introduced in 1997 and focuses on Daubenton's bat activity along waterways such as rivers and streams (but excludes ponds and lakes) as this species is known to have a high dependency on such waterbodies for foraging. In addition, this species is relatively easy to identify on such habitats so volunteers can participate with relatively little expertise in bat detection skills.

The survey methodology relies on the use of heterodyne bat detectors. This technology is relatively inexpensive and many surveyors own their own detector (e.g. Stag Electronic Bat Box III costs approximately €180). The simplicity of their use also makes participation in field surveys possible to a wider number of potential surveyors. It is considered that The Daubenton's Bat Waterway Survey is an ideal method to introduce inexperienced volunteers to bat surveying. Experience gained through participating in this survey provides an opportunity to improve bat detector skills and thereby leading to further participation in more complex bat surveys.

The BCT works closely with the Environment Agency UK (EA) and, where possible, survey existing EA River Habitat Survey (RHS) locations for Daubenton's bats. This approach adds value to the already compiled data set of habitat features of such sites and also allows cross analysis of both data sets. Results from research undertaken by Catto *et al.* (2003) data sets from both the RHS and Daubenton's Waterway Survey UK have shown that there is a positive relationship between Daubenton's bat activity, aquatic insect biodiversity and water quality. In the UK, therefore Daubenton's bat monitoring results can be used as an indicator of waterway health.

RHS sites are assigned to their land classes according to the Institute of Terrestrial Ecology (ITE) land classification system. This system defines the range in variation in the environment of the UK using numerous parameters such as topography, altitude; geology and habitat cover, and divides the land into land classes. These land classes are the basic strata used to undertake stratified random selection of RHS sites surveyed under the BCT Daubenton's Waterway Survey.

#### *2.2.1 Survey Methodology*

Surveyors are assigned a random 1km of waterway that lies in an existing RHS site that is within 10km of the surveyor's home address. Sites allocated to volunteers are representative of flowing waterbodies in the UK. Waterways less than 1m wide are excluded as they are considered to be too narrow for foraging bats (Catto *et al,* 2003). Surveyors undertake a day visit (with landowner's permission) to assess the site for safety. Ten points approximately 100m apart, are marked out along a 1km stretch. The surveyors then revisit the site on two evenings in August. At each of the ten points, the surveyor records Daubenton's bat activity for four minutes with a heterodyne bat detector and torchlight (Walsh *et al.,* 2001). The methodology is designed to be simple, robust and repeatable in order to meet the basic principles of monitoring theory (Catto *et al,* 2003).

Bat passes are either identified as Daubenton's bat or 'Unsure' Daubenton's bat. Daubenton's bat passes are identified only if the bat is heard and seen skimming the water surface. Bat passes that are heard and sound like Daubenton's but not seen skimming the water maybe another species. Therefore these heard but not seen bats are recorded as 'Unsure' Daubenton's bat passes. Results are quoted as the number of bat passes per survey period (No. of bat passes/40 minutes).

#### *2.2.2 Volunteer-base*

In the UK the volunteer network is considered to be the backbone of bat monitoring programmes. Field volunteers participating in the Daubenton's Bat Waterway Survey tend to be more experienced local Bat Group members and have some skill with bat detectors (Walsh *et al.,* 2001). Over the period 1997-2004 a total site network of 872 1km stretches of waterway were surveyed. In 2004, 262 sites were surveyed by a total of 211 volunteers, 66% of whom participated in 2003. Both the number of sites surveyed and volunteer participation had increased from 2003 to 2004. In 2003, 189 sites were surveyed by 157 volunteers. No volunteers from Northern Ireland participated in either 2003 or 2004 surveys.

For the entire National Bat Monitoring Programme in the UK (which includes summer and hibernation roost counts and other bat monitoring programmes for a total of eleven of the sixteen bat species breeding in the UK), a total of 979 volunteers participated in all surveys managed by BCT in 2004, 78.8% of whom participated in 2003.

Volunteer training is an essential component of all bat monitoring programmes in the UK. BCT works closely with local Bat Groups to ensure that adequate training is provided. In 2004, 15 workshops were organised throughout the UK with over 300 participants.

### *2.2.3 Data handling and analysis*

Data collated by the BCT from the Daubenton's Waterways Surveys in conjunction with other surveys is used to produce population trend data. In addition power analysis is carried out to determine whether these data are sufficient to detect IUCN Red and Amber Alert Levels.

An investigation undertaken by Catto *et al* (2003) demonstrated that the Daubenton's bat Waterway Survey UK database could contribute to an annual indication of overall environmental health of waterbodies in the UK. The study showed that there is a positive relationship between improved water quality, increased insect biodiversity and a higher number of Daubenton's bat encounters (Anon, 2004; Catto *et al,* 2003). Introducing this monitoring protocol in Ireland could also achieve similar goals in relation to water quality of rivers and canals as part of the EPA Water Quality programme.

## 2.3 INTRODUCING THE DAUBENTON'S BAT WATERWAY SURVEY IN IRELAND

BCIreland are proposing to pilot the Daubenton's Bat Waterway Survey based on the BCT UK current methodology in the Republic of Ireland and Northern Ireland in 2006.

### *2.3.1 Potential datasets: Rivers and canals*

The National River Site Coding System assigns a code to every bridge and convenient access point to rivers in the Republic of Ireland (McGarrigle *et al.,* 2002). Some 12,000 sampling sites have been defined and these are the basic source for sampling points under Environmental Protection Agency (EPA) water quality monitoring programmes. Approximately four thousand of these sites, those stations currently being sampled, have been mapped by GPS, accurate to <50m, to facilitate the EPA's GIS system (EPAIS) and site description on OS 1:50,000 Discovery Series maps.

The National Rivers Monitoring Programme under the management of the EPA lists sampling stations and the monitoring requirements in terms of national and European priorities. The ecological monitoring programme and the physio-chemical programme are the two main sub-programmes. Over 4,000 different sites along stretches of Irish rivers are included in this programme. Each site may be included in one or more of the current sampling programmes e.g. EPA National Ecological (Biological) Monitoring Programme, Fish Population monitoring, EUROWATERNET programme etc. Individual sites are weighted according to the number of programmes they are sampled under. The weight is scored from 0 to 10 with higher numbers indicating greater participation in monitoring programmes (Anon, 2002).

