ENGLISH NATURE

Report Number
576

An assessment of the efficiency of capture techniques and the value of different habitats for the great crested newt *Triturus cristatus*

English Nature Research Reports

working today
for nature tomorrow

English Nature Research Reports

Number 576

An assessment of the efficiency of capture techniques and the value of different habitats for the great crested newt *Triturus cristatus*

Warren Cresswell and Rhiannon Whitworth

ISSN 0967-876X

English Nature cover note

This report is the result of a project conducted by Cresswell Associates under contract to English Nature. The project examined a large amount of data collected mainly under Defra licences for great crested newt mitigation projects. The overall aims were to use this data to review existing mitigation practice, and to provide recommendations for future advice. The lead researchers were Warren Cresswell and Rhiannon Whitworth at Cresswell Associates, and the English Nature project officer was Jim Foster. The views in this report are the authors' own and do not necessarily represent those of English Nature.

The authors can be contacted at:

Cresswell Associates
Willow House
Slad Road
Stroud
Gloucestershire GL5 1QJ.
Tel: 01453 764450.

The project officer can be contacted at:

English Nature
Northminster House
Peterborough PE1 1UA.
Tel: 01733 455000.

Non-technical summary

This report presents the results of a study undertaken on behalf of English Nature to evaluate the efficiency of capture techniques and the value of different habitats for great crested newts. Licence return data were analysed in an attempt to assess the effectiveness of various different elements of the measures used to mitigate the effects of developments on newts. A further aim of the project was to assess the value of different habitats for newts by investigating the numbers captured in a variety of types of land across England. It was intended that the results of these analyses would help to predict development-related impacts and inform trapping, and other mitigation requirements, and thus help inform the development of best practice in mitigation projects involving this species.

The capture data revealed relatively clear associations between the numbers of newts caught and certain habitats. Four habitats were found regularly to predict the number of newts captured: woodland, arable land, post-industrial habitats and hedgerows. There was also a significant correlation between captures and proximity to breeding ponds, and the combination of habitats and proximity to ponds showed an even stronger relationship with numbers of newts captured. Whilst it is likely that newts were actively selecting the more suitable habitat types such as woodland and hedgerows, the role of arable land as a predictor of newt density and occurrence was more likely to be an artefact of the sampling. However, the results did show that arable farmland with a high density of ponds can support large newt populations. More research on newt habitat associations is required in order to investigate a more useful means of predicting newt density and distribution on the basis of habitat or land-use.

The information provided in the licence records was insufficient to provide clear-cut recommendations as to the type of capture method to use in all cases, because season, habitat, distance from a breeding pond, and life stage of the newts were all complicating factors within the analyses. There was, however, a significant positive correlation between the total number of newts captured and both the number of capture methods used and the overall project scores for capture effort.

Pitfall trapping was the most widely employed technique and generated the largest capture totals (excluding captures of larvae). The effectiveness of pitfall trapping varied considerably depending upon whether or not the trapping operation involved the use of a fence around a breeding pond. Only bottle trapping showed a positive correlation between effort and numbers caught for both adults and larvae.

Far more adults were captured than any other life stage. Netting appeared to be the most effective technique for capturing larvae, and can be useful in capturing adult newts also, but is far more efficient when combined with some form of ‘draining-down’ operation. Although slightly more effective at capturing sub-adults, refuges appeared to be generally ineffective at capturing newts in substantial numbers. By contrast, pitfall trapping was more efficient, particularly in capturing adult newts. As with the use of fences and traps in other situations, the over-riding influence appeared to be the proximity to breeding ponds. By far the most captures were recorded within 50m of ponds and few animals were captured at distances greater than 100m.

Generally the results of the various investigations supported the details and advice presented in English Nature's *Great Crested Newt Mitigation Guidelines.* However, it was also possible to make the following further recommendations:

- Where the more suitable habitats occur in conjunction with breeding ponds, it is necessary to consider a comprehensive mitigation programme. However, it would be misleading to discount any habitats if closely associated with breeding ponds.

- The most comprehensive mitigation, in relation to avoiding disturbance, killing or injury is appropriate within 50m of a breeding pond. It will also almost always be necessary to actively capture newts 50-100m away. However, at distances greater than 100m, there should be careful consideration as to whether attempts to capture newts are necessary or the most effective option to avoid incidental mortality. At distances greater than 200-250m, capture operations will hardly ever be appropriate.

- The use of multiple capture methods has also been shown to be important, particularly (i) if attempting to catch newts away from breeding ponds, and (ii) where, for whatever reason, the early-season elements of an operation to exclude and relocate newts from a breeding pond have been less effective at keeping adult newts out of the pond, and hence some could go on to breed.

- The significantly better performance of netting as a technique when associated with draining-down operations should be considered when this approach is being proposed. In addition, the increased effectiveness and usefulness of nocturnal searching of terrestrial habitat in the zone beside drift fences, both during the first warmer, wet nights of the early season, for adults; and during similar climatic conditions from mid-August to the end of September for juveniles should also be recognised.

- It was clear from the data that consistently, sub-adult life stages were captured less effectively than the others. Unless captures over successive seasons are possible, it is necessary to attempt to capture sub-adults in terrestrial habitats away from ponds. However, the analysis of capture results shows clearly that in almost all cases catching newts at a distance from breeding ponds is labour-intensive and inefficient.

- It has also been possible to identify a clear relationship between 'effort' and capture success for bottle traps, meaning that the more traps employed the more newts will be caught. Thus, recommended trap densities could be increased to accelerate captures in key periods (for example, early in the season, to minimise successful breeding in ponds to be cleared).