Sampling locations for the proposed Irish Daubenton's Bat Waterway Survey could correspond with sites already monitored by the EPA. This would provide additional information for data set analysis. The EPA's Ecological (Biological) Monitoring Programme is currently based on a 3-year cycle where approximately 3,000 sites covering 13,200 km channel length from 1132 of the country's rivers and streams are monitored (McGarrigle *et al.,* 2002). A quality assessment using macroinvertebrates is carried out at these sites based on the EPA's Quality Rating System (Q-Value system). Additional parameters recorded include information on aquatic plants, algae, riparian verge, hydromorphology and general catchment land use patterns (Anon, 2002). All of the ecological sites have also been characterised in terms of land use, topography, agricultural statistics, human population, geology and other features using the EPAIS (EPA's GIS system). Minimum physio-chemical parameters sampled for by the EPA include the following: Dissolved Oxygen (DO), temperature, pH, conductivity, Biological Dissolved Oxygen (BOD), MRP (unfiltered molybate reactive phosphate), oxidised Nitrogen, ammonia, chloride, colour, hardness and alkalinity.

This is to allow individual rivers to be assigned to ecological types and compared with requirements under the Water Framework Directive (EU Directive 200/60/EC Establishing a Framework for Community Action in the field of Water Policy). Individual drainage area boundaries are drawn for each river sample site. These polygons were overlaid on maps of land use, topography, agricultural statistics, human population and geology in order to give natural catchment characteristics for the sites and also an indication of the pressure impacting on the river. This will allow individual rivers monitored under the Framework Directive to be assigned to an ecological type (Anon, 2002).

Sampling areas for the Daubenton's Waterway Survey should include sites sampled under both the EPA's ecological and physio-chemical programmes. This will optimise the range data available for future analysis. Further selection of potential sites could be fine tuned to include sampling sites with additional monitoring programmes attached. A number of such programmes are briefly described below.

Within the Ecological Programme a sub-programme (Operational Programme for Protected Areas) includes rivers in or near Special Areas of Conservation (SACs), Special Protected Areas (SPAs) and other areas designated under national, European and international legislation and agreements. Approximately 300 sampling sites are included in this programme (Anon, 2002).

Potential canal sampling sites can be sourced from the Canals Monitoring Programme currently managed by Waterways Ireland and the Central Fisheries Board. The programme will be fully in place for all canals by 2006 as required by the Water Framework Directive. A total of 76 canal sites and 38 feeder streams were sampled in 2003 (Toner *et al,* 2005).

Small Stream Survey is a sub-programme of the Surveillance Monitoring Programme undertaken by the EPA and covers minor first-order streams that are not shown on the OS Catchment map (Anon, 2002). However, streams with a width of 1m or less would be excluded from a potential sampling database.

The Water Framework Directive requires that catchment areas are assigned into River Basin Districts (RBDs) with a number of cross-border RBDs as units for water resource management. Seven RBDs have been assigned three of which are shared with Northern Ireland. Co-ordinating the Daubenton's Waterway Survey with the Northern Ireland Bat Group and BCT will make a more effective dataset for this proposed monitoring programme for the whole of the island.

In relation to Water Quality datasets for Northern Ireland, 5,100km of river network is currently monitored by the Water Management Unit (WMU) of the Environment and Heritage Service (EHS). Primary and Secondary Rivers (at least 3m wide) are monitored for both biological and chemical parameters and this comprises of 4,100km of river network. The remaining 1000km of river network currently monitored is classified as Minor Rivers (less than 3m wide) and are only monitored in relation to biological parameters.

#### *2.3.2 Volunteer-base in Ireland*

The number of trained bat workers in Ireland is limited. The Car-based Bat Monitoring Protocol was devised as such due to the insufficient capacity to deliver a country-wide foot-based bat detector survey from the present pool of experienced bat workers. However, the

Daubenton's Water Survey focuses on a single species of bat with a characteristic foraging style that makes it relatively easy to identify in the field.

Bat Conservation Ireland (BCIreland) has undertaken three bat detector workshops (2005, 2004 & 2003) for the general public. Additional workshops have been carried out for NPWS Regional staff and in association with national and international bat conferences since 1996. There are currently 86 members in BCIreland, 11 of whom have greater than 3-years bat detector experience with an additional 28 members having attended at least one bat detector workshop since 2003. Additional recruitment of volunteers from the Northern Ireland Bat Group and NPWS Regional and Research staff is a potential additional source of volunteers as well as staff from wildlife groups in Northern Ireland. To widen the scope and attract new volunteers one-evening training courses catering specifically for the Daubenton's Bat Waterway Survey could be undertaken on a regional basis and advertised through local wildlife organisations and groups.

### *2.3.3 Proposed Survey Methodology*

The current BCT UK Daubenton's Waterway Survey methodology was tested by six surveyors in the Republic of Ireland in 2005, the results of which will be discussed in Chapter 3.

The BCT has expressed an interest in liaising with BCIreland, NPWS, The Heritage Council and other appropriate bodies, in an advisory role, in relation to introducing a cost effective and statistically robust Daubenton's Bat Waterway Survey in Ireland (K. Parsons, *pers. comm.)*.

The BCT is currently investigating potential changes to the current methodology of the Daubenton's Bat Waterway Survey to increase its cost effectiveness and to expand the species range detected during surveying. With the onset of the widespread of use broadband technology, BCT is more favourable towards using such equipment to increase suite of bat species identified along the 1km waterway transect. While it is continuing to undertake the Daubenton's Bat Waterway Survey with heterodyne bat detectors, it undertook a pilot study in August 2002 with Bat Duet Frequency Division detectors (Catto *et al,* 2003).

In 2003, the feasibility of expanding the scope of this survey was tested by 25 experienced volunteers. This group tested the Bat Duet, a bat detector that combines both heterodyne and frequency division systems (See Glossary from description of systems). This detector was piloted because it uses both systems allowing a transition between the systems for volunteers using the new detector. Therefore, the volunteer continued to record 'bat passes; using the heterodyne function while recording the survey period (4 mins/spot) using the frequency division mode to minidisc recorder. Recorded minidisks were then sent to BCT for sonogram analysis. One-minute from each 4-minute recording (from each spot, 10 spots/transect, 25 transects in total repeated twice for pilot).

The range of species recorded during the pilot are: Daubenton's, common pipistrelle *Pipistrellus pipistrellus*, soprano pipistrelle *Pipistrellus pygmaeus*, Noctule *Nyctalus noctula*. Other *Myotis* species were recorded but not identified to species level.

It was concluded that the pilot demonstrated that the introduction of the Bat Duet bat detector effectively widened the scope of the survey without significantly increasing the amount of survey effort (Catto *et al,* 2003).

# Chapter 3: Pilot Daubenton's Bat Waterway Survey in Ireland, 2006

This chapter will report details of a mini-pilot of the Daubenton's Bat Waterway Survey undertaken in August 2005. Recommendations will then be presented in relation to a proposed national pilot of the survey for both the Republic of Ireland and Northern Ireland in 2006.

## 3.1 MINI-PILOT OF SURVEY METHOD 2005

Six volunteers tested the BCT UK Daubenton's Bat Waterway Survey methodology in the republic of Ireland in August 2005 (Field Manual/Methodology in Appendix I). Details of survey locations and results are given in Appendix II.

A total of five waterways were surveyed (3 rivers and 2 canals). One site was surveyed once by a team of two people using four different bat detector models to investigate the sensitivity of bat detector models to Daubenton's bats' echolocation calls. The remaining four sites were surveyed twice by four different teams of people. All surveys were undertaken in August 2005.

### *3.1.1 Results & Discussion of Heterodyne Bat Detector Survey*

Results are present in Appendix B. Confirmed Daubenton's bat passes are noted only when heard by bat detector and seen by torch light skimming the water surface. 'Unsure' bat passes, i.e. bats heard but not seen, are also noted on the Record Sheet but may be passes of another bat species. For each survey evening, surveyors calculate the total number of bat passes and recorded weather conditions. Results are presented in Table E, Appendix II.

#### *3.1.1.1 Number of 'bat passes'*

The mean number of Daubenton's bat 'bat passes'/spot from all survey evenings is 3.8, n=9). This value is lower when compared to the means reported from BCT UK results (5.3 in 2002, n=326; 5.8 in 2003, n=302). Identification of what a 'bat pass' involved needed some clarification in the 2005 mini-pilot. However, no training courses were provided for any of the volunteers in 2005, just a written description of what constitutes a 'bat pass' according to Fenton (1970).

Training courses would need to be a major component of any national survey to ensure that all volunteers are given a practical demonstration of 'bat passes' prior to undertaking a survey themselves. Therefore, it is predicted that with training, a greater number of 'Unsure' Daubenton's bat 'bat passes' will be positively identified as Daubenton's 'bat passes' in future monitoring schemes. With this in mind, combining Daubenton's 'bat passes' and 'Unsure' Daubenton's bat 'bat passes' for results from 2005 increases the mean of Daubenton's bat 'bat passes'/spot from all survey evenings to 4.5 (n=9). However, this is still lower than BCT UK results which may mean that activity levels of Daubenton's bats are lower in Ireland or the low number may simply be attributable to the low sample size involved.

#### *3.1.1.2 Survey duration and starting time*

Feedback from surveyors was positive in relation to the short duration of undertaking this survey and the ease of surveying due to the fact that it focused on one bat species. On average, sampling time was 71 minutes (n=9, range = 50-83mins).

One surveyor recorded no Daubenton's bat 'bat passes' within the duration of the two survey evenings but recorded *Myotis* bats travelling to the survey site after completing the surveys. BCT UK Daubenton's Bat Waterway Surveys are undertaken approximately 40 minutes after sunset. This protocol was also used during the mini-pilot programme here in Ireland. However, international research has demonstrated that Daubenton's bats may not appear at a site for up to two hours after sunset depending on various factors such as weather conditions, light levels and distance of foraging site from roost.

The BCT undertook an investigation in the influence of survey duration on the number of Daubenton's bat passes recorded (Anon, 2004). It was shown that the survey duration had a significant effect on encounter rate with encounter rate increasing as the survey duration increased. While the number of bat passes are recorded only for specified length of time (4 minutes/spot, a total of 40 minutes for ten spots over 1 km transect), factors, such as, difficulty of terrain and walking speed of the surveyor, could increase of length of time for the surveyor in the field. Therefore, it is possible that the longer it takes for the surveyor to complete the 1km transect, the greater the chance of encountering Daubenton's bats travelling to the waterway to forage.

The start time for surveys in the Car Based-Bat Monitoring Protocol was set originally for 30 minutes after sunset for the pilot study in 2003 (Catto *et al,* 2004). Analysis of encounter rate of bats against the time at which transects were monitored indicated that bat encounters were lowest during the early transects. Therefore, to increase overall bat encounter rate, it was recommended to delay the start time of the surveys till 45 minutes after sunset. Results from the 2004 indicate that the later start time encounter a greater number of bats compared to 2003 and recommended that the starting time for future years of monitoring under this protocol should be set at the 45 minutes after sunset (Roche *et al,* 2005).

To increase the encounter rate at waterways for the pilot of the Daubenton's bat Waterway Survey, it maybe necessary to delay the starting time. However, BCT were contacted in relation to this proposal and they responded that the start time was set to achieve a balance between emergence time of Daubenton's bats, insect availability and the possibility of the temperature dropping over the course survey period and at a time that was accessible for volunteers (a later start time may reduce volunteer participation). Their response also considered that to change to the protocol, in operation in the UK since 1997, would result in Irish data not being comparable to their data, an important point in relation to reporting responsibilities for Northern Ireland. It was also stressed that activity times of foraging bats will vary anyway over a wide geographical and at a site from night-to-night so a consistent approach is more important overall than ensuring that maximum abundance is recorded (pers comm. Karen Haysom, BCT).

*3.1.1.3 Bat detector models*

A wide range of heterodyne bat detectors is available to bat workers and this is reflected in the results of the mini-pilot. Although only six volunteers participated, five different detector models were used in heterodyne mode. In addition, two broadband detectors (Time Expansion – Transect Tranquility and Frequency Division – Bat Duet) were used to record bat activity to a minidisc recorder. Therefore, in total, seven different detector models were used in mini-pilot of the survey.