- It has also been possible to identify that the efficient capture of juvenile newts relies on rather 'narrow' and potentially very important 'windows' in late summer/early autumn. In addition, because of the size and behaviour of juveniles, the details of some mitigation techniques (particularly the quality of installation of drift fences and pitfall traps) are more critical and these methods can be much less successful than for adult newts.

- The results supported the idea of not attempting to capture newts in terrestrial habitats at temperatures below 5-6^{o}C. The key finding with regard to the influence of weather patterns was that it is seldom worth attempting to capture newts away from ponds during spells of dry weather between June and mid-August inclusive.

- Very few of the projects provided a clear test of the comprehensive ‘compartmentalisation’ recommended in English Nature’s *Guidelines*. Whilst newts were caught in these circumstances, in most cases only small numbers were caught compared to the lengths of fencing and numbers of traps employed. In addition, assessing the amount of excavation etc., necessary to install large amounts of fencing in areas known to contain newts, raised some concerns about the possibilities of incidental mortality when mechanically installing ‘compartmentalising’ fencing.

- Where there were no obvious features to ‘target’ with fencing, capture success along fences declined sharply with distance from ponds, and captures within the 50-100m zone were generally inefficient. Captures on fences (and by other methods) at distances between 100m and 200-250m from breeding ponds tended to be so low as to raise serious doubts about the efficacy of this as an approach, although a small number of projects did report captures on significant linear features at distances of approximately 150-200m from ponds.

- It is important that mitigation design is based upon a carefully considered risk assessment, with regard to the likelihood of the development-related activities resulting in disturbance, killing or injury of newts and interference with population processes. The scale of the mitigation and the resources allocated to it also needs to take account of the likely outcomes of different mitigation options in relation to these potential impacts, the numbers of newts involved and the likelihood of success of the various mitigation options.

Contents

1. Introduction

In November 2002 Cresswell Associates were asked to undertake a study on behalf of English Nature to evaluate the efficiency of capture techniques and the value of different habitats for the great crested newt (*Triturus cristatus*). The intention was for the results to help inform the development of best practice in mitigation projects involving this species.

1.1 Background to the project

Great crested newts receive both national- and European-level protection in the UK, under the Wildlife and Countryside Act 1981 and the Conservation (Natural Habitats &c.) Regulations 1994. They require a range of habitat types throughout their life cycle, and at different times of year, for breeding, foraging and hibernating, and can use terrestrial habitats some distance from their breeding ponds. Developments can therefore have both direct and indirect impacts upon great crested newt populations, by the loss or fragmentation of any of the individual habitats on which the population, or meta-population depends, and potentially through incidental mortality.

Mitigation for developments affecting newts currently takes place under licences issued by Defra (previously, until March 2000, these licences were issued by English Nature). Guidance on the principles and methods of mitigation is given in English Nature's *Great Crested Newt Mitigation Guidelines* (hereafter referred to as (*the Guidelines).* Such mitigation can typically involve the capture and exclusion of newts and their removal to areas of restored, enhanced or created habitat. In recent years there has been a substantial increase in the numbers of such projects. Consequently, through the licence return process, a substantial amount of capture data for newts now exist.

When planning mitigation works, it is important to be able to predict what combination of methods, effort and timing will be most effective. Therefore the aims of this project were, through analysis of licence return data, to attempt to assess the effectiveness of the various mitigation measures and thus to help inform best practice in the future. In addition, given that the various projects have involved capturing newts from a variety of habitats across England, a further aim of the project was to investigate the capture results from different habitat types. It was intended that the results of these analyses would help to predict development impacts and inform trapping, and other mitigation requirements.

2. Specific objectives

The specific objectives of the study were as follows:

(a) To evaluate the efficiency of capture methods for the great crested newt, using existing data from licence returns.

(b) To use these capture data to assess the value of different habitats for the great crested newt.

(c) To make recommendations for additions and/or amendments to good practice in mitigation.

3. Literature review

3.1 Value of habitats

Predicting the value of various habitat types for great crested newts can help inform the methods, effort and timing required for specific mitigation projects. Previous studies have attempted to determine the suitability of different habitats for this species (e.g. Oldham *et al*, 2000, Franklin, 1993). However, there is a lack of information concerning the terrestrial habitat preferences of great crested newts (Oldham *et al*, 2000).

Among the habitat types thought to be preferred by great crested newts are: deciduous woodland (Latham *et al* 1996; Malmgren, 2002), particularly in the vicinity of ponds (Beebee, 1977; Beebee, 1981); shrubs, hedgerows and trees (Jehle and Arntzen, 2000); and scrub and mixed garden habitat (Oldham and Nicholson, 1986). Deciduous woodland is thought to be particularly valuable as habitat for over-wintering newts (Duff, 1989; Franklin, 1993). Dense ground vegetation cover has also been found to indicate the presence of great crested newt populations (Oldham and Nicholson, 1986).

Pasture has also been suggested as indicating the likely presence of great crested newt populations (Oldham and Nicholson, 1986). However, Oldham and Nicholson surmised that this was likely to be an artefact of pond distribution, since they found that great crested newts were not utilising the pasture land. Newts have been found to occur more frequently on land with a low intensity of agricultural use rather than on pasture and arable land (Laan and Verboom,1990; Swan and Oldham 1993, 1994). Beebee, 1980 suggests that pasture may not constitute good amphibian habitat in the absence of some secondary vegetation such as scrub or hedgerows. This is supported by the finding that the occurrence and abundance of newts within pasture is related to the presence and width of uncultivated habitat features (Oldham *et al*, 2000).

In order to inform best practice mitigation procedures, it is important to determine zones around breeding ponds where capture efforts would be best concentrated. Great crested newts display a directional bias towards the preferred habitat during migration between the breeding pond and surrounding terrestrial habitat (Franklin, 1993; Jehle and Arntzen, 2000; Malmgren, 2002). The directional preferences of adult great crested newts tend to be reliable indicators of the location of suitable terrestrial habitats (Malmgren, 2002). The least favoured direction of terrestrial dispersal has been found to be towards the habitat least likely to provide a favourable conditions: arable land (Franklin, 1993) and open areas (Jehle and Arntzen, 2000). Jehle and Arntzen (2000) found that migration in the direction of a suitable habitat type, characterized by trees and underground shelters, was favoured over migrations toward other areas. Malmgren's (2002) research revealed a preference to leave a pond where forest, as opposed to open fields, adjoin it. The data suggested that dispersal directions approach uniformity when a pond is surrounded by equally favourable forest habitat (Malmgren, 2002).

In terms of distances travelled from the breeding ponds, newts have been found at high densities in the terrestrial habitats up to 200m away from a breeding pond (Franklin, 1993). Although great crested newts have been found to move up to 1.3km between breeding ponds, a maximum migratory range has been estimated as 250m from a pond (Franklin, 1993; Oldham and Nicholson, 1986; Jehle, 2000), although one study has estimated this range to be only approximately 150m (Jehle and Arntzen, 2000).

3.2 Capture methodologies

3.2.1 Different capture techniques

Amphibian survey methodology in the U.K. is well established (e.g. Griffiths, 1985, Swan and Oldham, 1993), and various attempts have been made to produce and improve upon standardised methodologies (Griffiths *et al.* 1996). However, there is little information regarding the efficiency of these methodologies as tools for mitigation.

Bottle-trapping is generally favoured as a survey technique. In terms of the numbers captured, it has been found to be the best survey method (Griffiths *et al,*1996). It has also been suggested that it is the most efficient technique when there are few newts in a pond (Cooke 1995).

Netting has been found to be generally inefficient as a survey technique when compared to torch counts or bottle trapping (Cooke, 1995; Griffiths *et al*, 1996). However, as a mitigation tool, netting is often used in conjunction with a destructive search or a draining-down procedure, which may substantially increase its efficiency, particularly for larvae.

Several studies have included information on fencing in combination with pitfall trapping, as a method for capturing newts. Two studies in particular focussed on the perceived efficiency of capturing newts during their seasonal immigrations and emigrations from breeding ponds. During the immigration period (i.e., moving from hibernation sites to breeding ponds), the percentages of the breeding population captured were estimated as 67-100% (Kupfer and Kneitz, 2000) and 45-61% (Arntzen *et al,* 1995). Lower percentage captures were observed during emigration: 32-83% (Kupfer and Kneitz, 2000) and 34-40% (Arntzen *et al,* 1995). This lower efficiency was perhaps due to newts having circumvented the fences or hibernated within the fenced area (Kupfer and Kneitz, 2000). A suggested improvement upon the effectiveness of this technique is to place an additional line of drift fence at 90 degrees to existing drift fences (Kemp, 2001).

3.2.2 Capturing different life stages

The limited data on newt life tables suggest that in a productive population, approximately 70% of the population is comprised of non-breeding animals (Arntzen and Teunis, 1993; Halley *et al*, 1996). There are few reliable data on the efficacy with which different capture techniques and methodologies sample breeding and non-breeding animals, but the general trend is that these methodologies are either biased toward captures of breeding adults or larvae.

4. Methodology

4.1 Selection of licensing files

Following a brief initial review of the documentation, a ‘two-step’ approach to data analysis was adopted:

Out of the approximately 100 licensing files collated for the purpose of this project, 81 were suitable for inclusion within the first level of analysis. The remainder were deficient in one or more key items of information. In addition, a further six ‘in-house’ projects were included, for which relatively comprehensive capture data could be extracted from the project files. The results from one of these, a particularly large pipeline project in Kent, were subdivided into 12 separate ‘cases’, giving a total sample of 98 ‘cases’ for this first level of analysis. Whilst it is acknowledged that this approach could potentially introduce an element of pseudo-replication, the mitigation works and the characteristics of the various pipeline sections (which formed the 12 ‘cases’) were substantially different; calculating meaningful summary variables for this project was impossible without some level of sub-division; and it was important that the cases/projects were all approximately the same scale.

Together these projects provided data for a general analysis of the following variables:

- the type of capture method(s) employed;
- the habitat type(s) involved;
- the relationship between the initial survey data (if provided) and the final numbers of captured newts;
- the time of year during which the mitigation took place;
- the degree of effort employed throughout the mitigation;
- the magnitude of the impacts associated with the proposed development.

The intention of this first level of analysis was to help investigate, in particular, broad trends in the associations between great crested newts and different habitat types, and to undertake a very general assessment of the effectiveness and frequency of use of different capture methods.

A sub-set of 44 projects (55 cases) were selected for more in-depth review and analysis on the basis that they included representative samples of the variables given above, as well as providing at least some information on the following:

- the ‘effort’ applied for each capture method;
- the use of capture methods in different habitat types;
- the numbers of different life stages captured;
- the numbers captured using each method;
- the distance from the breeding pond at which newt mitigation occurred;
- whether information on the spatial configuration of the trapping apparatus was provided;
- whether monitoring was carried out.

In addition, a small proportion of the projects supplied details of weather conditions and ambient temperature. A large proportion of the 81 projects involved no total captures of newts. Since no newt captures would restrict opportunities for analysis, the number of files with no captures to be selected for detailed analysis was restricted to 5.