*3.1.2 Results and Discussion of Broadband Bat Detector Survey*

At one site surveyed during the mini-pilot in August 2005 (River Boyne), broadband technology was employed along with a heterodyne system. A Tranquility Transect Time Expansion bat detector and Bat Duet Frequency Division detector were each attached to a camera tripod with respective microphones directed across the river surface. Both detectors were connected to minidisc recorders for later sound analysis.

Recordings were analysed using Bat Sound ™ software. Species identified from time expansion recordings included Leisler's bat, soprano and common pipistrelle (unidentified pipistrelles labelled as PIP in Table 3.1.2), brown long-eared and Myotis species (tentatively identified as Daubenton's bat (8 spots) and Natterer's bat (2 spots)).

**Table 3.1.2:** Presence/absence for ten spots at River Boyne site (0= bats absent; 1= bats present)

| Spot | CP | SP | L | BLE | MY | PIP |
|---|---|---|---|---|---|---|
| ***1*** | 1 | 1 | 0 | 0 | 1 | 0 |
| ***2*** | 0 | 1 | 0 | 0 | 1 | 1 |
| ***3*** | 0 | 1 | 0 | 0 | 1 | 1 |
| ***4*** | 0 | 0 | 1 | 1 | 1 | 1 |
| ***5*** | 1 | 1 | 1 | 0 | 0 | 0 |
| ***6*** | 0 | 1 | 1 | 0 | 0 | 1 |
| ***7*** | 1 | 1 | 1 | 0 | 1 | 1 |
| ***8*** | 0 | 1 | 1 | 0 | 1 | 1 |
| ***9*** | 1 | 1 | 0 | 0 | 1 | 1 |
| ***10*** | 1 | 1 | 1 | 0 | 1 | 1 |
| ***Total*** | ***5*** | ***9*** | ***6*** | ***1*** | ***8*** | ***8*** |

*CP:common pipistrelle SP:soprano pipistrelle L:Leisler's bat BLE:brown long-eared MY:Myostis sp*

Due to the fact that recordings are of 4 minute intervals at a stationary position, it is difficult to measure bat passes when activity is constant. Time expansion recordings were sampled at 320ms. This recording period allows at least two echolocation calls to be recorded to aid identification (Catto *et al,* 2004). Sampling at 320ms also means that a more even picture of bat activity is recorded (*pers comm.* Jon Russ).

Sampling at 1.28s will provide a longer echolocation call sequence to aid the identification of 'bat passes'. However, it does mean a longer 'blind' period since 1.28s of recording will take 12.8 seconds for the recording to be processed and recorded to mini-disc.

An alternative method is to sample at 320ms and count the number of echolocation call pulses as a measure of abundance (*pers comm.* Jon Russ). Then the next step is to try and identify bat passes (quiet to loud to quiet) across adjacent 320ms sections.

Recordings from the Bat Duet detector were cruder and more difficult to analyse in comparison to the time expansion recordings.

Time spent on the time expansion recordings were as follows:

a. Downloading of recordings 1 hour

b. Sonogram analysis 2 hours

## 3.2 SAMPLING METHODOLOGY

The current structure of the BCT UK Daubenton's Bat Waterway Survey, in relation to distribution of sites and number of survey visits, is considered to be adequate (C. Catto, *pers comm.*). With this in mind, decisions in relation to the sampling methodology for an Irish Daubenton's Bat Waterway Survey will need to consider the following.

### *3.2.1 Representative sample*

Any monitoring programme must ensure that its results can be justifiably generalised to infer what the population as a whole is doing. To make inferences about Irish populations, surveying must encompass a representative sample of the island's landscape and habitat types along with climatic gradients. Applying stratified random-sampling with a large number of small sample units would be the most efficient method to achieve this.

Since different land classifications arise due to variation in the environment such as altitude, topography, geology, climate and habitat cover, a land classification system could be a suitable parameter with which to stratify the initial sampling sites. Land class was found by Walsh and Harris (1996) to be a significant factor influencing abundance in the National Bats and Habitats Survey in the UK. In Ireland waterways land classes should be sampled in proportion to their availability. Further information on available land classification systems in Ireland is required for this initial aspect of site sampling.

### *3.2.2 Power analysis*

Ecological research has demonstrated that bat populations naturally fluctuate as a result, for example, of the effect of weather changes on reproduction and survival (Walsh *et al.,* 2001). In addition direct or indirect man-made influences may result in bat population fluctuations. Any monitoring programme must be robust enough to allow extrapolation to overall population. To do this requires applying statistical tests to assess whether the population remains unchanged over time or not. The design of the monitoring programme must ensure that the probability of detecting a change (known statistically as the 'power' of the test) is high.

Power is influenced by many factors including sample size and population changes. Good monitoring design can help reduce these effects and maximise Power. Such design parameters include annual surveys undertaken at the same time of year and with the same equipment and methods. Power statistics can also help to identify optimum sample sizes (Catto *et al.,* 2004). Rigourous Power testing of results from the Pilot Daubenton's Waterway Survey should be undertaken to ensure a robust sampling protocol preferably using a statistician with expertise in bat monitoring.

### *3.2.3 Minimum sampling effort*

Advice was sought from Colin Catto (BCT) in relation to developing the waterway survey in the Republic of Ireland. At the time of discussion, sampling of the whole of the island was not considered. In discussion with Steave Langton, statistician, he considered that 50 sites (surveyed twice) is a reasonable goal. Mr. Langton assessed the width of confidence intervals in the regional data for the BCT Daubenton's Bat Waterways Survey. With data from 50 sites surveyed twice, the standard error is around 19%, suggesting that it would allow detection of a 40% change over 8 years. Sampling only 25 sites (Standard error of 28%, detection of 60% change over 8 years), twice would be too imprecise while 100 sites, sampled twice, does not improve things dramatically (Standard error of 14%, detection of 30% over 8 years).

Assuming similar levels of bat activity in Ireland and for power statistics to be effectively applied to results, he advised that a minimum of fifty randomly-selected waterway sites throughout the Republic of Ireland (surveyed twice annually in a one month period) is required to reach IUCN Red Alert Levels. Alternatively, one hundred randomly selected waterways sites could be surveyed once annually. However, repeated sampling within the same month is considered to have greater Power than single sampling (Walsh *et al.,* 2001).