4.2 Transforming and scaling selected variables

For some of the variables it was appropriate to use raw data: for example, the areas (in m^2) of different habitat types within which mitigation works were undertaken; or the total numbers of each life stage of newts that were captured. However, for many of the variables it was necessary to devise suitable scales, and combinations of scales, by which they could be classified. For several variables it was also necessary to derive scales and categories that were based, at least to some extent, on subjective criteria. Each variable for each database is listed in Appendix I and, where appropriate, an explanation of the devised scale is provided. Similarly an explanation of the variable names is also given in Appendix I, as part of a more general Glossary of technical terms.

4.3 Data collation

Data were collated, organised and stored in a series of four databases. One contained summary data collated from the first level of analysis, with one set of data for each ‘case’. Another contained summary data collated for the second level of analysis, again with one set of data for each ‘case’. A third database contained capture details for each capture method used. The final database contained these capture details for each season.

4.4 Analytical techniques

4.4.1 Statistical analysis

A range of analytical techniques were used to investigate trends, patterns and relationships within the capture data, focussing on the specific objectives of the project. Details of the specific investigations, and of the various statistical tests employed are presented in Section 5.

4.4.2 Qualitative analyses

For several of the potential relationships, the sub-divided sample sizes were simply too small and the data too fragmented and variable to permit statistically robust analysis. Nevertheless, the information presented in the licence returns was potentially valuable. In these circumstances a more descriptive, qualitative approach was adopted, and particularly cogent examples are included as appropriate in Section 5.

5. Results

5.1 Key variables

A breakdown of the variables and the layout of each of the databases are presented in Appendix I. Where appropriate, the scales or categories derived for each variable are also set out.

5.2 Locations of mitigation projects

Figure 5.2.1 indicates those counties within which the 87 projects which were used in the first level of analysis were undertaken. Although this sample included a relatively large number of projects from the north-west, it also incorporated one or more representative examples from most regions.

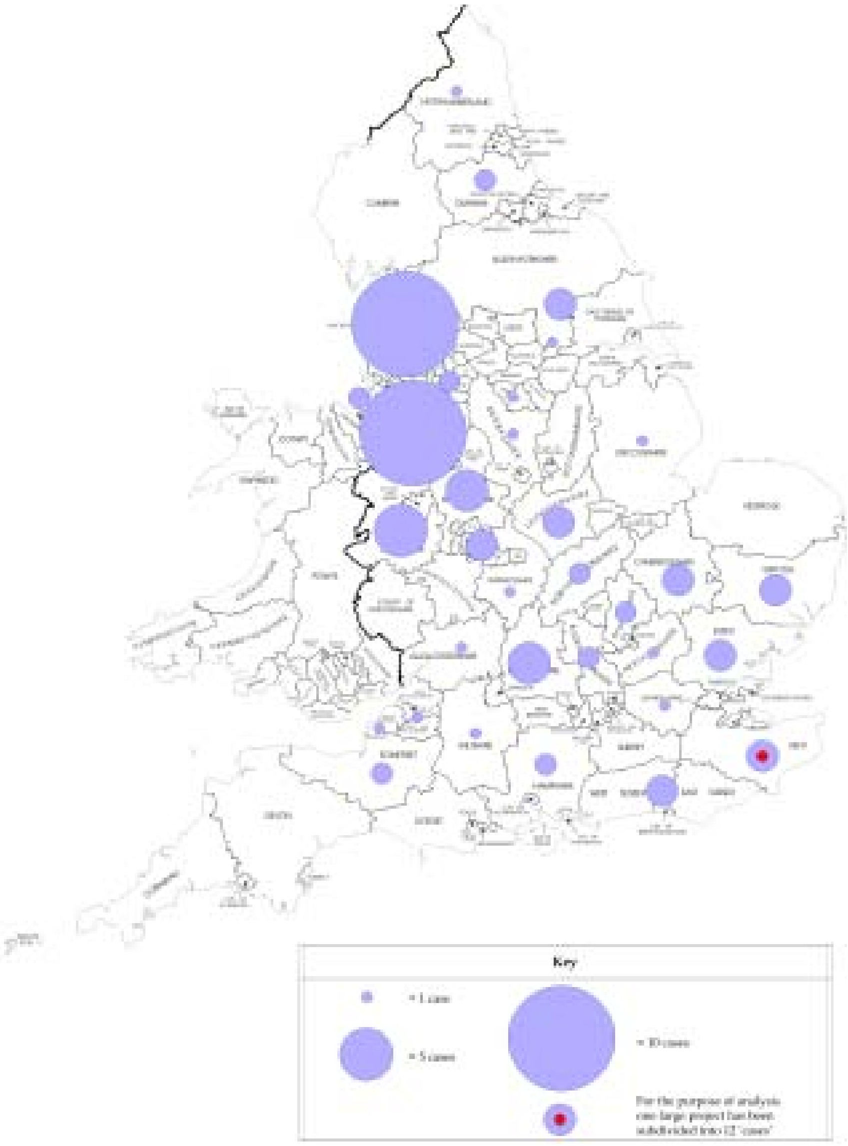


Figure 5.2.1 Locations of the 87 cases included in the first level of analysis

Figure 5.2.2 presents equivalent information for the 44 projects included in the second level of analysis. Once again, this constituted a reasonably even spread of projects across the country.

Figure 5.2.2 Locations of 44 cases included in the second level of analysis

No significant differences were detected between mean numbers of newts captured from the different counties or from different regions (aggregations of counties), across the 98 cases included in the first level of analysis. Similarly, no significant differences could be detected between mean numbers of newts captured (based on totals of all life stages and totals excluding larvae) from the different counties or regions across the 44 more detailed cases.

5.3 Habitat associations

5.3.1 Habitat categories

Figure 5.3.1 indicates the range of habitat types defined within the various projects included in the overall sample (of 87 projects). To facilitate a more robust analysis of any habitat associations, these habitat types have been aggregated to create eight broad habitat categories, as presented in Figure 5.3.2 (how the habitat groupings were created is set out in Appendix I).

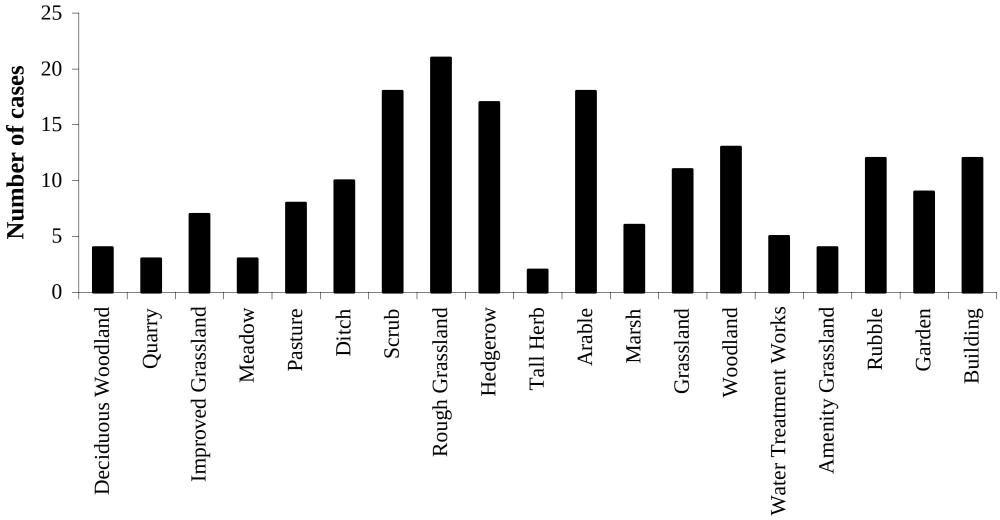


Figure 5.3.1 Habitat types recorded in each project

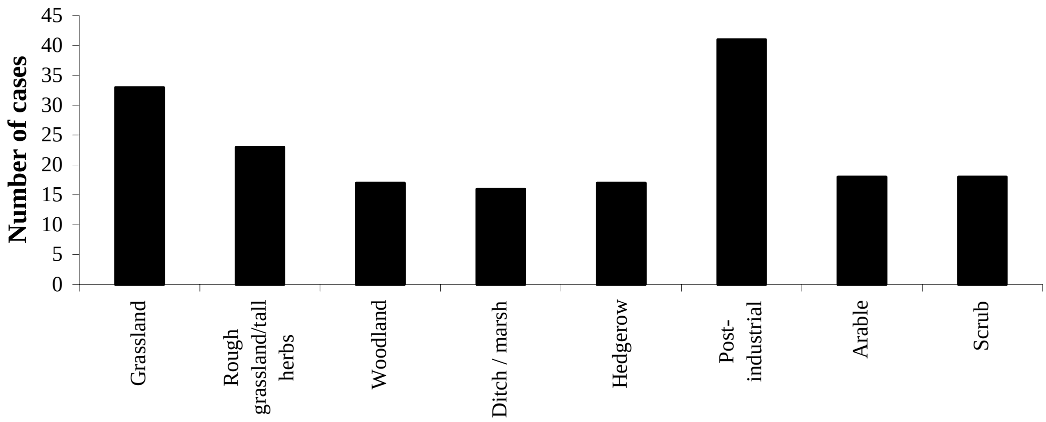


Figure 5.3.2 Habitat groupings recorded in each project

5.3.2 Analysis of habitat associations using the more general data

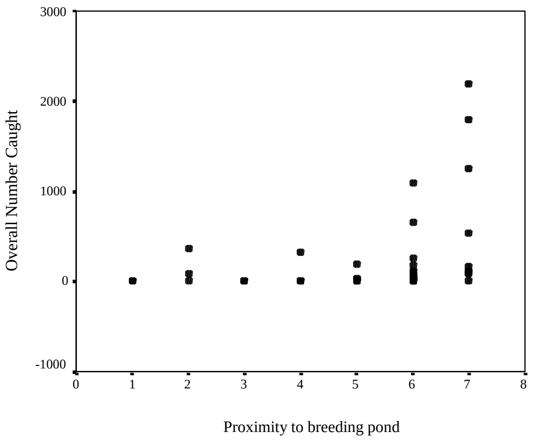
Analysis of Variance (ANOVA) was used to investigate captures from different habitats, based on the presence of one or more of the eight habitat categories in each of the 98 cases. Very few trends were discernable and there were no statistically significant differences in capture totals between different habitats. There was a weak (positive) association with the presence of hedgerows ($F = 1.68$; $p = 0.065$). That no clear relationships could be discerned on the basis of this more general analysis is not surprising: there was significant ‘noise’ in the capture totals (not least that, for this level of analysis, the total captures for each life stage were not identified separately, so the data may be biased by high larval captures); there was no account taken of fence/trap configuration or the season within which the captures took place; and multiple habitat categories within a single case had to be assigned the same capture totals.