If population trends are to be considered for the island as a single unit, it may be possible that the minimum of fifty randomly-selected waterway sites will be sufficient once the sites are randomly selected from throughout the island in proportion to land classes present. However, if Northern Ireland and the Republic of Ireland need to be considered separately in relation to population trends, then the sample size will need to be greater. The exact sample size may be determined based on UK Daubenton's results to date and this can be fine-tuned based on Irish results following the proposed pilot in 2006.

### *3.2.4 Possible changes to methodology*

As mentioned briefly in 2.3.3 BCT may be proposing changes to its current sampling methodology to extend the range of species detected during waterways to include common pipistrelles, soprano pipistrelles and Noctule bat. By using a broadband detector model (such as the type used by the Car-based Bat Monitoring Scheme) fewer people may be required for fewer field nights. More species could also be identified at a site using broad-band technology.

## 3.3 VOLUNTEER-BASED DAUBENTON'S BAT WATERWAYS SURVEY

### *3.3.1 Irish volunteer base and Bat Detector Models*

In preparation for this report, all BCIreland members were contacted by email in relation to their possible participation in a potential national pilot of the Daubenton's Waterway Survey in 2006. Those members interested in

participating also provided information about the heterodyne bat detector model they owned.
A total of 26 members put their names forward, 22 of whom have received training in the use of bat detectors. Twenty-one of these members own a heterodyne bat detector or have use of a bat detector. Seven models of bat detectors are included in the range of detectors owned and Stag Electronic Bat Box III proved to be the most popular model (52%).

#### *3.3.2 Recruitment of volunteers and Training*

To fulfil the minimum sampling effort recommended by BCT, recruitment of volunteers will be required. Recruitment efforts should be prioritised within BCIreland and the Northern Ireland Bat Group followed by recruitment from an audience already interested in wildlife or participating in other wildlife monitoring schemers e.g. Countryside Bird Scheme (CBS). Widespread advertisement in wildlife publications e.g. Wings; outdoor groups e.g. Hill Walking groups; ecological and scientific conferences and zoological departments within colleges and universities. Once a list is compiled of interested volunteers, evening workshops should be organised regionally during May/June. Workshops should be organised in association with local wildlife groups e.g. Galway Naturalist Field Club and facilities e.g. The Education Centre, Wicklow Mountains National Park.

In addition, volunteers can be sought from within the ranks of NPWS Regional Staff and equivalent wildlife body from Northern Ireland.

In preparation for the CBS, BirdWatch Ireland organised 24 workshops around the country before compiling a list of volunteers prepared to undertake long-term monitoring of CBS squares. While a core of volunteers is now well established for the scheme, follow-up sessions are organised each spring to recruit new volunteers. Regular feedback e.g. reports and newsletter, to make volunteers feel that their contribution is worthwhile is the key to holding onto volunteers (Dick Coombes, *pers com.*).

#### *3.3.3 Volunteer Information Pack*

In preparation for recruiting volunteers, it is recommended that an information pack is collated. The pack would provide potential volunteers with information on bats in Ireland, the waterways survey methodology with a specific information sheet detailing what is required from volunteers on the survey night, general surveying techniques, bat detector usage and model descriptions, importance of monitoring protocols and potential use of information collated from such monitoring protocols.

#### *3.3.4 Extension of protocol to include other species of bat*

Identifying bats on field surveys with heterodyne bat detectors requires training and practice. A skilled bat detector volunteer base does not currently exist in Ireland. Therefore, to limit the number of misidentified bat passes, any proposed surveying protocol for Ireland can only focus on bat species that can be identified with ease. A greater number of bat species to be identified increases the need for a large skilled volunteer network. Therefore, a large scale volunteer based survey for Ireland could only focus on a bat species like Daubenton's under present circumstances.

The use of broad-band detectors such as the Tranquility Transect used by the Car-based Bat Monitoring Scheme would somewhat negate the requirement for skilled bat workers. However, since both surveys (Daubentons Waterwater Survey and Car-based Bat Monitoring) take place in the month of August it would not be feasible to use the same equipment for the Daubenton's survey.

However, a trial-run in the month of August of a proportionately smaller number of sites (ten in total) could be undertaken alongside the heterodyne survey. Volunteers participating in the Daubenton's Waterway Survey and who own or have use of a Time Expansion could have the option to record bat activity to mini-disc recorder while spot sampling under the heterodyne method. The sampling protocol will require that transects will be undertaken by a pair of volunteers for safety reasons. While one trained volunteer (Volunteer A) will operate the heterodyne bat detector, the second volunteer (Volunteer B) can operate the Time Expansion detector. Volunteer (B) will not be required to have extensive knowledge of this type of detector as he/she will only be required to operate the minidisc recorder and record bat activity for same four minutes/spot surveyed by Volunteer A. The minidisc is then sent to BCIreland for analysis, thereby negating the need to provide additional training.

Information on bat activity collated in this trial could be used to determine overall species activity levels at the waterways and the potential for using this type of detector for long-term bat monitoring. This would also provide information on relative activity of the two pipistrelle species along waterways (soprano pipistrelle bats are generally less active than common pipistrelle bats along roads surveyed by the car monitoring programme (Roche *et al.,* 2005)).

## Chapter 4: Additional Monitoring Protocols for Irish Bat Species

BCIreland were also asked to provide information on potential monitoring protocols for monitoring all Irish bat species. The Car-based Bat Monitoring Scheme successfully monitors three bat species (Leisler's bat, common pipistrelle and soprano pipistrelle) at a level to provide information in relation to IUCN Amber and Red Alerts along roadways (Roche *et al,* 2005). The proposed Daubenton's Bat Waterways Protocol aims to provide information for this species in relation to Amber and Red Alerts. Additional monitoring of waterways using broadband technology has the potential to increase the suite of species monitored along this habitat type. Monitoring of a select number of lesser horseshoe winter and summer roosts are undertaken annually by the NPWS regional staff. The remaining five species of bats are not included in any monitoring programme. Potential monitoring protocols catering for the remaining species are proposed below.

This report primarily focuses on the Daubenton's bat species. Therefore, information provided below in relation to potential monitoring protocols for additional bat species is not comprehensive.

### *4.1 BCIreland Database and Bat Records*

BCIreland received funding from The Heritage Council in 2004 to employ an IT specialist to design a single depository web-based database. A proportion of historical bat records were entered on to the database during this funding period. In 2005, additional funding was received from the NPWS to continue work on the database and add remaining bat records on to the system. This project is currently in progress.