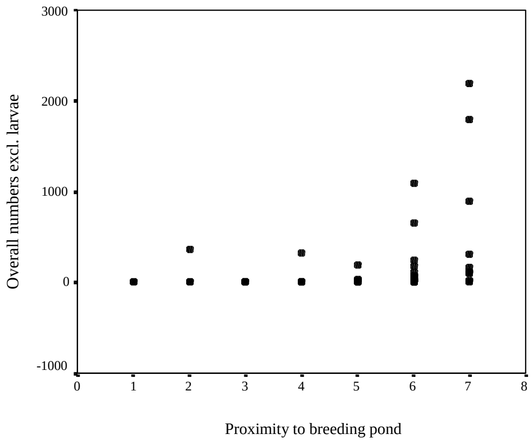
Notwithstanding these limitations, this level of capture information did appear likely to reveal more if the influence of habitat categories on capture totals could be analysed in combination. These data were therefore incorporated within a multiple (stepwise) regression with capture totals as the dependent variable and the habitat categories as predictors. A combination of the presence of woodland, arable, post-industrial habitats and hedgerows (entered into the regression model in that order) produced a regression which explained a little less than 50% of the variation in capture totals ($R = 0.67$; % explained variation 44.8%; $p<0.001$) [1]. Although the presence of woodland was most strongly correlated with increasing total captures, each of the four habitat categories had a similarly important input to the model (on the basis of their beta weights). In addition, all were positively correlated with total captures. A simultaneous regression, involving all habitat variables produced a similar result ($R = 0.68$; % explained variation 45.8%; $p<0.001$).

5.3.3 Analysis of habitat associations using the more detailed information

Using capture data from the 44 projects (55 cases) it was possible to control, and sub-divide, more variables. It was also possible to generate a composite (scalar) variable by weighting the presence of a habitat category with distance from one or more breeding ponds. This was important since, as expected, a significant correlation was revealed between the total captures (of all life stages and totals excluding larvae) and proximity to breeding ponds. A seven point scale was used to categorise distance from breeding pond. This is illustrated in Figure 5.3.3 overleaf.

[1] Regression statistics: R = multiple correlation coefficient. R square was used as a measure of the percentage variation explained by the regression model. For stepwise regressions default settings for entry: $F = 0.05$ and removal: $F = 0.1$; where these were varied, revised F-to-enter and F-to-remove are quoted. ANOVA was used to determine regression significance by testing the significance of the regression mean square vs the residual mean square (p is given). In each case residuals were examined using standardised residual plots to confirm the appropriateness of the data for this form of analysis.





Scale:
1 = Breeding pond greater than 1km away
2 = Breeding pond 500-1000m away
3 = Breeding pond 200-500m away
4 = Breeding pond 50-200m away
5 = Single breeding pond less than 50m away
6 = Multiple breeding ponds less than 50m away
7 = Work within breeding pond

Spearmans Rho		**Proximity to breeding pond(s)**
Total Captures	Correlation Coefficient	0.507**
	Sig. (1-tailed)	0.000
	N	52
Overall numbers excl. larvae	Correlation Coefficient	0.522**
	Sig. (1-tailed)	0.000
	N	52

** Correlation is significant at the 0.01 level

Figure 5.3.3 Relationships between capture totals and the proximity to one or more breeding ponds

A matrix of simple, non-parametric correlations between total numbers of newts caught and totals excluding larvae, and the weighted habitat variables, indicated similar relationships as those selected during the multiple regression analysis using the more general data; a list of correlations are presented in Table 5.3.1.

Although a number of correlations were identified with the full capture data, restricting the data to only fence/trap configurations not involving breeding ponds revealed no significant correlations between habitats and capture totals.

Table 5.3.1 Correlations between the presence of different habitats weighted by their proximity to breeding ponds, and newt capture totals

		Overall number Caught	**Overall numbers excl. larvae**
Weighted grassland	*Correlation Coefficient*	0.125	0.144
	Sig. (1-tailed)	0.190	0.156
	N	51	51
Weighted rough grass	*Correlation Coefficient*	0.057	0.072
	Sig. (1-tailed)	0.346	0.308
	N	51	51
Weighted woodland	*Correlation Coefficient*	0.284*	0.282*
	Sig. (1-tailed)	0.022	0.023
	N	51	51
Weighted wet habitats	*Correlation Coefficient*	0.197	0.184
	Sig. (1-tailed)	0.083	0.098
	N	51	51
Weighted hedgerows	*Correlation Coefficient*	0.374**	0.374**
	Sig. (1-tailed)	0.003	0.003
	N	51	51
Weighted post-industrial	*Correlation Coefficient*	0.333**	0.275*
	Sig. (1-tailed)	0.009	0.026
	N	51	51
Weighted arable	*Correlation Coefficient*	0.358**	0.376**
	Sig. (1-tailed)	0.005	0.003
	N	51	51
Weighted scrub	*Correlation Coefficient*	0.224	0.213
	Sig. (1-tailed)	0.057	0.067
	N	51	51

* Correlation is significant at the 0.05 level
** Correlation is significant at the 0.01 level

Since it is possible, with repeated correlations, to obtain some relationships by chance, the more robust approach of multiple regression was also pursued, to investigate a number of possible associations.

Using total numbers caught as the dependent variable in a stepwise regression, a similar model was formed as for the data extracted from the first level of analysis. In this instance a model comprising: the presence of woodland weighted by distance from breeding pond(s) (weighted woodland); weighted arable; and weighted post-industrial habitats was selected. Once again, woodland was the variable most strongly correlated with increasing captures and all variables made substantial contributions to the model. In this case the regression model explained a rather greater proportion of the variation in total captures than the model derived from the general data (R = 0.80; % explained variation 63.8%; p<0.001). A simultaneous regression using all weighted habitat variables produced a similar, slightly stronger correlation (R = 0.82; % explained variation 67.8%; p<0.001).

Using total captures excluding larvae as the dependent variable produced a similar result: woodland, arable, post-industrial habitats and hedgerows (all weighted by their proximity to breeding ponds) forming the stepwise regression equation (R = 0.80; % explained variation 64.3%; p<0.001).

Looking only at fence/trap configurations not involving breeding ponds (using total captures excluding larvae as the dependent variable) some associations were identified, although these appeared to be weaker and more subtle than for the combined data. Stepwise regression added only the presence of hedgerows weighted by distance from breeding ponds to the regression model ($R = 0.49$; % explained variation 25%; $p < 0.01$) regardless of variations in F-to-enter. However, a simultaneous regression using all weighted habitat variables produced a stronger correlation ($R = 0.74$; % explained variation 55%; $p < 0.01$). Hedgerow; Woodland; Post-industrial habitats; 'wet' habitats and rough grassland (all weighted by their proximity to breeding ponds) all contributed substantially to the regression.

For a relatively small number of projects, it was possible to extract measurements of the approximate areas of the different habitats involved and/or a measure of differential trapping effort within the different habitats. However, the sample sizes involved were too small and the data too variable to permit a robust analysis. The only clear trend that could be discerned was that, for trapping away from ponds, captures from woodland and, to a lesser extent, boundary features (not just hedges, but woodland/scrub edges, ditches and other habitat interfaces) were consistently greater than for other habitats and that this effect was magnified substantially with increasing proximity to ponds. The trend for increased captures from woodland habitat was clear, but too few projects were involved to permit a robust statistical analysis. With regard to habitat boundaries, captures were biased towards these locations in several projects but not in all. Variations in capture effort and fence alignment meant that this could not be tested in a quantitative manner. Both these habitat relationships became much less clear when fence configurations actually encircled a breeding pond.

5.3.4 Summary of habitat analyses

The capture data revealed relatively clear associations between numbers caught (both total captures and totals excluding larvae) and certain habitat variables. There was also a significant correlation between captures and proximity to breeding ponds, and when habitat and proximity variables were combined the relationships were much stronger.

Four habitat variables appeared regularly as predictors of newt captures: woodland, arable land, post-industrial habitats and hedgerows. The status of woodland and post-industrial habitats as predictors appeared to arise as a result of their correlation with increased capture totals across a range of projects.

Arable land as a predictor of newt numbers appeared to be selected on the basis of fewer projects, but those involving relatively large numbers of newts. In addition, proximity of breeding ponds appeared to have a greater influence on the correlations between arable habitats and newt numbers than for some of the other habitat variables. It did not appear, therefore, that newts were actively selecting arable *per se*, but that several of the projects which involved relatively large newt populations and clusters of breeding ponds were located within arable farmland. There were overall relationships between hedgerows and newt captures also and this habitat variable was most closely correlated with captures away from breeding ponds. However, the habitat relationships associated with captures away from ponds were subtle, with a range of other habitat variables also highlighted: woodland; post-industrial habitats, 'wet' habitats and rough grassland.

These relationships and their consistency or otherwise with findings in the literature, are discussed further in Section 6.1.

5.4 Capture details

5.4.1 The use of different capture techniques

Figure 5.4.1 indicates the frequency with which different capture techniques were used (across all 87 projects). Pitfall traps were the most frequently employed (in almost every case these were associated with drift and/or exclusion fencing).

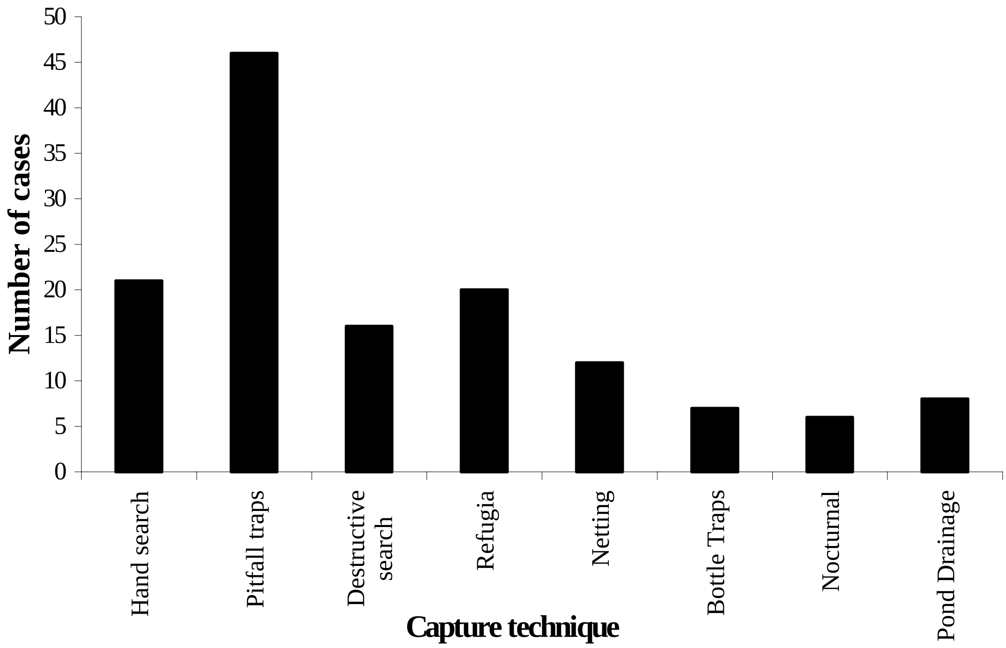


Figure 5.4.1 Use of different capture techniques

NB: These capture techniques are defined in Appendix 1

5.4.2 Effectiveness of capture methods

Table 5.4.1 indicates the overall performance of each capture method across the 55 cases for which more detailed information was collated. Histogram plots for each of the capture methods are presented in Appendix II. Clearly these data contain a significant degree of variation and have not, for the purposes of this overall analysis, been sub-divided by season etc. Nevertheless, the data illustrate some basic principles. Aside from pitfall trapping, for which there were a reasonable range of capture totals across the projects, many of the capture totals for the other methods exhibited a bi-modal distribution. In almost all cases a reason could be identified for these apparent anomalies, but this has made discerning trends in these data extremely difficult.