This database has the potential to be a valuable tool for selecting monitoring sites for all bat species. Potential monitoring sites can be identified from data in the form of roosts (both maternity and hibernation) or hot spots for bat activity or prime habitat sites suitable for certain species (e.g. woodland for whiskered bats).

Maternity Colony Counts and Hibernation Site Counts are frequently used to estimate bat population numbers. In relation to Maternity Colony Counts, external emergence counts offer the least disturbance method. Counts are undertaken annually pre-birth and post-birth to provide information in relation to the number of adults within the colony and the number of young born in a particular season. This method would be suitable for monitoring all bat species but it is dependent on the number of roosts known.

Hibernation Site Counts is reported by Walsh *et al* (2001) as the traditional assessment of bat populations most widely employed by bat researchers across Europe. The UK BCT methodology involves two counts (one in January and one in February). Again, this method is dependent on the number of roosts known.

Analysis of the information on the database (once completed) should be undertaken to identify potential Maternity and Hibernation sites, especially, for the remaining five species currently not involved in any monitoring or proposed monitoring schemes. Analysis of the database could also yield information or regions in the country that lack information on bats.

### *4.2 BTO Constant Effort Sites (CES) Scheme*

The Constant Effort Sites (CES) scheme is a standarised ringing programme within the British Trust for Ornithology (BTO) Ringing Scheme. This scheme has been in operation since 1983. The scheme involves bird ringers setting their nets in the same pattern, for the same period time period at regular intervals throughout the breeding season. Currently, 130 sites are monitored throughout Britain and Ireland. The scheme provides valuable information on changes in population size, changes in breeding success and adult survival rates for 28 species of common songbird.

The CES scheme uses comparisons of the numbers of birds (adults and juveniles) caught each year to provide indices of population change for 28 species and are added to the BTO Integrated Population Monitoring (IPM) programme. Information from this scheme is used to complement information gathered from other BTO schemes (e.g. Common Bird Census (CBC), Nest Record Scheme (NRS), Breeding Bird Survey (BBS) and BTO Ringing Scheme) all of which form part of the IPM programme.

The CES scheme involves erecting a standarised mist-net in the same position and for the same length of time during 12 visits between early May and late August each year. Changes in the total number of adult birds captured provide a measure of changing population size. The proportion of juveniles caught in mist-nets forms an index of breeding success while retraps of ringed birds is used to estimate annual survival rates.

This scheme requires highly skilled volunteers to participate. There is also a large degree of effort required to complete 12 sites visits over a 4 month period.

A search was undertaken to determine whether a similar scheme to the CES was currently being undertaken for bats in Europe. Apart from university research projects, no widespread scale studies are undertaken using mist-nets as a means of collating data on population changes in bats.

Also, in consideration of Ireland's skilled bat specialist bat population, it is felt that a CES scheme designed for bats could not be undertaken in Ireland under present circumstances.

### *4.3 BCT Woodland Transect Surveys*

Four species of bats in Ireland can be described as typical woodland species (Natterer's, Brandt's, whiskered and brown long-eared bats). The BCT are currently piloting a new survey methodology to monitor such woodland species. This methodology simply involves transects through selected woodland areas. The volunteer continuously records bat activity using broadband technology throughout the duration of walking the selected transect. Recordings are then returned to BCT for analysis.

This methodology could potentially be employed in Ireland and undertaken in prime habitat areas (e.g. cSACs) suitable for the four woodland bat species.

However, this method would still not allow distinction between the sibling species – whiskered and Brandt's bat - unless continued work on echolocation calls results in the discovery of identifying echolocation call features to achieve differentiation.

### *4.4 Nathusius' Pipistrelle Pipistrellus nathusii*

Records for this species in the Republic of Ireland are limited and are only in the form of single detector records. Maternity colonies are documented in Northern Ireland and have been correlated to areas containing large waterbodies (e.g. Lough Neagh). Potential monitoring methods for this species may encompass walking transects of lake areas using broadband technology similar to methodology employed for the BCT Woodland Transect Surveys.

## RECOMMENDATIONS

| | |
|---|---|
| **Recommendation 1** | Extend the pilot the Daubenton's Waterway Survey using BCT's current methodology to include all counties in the Republic of Ireland and Northern Ireland. |
| **Recommendation 2** | Sample sites should be randomly selected from a suitable dataset of sites currently sampled for both biological and chemical parameters by the EPA (Republic of Ireland) and EHS (Northern Ireland). Sites included in dataset should have additional information collated in relation to land use, geology etc. |
| **Recommendation 3** | A minimum of 500 sites should be prepared prior to the scheme commencing. Volunteers should be allocated three potential ten-figure 'Grid Referenced Water Quality Sampling Sites' within a 10 km radius of their address, where possible. Volunteers should choose one suitable site to survey. If volunteers are favourable to survey additional sites, further prepared sites will be available to them. |
| **Recommendation 4** | All volunteers should be provided with maps, recording sheets etc. of their chosen site. 1km route selection should end or start with 'Grid Reference' allocated to volunteers. Maps marked with 1km route should be submitted with results. Master copies should be deposited with BCIreland and stored for future reference. |
| **Recommendation 5** | The Daubenton's Bat Waterway Survey should take place in the month August 2006. |
| **Recommendation 6** | A minimum of 50 sites are required to be surveyed twice in the month of August 2006. |
| **Recommendation 7** | The start time should be 40 minutes after sunset, as stated in the BCT's current methodology. |
| **Recommendation 8** | Participating surveyors can be volunteers or professionals and training should be provided prior to surveying. Plan a standarised training resource pack with training CD and make available to local bat groups to assist with recruitment. |
| **Recommendation 9** | Recruitment should begin early in 2006. All wildlife organisations and potential sources for volunteers should be contacted to advertise the monitoring programme. Training programmes should be organised throughout the 32 counties to provide access to potential volunteers. |
| **Recommendation 10** | Invest in a pool of heterodyne bat detectors (purchase one model type) for use by volunteers who do not own one. |

**Recommendation 11** A professional statistician should carryout analysis and should have experience in relation to interpretation of bat data. Power analysis should be carried out on 2006 results to determine the robustness of survey methodology.

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

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

**Recommendation 14** The use of Global Positioning Systems would provide accurate grid references for transects and their use should be considered.

**Recommendation 15** Record other wildlife encountered during survey.

**Recommendation 16** Provide participants with copies of annual reports and invite them to an annual workshop to discuss survey progress.

**Recommendation 17** Provide annual training courses as a means to recruit new volunteers.

**Recommendation 18** Collation of information of all different heterodyne bat detectors being used should be carried out and review whether weighting factors should be incorporated into trend estimation models to account for sensitivity differences.

## GLOSSARY

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

**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.

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

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## VOLUNTEERS

Annette Lynch, Paul Scott, Mairead Farrell, Áine Lynch, Enda Mullen, Noel Clancy and Ailbhe Kavanagh.

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## APPENDIX A
## FIELD INSTRUCTIONS MANUAL/METHODOLOGY TESTED IN AUGUST 2005

Welcome Note
Thank you for volunteering to take part in the mini-pilot ROI Bat Monitoring Programme for Daubenton's bats. This project funded by the Heritage Council and the NPWS, Department of the Environment and Local Government and is managed by Bat Conservation Ireland. The survey methodology to be piloted by this programme is currently in use in the UK as part of the UK's National Bat Monitoring Programme for Daubenton's bats.

Introduction
Monitoring trends of bat populations is an essential component of bat conservation and addresses obligations under the EUROBATS Agreement and the Habitat Directive. At present in Ireland, there is little available bat population trend data.

In Spring 2003, the Heritage Council asked the Bat Conservation Trust UK to develop and evaluate a novel bat detector-based monitoring project for the ROI. In 2004, Bat Conservation Ireland, in partnership with The Bat Conservation Trust UK, administered the second year of the pilot study under the direction of The Heritage Council and National Parks and Wildlife Service.

Targets for monitoring sensitivity were based on IUCN-developed criteria for measured population declines

- 'Amber' Alert – 25-49% decline after 25 years
- 'Red' Alert – 50% (or greater) decline after 25 years

This monitoring programme involved a car transect method whereby roads are driven by car and bat activity is recorded through a time expansion detector. Sonogram analysis is then undertaken to identify species recorded during driven transects. In 2005 twenty randomly generated 30km$^3$ blocks will be surveyed throughout the ROI. Seventeen of these blocks were surveyed in 2004 and eight in 2003.

Power analysis of results from 2004 demonstrated that Red Alert and Amber Alert targets for common pipistrelles, soprano pipistrelles and Leisler's bats could be met after a definite number of years of monitoring. Encounter rate of *Myotis* bats by this method was too low to be statistically analysed. Therefore, additional surveying methods are required to monitor population trends of other bat species in the ROI.

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

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

   b. Equipment and Materials
   - tuneable bat detector
   - stopwatch
   - recording sheets
   - pencil/clip board
   - maps (3 copies)
   - torch
   - health and safety guidelines
   - landowner form
   - spot descriptions form
   - landowner letter
   - sunset timetables
   - thermometer (outdoor)

   c. Selecting a route
   Twenty randomly selected 30km$^2$ survey blocks are currently being sampled by the Car-based Monitoring Protocol. If you are located within or near to one of these squares,

please select a survey route within your nearest block (information given in appendices, Figure 1). Otherwise, please select a survey route at your convenience.

- Select a stretch of river or canal on an OS map. Identify a potential route of over 1km in length with a 6-digit reference point for the mid-point of your route.

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

- Select a start point that is convenient for both reaching the bank and standing to record bats. Clearly mark this as your first spot on the map.

- From this starting point walk along the river/canal, pacing out rough 100m intervals as you go. After each 100m, select the nearest point at which you can see the water-surface. Make a descriptive note of the survey spots for future reference on the Spot Description Form. Repeat this until you have a total of ten points or survey spots.

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

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

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

d. Landowner permission

It is important that you gain permission in advance for any landowners or custodians if you are entering private property or sites with restricted access.

If you are surveying such sites, please record landowner details and which section of your route that they apply to on the form provided.

e. Field methodology

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

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

- At each survey spot, tune your detector to 35 kHz and simultaneously use a torch to scan the water to check whether Daubenton’s bats can be seen skimming the water-surface.

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

- Stand still and count the number of Daubenton's bat passes for a total of 4 minutes. Record the number of passes on the recording sheet.

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

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

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

3. Safety At Night

Please read the Health and Safety note enclosed.

4. What to Return
   - Recording Sheet
   - Spot Description Form
   - Map with 1km route and 10 survey spots marked on
   - Landowner information (if applicable)

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

Many thanks for helping with this important pilot study. We would also like to thank the following for their valuable contribution to the ROI Bat Monitoring Programme. Survey methodology is based on that devised by The Bat Conservation Trust.

An Roinn Comhshaoil, Oidhreachta agus Rialtais Áitiúil
Department of the Environment, Heritage and Local Government

An Chomhairle Oidhreachta
The Heritage Council

The Bat Conservation Trust

# ROI Bat Monitoring Programme: Daubenton's

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

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

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

Waterway Characteristics

What % of waterway is sheltered by trees or overhanging vegetation?

None ☐ up to 50% ☐ greater than 50% ☐

How much of the waterway surface that is calm/smooth?

None ☐ up to 50% ☐ greater than 50% ☐

Approximate width of majority of waterway ________m

Number of spots with a clear view of the water ________

Additional notes:

**Thank You for your valuable contribution**

**APPENDIX B**
**DETAILS OF MINI-PILOT, AUGUST 2005**

**Table A:** Details of Volunteers' experience and bat detector models used

| Volunteer | Bat experience | Identification skills | Bat detector model |
|---|---|---|---|
| Volunteer A | > 3 yrs | Very good | Pettersson D100 |
| Volunteer B | > 3 yrs | Very good | Pettersson D200<br>Bat Duet *<br>Transect Tranquillity * |
| Volunteer C | < 1 yr | Okay | Bat Box III |
| Volunteer D | 2-3 yrs | Good | Pettersson D300 |
| Volunteer E | Occasional | Okay | Bat Box III |
| Volunteer F | 2-3 yrs | Good | Petterson D240x |

** Bat detector models connected to minidisc recorder*

**Table B:** Details of Survey Locations

| Volunteer | Waterway name | Site name | Survey date(s) Survey 1 | Survey date(s) Survey 2 |
|---|---|---|---|---|
| Volunteer A | Derry River | Tomnafinoge Wood | 5/8/05 | 16/8/05 |
| Volunteer B | River Boyne | Ramparts | 11/8/05 | |
| Volunteer C | Tolka River | Dunboyne | 16/8/06 | 30/8/05 |
| Volunteer D | Royal Canal | Castleknock | 15/8/05 | 21/8/05 |
| Volunteer E | River Boyne | Ramparts | 11/8/05 | |
| Volunteer F | Grand Canal | Tullamore | 15/8/05 | 29/8/05 |

**Table C:** Details of Waterway Characteristics of Survey Locations

| Waterway name | % shelter by riparian veg. | % calm/smooth waterway surface | Approx. width of waterway | No. of spots with clear view |
|---|---|---|---|---|
| Derry River | None | > 50% | 10m | 10 |
| River Boyne | Up to 50% | > 50% | 30m | 10 |
| Tolka River | Up to 50% | > 50% | 3m | 10 |
| Royal Canal | Up to 50% | > 50% | 8-10m | 10 |
| Grand Canal | > 50% | > 50% | 5m | 10 |

**Table D:** Weather conditions and Start/Finish times on survey dates

| Waterway name | Survey date(s) Survey 1 | | Survey date(s) Survey 2 | |
|---|---|---|---|---|
| **Derry River** | **5/8/05** | | **16/8/05** | |
| | ***Temp (°C)*** | 14.4 °C | ***Temp (°C)*** | 14 °C |
| | ***Wind*** | Calm | ***Wind*** | Calm |
| | ***Cloud*** | Patchy (⅓-⅔) | ***Cloud*** | Clear (0-⅓) |
| | ***Rain*** | Dry | ***Rain*** | Dry |
| | ***Start time*** | 22.01 hrs | ***Start time*** | 21.32 hrs |
| | ***Finish time*** | 23.30 hrs | ***Finish time*** | 22.55 hrs |
| **River Boyne** | **11/8/05** | | | |
| | ***Temp (°C)*** | 14.5 °C | ***Temp (°C)*** | |
| | ***Wind*** | Calm | ***Wind*** | |
| | ***Cloud*** | Patchy (⅓-⅔) | ***Cloud*** | |
| | ***Rain*** | Dry | ***Rain*** | |
| | ***Start time*** | 21.54 hrs | ***Start time*** | |
| | ***Finish time*** | 23.16 hrs | ***Finish time*** | |
| **Tolka River** | **16/8/06** | | **30/8/05** | |
| | ***Temp (°C)*** | 15 °C | ***Temp (°C)*** | 15 °C |
| | ***Wind*** | Calm | ***Wind*** | Calm |
| | ***Cloud*** | Clear (0-⅓) | ***Cloud*** | Clear (0-⅓) |
| | ***Rain*** | Dry | ***Rain*** | Dry |
| | ***Start time*** | 21.50 hrs | ***Start time*** | 21.00 hrs |
| | ***Finish time*** | 23.00 hrs | ***Finish time*** | 22.10 hrs |
| **Royal Canal** | **15/8/05** | | **21/8/05** | |
| | ***Temp (°C)*** | 19 °C | ***Temp (°C)*** | 16 °C |
| | ***Wind*** | Calm | ***Wind*** | Calm |
| | ***Cloud*** | Patchy (⅓-⅔) | ***Cloud*** | Patchy (⅓-⅔) |
| | ***Rain*** | Dry | ***Rain*** | Dry |
| | ***Start time*** | 21.35 hrs | ***Start time*** | 20.41 hrs |
| | ***Finish time*** | 22.45 hrs | ***Finish time*** | 21.51 hrs |
| **Grand Canal** | **15/8/05** | | **29/8/05** | |
| | ***Temp (°C)*** | 18 °C | ***Temp (°C)*** | 16 °C |
| | ***Wind*** | Calm | ***Wind*** | Calm |
| | ***Cloud*** | Patchy (⅓-⅔) | ***Cloud*** | Full (⅔-1) |
| | ***Rain*** | Dry | ***Rain*** | Dry |
| | ***Start time*** | 21.40 hrs | ***Start time*** | 21.15 hrs |
| | ***Finish time*** | 22.30 hrs | ***Finish time*** | 22.15 hrs |

**Table F:** Number of bat passes recorded at individual sites on survey dates

| Waterway name | Survey date(s) Survey 1 | | Survey date(s) Survey 2 | |
|---|---|---|---|---|
| **Derry River** | **5/8/05** | | **16/8/05** | |
| | *Daub bat passes/40mins* | 17 | *Daub bat passes/40mins* | 25 |
| | *Unsure bat passes/40 mins* | 48 | *Unsure bat passes/40 mins* | 19 |
| **River Boyne** | **11/8/05 Pettersson D200** | | **11/8/05 Bat Box III** | |
| | *Daub bat passes/40mins* | *26* | *Daub bat passes/40mins* | 18 |
| | *Unsure bat passes/40 mins* | *22* | *Unsure bat passes/40 mins* | 27 |
| **Tolka River** | **16/8/06** | | **30/8/05** | |
| | *Daub bat passes/40mins* | 0 | *Daub bat passes/40mins* | 0 |
| | *Unsure bat passes/40 mins* | 1 | *Unsure bat passes/40 mins* | 0 |
| **Royal Canal** | **15/8/05** | | **21/8/05** | |
| | *Daub bat passes/40mins* | 0 | *Daub bat passes/40mins* | 0 |
| | *Unsure bat passes/40 mins* | 1 | *Unsure bat passes/40 mins* | 0 |
| **Grand Canal** | **15/8/05** | | **29/8/05** | |
| | *Daub bat passes/40mins* | 107 | *Daub bat passes/40mins* | 99 |
| | *Unsure bat passes/40 mins* | 0 | *Unsure bat passes/40 mins* | 0 |

*Daub bat passes = Daunbenton's bat 'bat passes'*
*Unsure bat passes = Unsure Daubenton's bat 'bat passes'*

**Mean no. of Daubenton's bat 'bat passes'/total number of survey evenings = 3.8**
**Mean no. of both types of 'bat passes'/total number of survey evenings = 4.5**

***N=9 survey evenings***

***Note: Survey results from River Boyne 11/8/05 Pettersson D200 results only included in calculation, Bat Box III results excluded.***