Table 5.4.1 Capture method performance (55 detailed information cases)

		N	Range	Median	Mean	± Std. Error
Hand Search	*Total No. of Newts excl. larvae*	19	0-48	2.0	7.16	2.61
Destructive Search	*Total No. of Newts excl. larvae*	16	0-128	3.0	16.38	8.73
Pond Drainage	*Total No. of Newts*	5	1-18	5.0	7.80	3.31
	Total No. of Newts excl. larvae	5	1-6	2.0	3.20	0.97
Netting	*Total No. of Newts*	9	0-462	42.0	95.33	49.07
	Total No. of Newts excl. larvae	9	0-164	6.0	37.00	19.89
Nocturnal	*Total No. of Newts excl. larvae*	5	0-71	5.0	17.20	13.50
Refuges	*Total No. of Newts excl. larvae*	18	0-17	0	2.94	1.43
Bottle Traps	*Total No. of Newts*	6	7-233	34.5	69.17	34.98
	Total No. of Newts excl. larvae	5	7-233	38.0	79.60	40.83
Pitfalls	*Total No. of Newts excl. larvae*	42	0-360	4.0	31.00	10.04
Pitfalls (associated with breeding ponds)	*Total No. of Newts excl. larvae*	12	0-360	29.0	70.08	28.02
Pitfalls (not associated with breeding ponds)	*Total No. of Newts excl. larvae*	30	0-135	1.0	14.70	5.99

Hand searching (during daylight): The majority of these data were obtained from pipeline projects which involved searching spoil mounds etc. These generated totals of approximately 20-50 newts. Other projects tended to involved far fewer captures.

Destructive searches: More so than for hand searching vegetation, the vast majority of projects which included destructive searching yielded few newts (less than 20) and the destructive search tended to be preceded by extended capture periods. However, one project was an exception. This involved captures of newts from within a large pile of fissured clay spoil and debris close to a breeding pond. Refuges and pitfall traps (largely without drift fences) were used during March and April and approximately 200 newts were caught during this period. Captures declined during April reportedly as a result of removals and the remaining newts' responses to increasingly warm weather (but presumably also, at least in part, as a result of their continuing seasonal migration towards the breeding ponds). A destructive search using heavy machinery was then carried out, yielding a further 128 newts, approximately 65% of the total caught prior to the destructive search, and nine known mortalities (and presumably a number of undetected dead animals).

Pond drainage: When the data were collated from the original project files, capture totals for this method were limited to 'rescues' from drained ponds. Captures using other techniques (primarily netting) used in conjunction with pond drainage were assigned to the other relevant capture methods. Thus the numbers recorded for pond drainage were always small and related largely to adult and larval newts recovered by hand from exposed sediments, the mesh screens of drainage equipment and/or moved with the drained water.

Netting: Capture totals for netting were highly variable. When not combined with a drainage procedure relatively few animals were caught, although this did seem to vary substantially with pond size (and presumably also with the density of vegetation and the amount of submerged debris, although this was rarely noted). Intensive netting in smaller ponds did appear to generate reasonable captures, particularly of larvae. The netting operations that generated the largest captures were undertaken in combination with drainage operations and involved open, gently shelving ponds with little vegetation and few submerged structures. Some of these ponds were small, but the largest captures of adults and larvae came from larger ponds with medium/large populations, where migration into the pond had not been prevented (either at all or, at least, not effectively) by exclusion fencing.

Nocturnal searches: As with the capture data for many of the other methods, the capture totals for nocturnal searches were strongly bi-modal. The majority of projects yielded very few newts by this method. However, on a small number of occasions the numbers captured were substantially higher. In each case these coincided with extremely favourable conditions: warm, wet nights early in the year and the searches were conducted, at least in part, along drift fences, which had concentrated the animals into a particular ‘zone’.

Refuges: Captures from beneath refuges were never frequent and on several projects they were totally ineffective. Refuges appeared to yield more newts when used in association with drift fencing.

Bottle traps: This method was used in relatively few projects and the capture totals obtained using bottle traps were extremely variable. The data were biased to some extent by large numbers of newts having been captured in this manner in a small number of projects. In one case 233 adult and sub-adult newts were captured in bottle traps (the number of larvae caught in this way were not included since these were recorded differently and could not be split by capture method for this project). As with netting, the largest capture totals came from ponds where migration into the pond had not been prevented effectively.

Pitfall traps: This was the most widely employed technique and generated the largest capture totals (excluding captures of larvae). The effectiveness of pitfall trapping varied considerably depending upon whether or not the trapping operation involved the use of a drift fence around a breeding pond. Where data were presented with regard to precisely where newts were captured and when, this effect was even more pronounced, with those traps positioned on exclusion fences erected prior to the seasonal migration into the ponds in early spring being many times more likely to capture newts, than traps positioned elsewhere or established later in the season.

Other methods: A small number of other ‘techniques’ were included in the sample projects, which occurred too infrequently to analyse formally, but are worthy of reporting:

A number of projects recorded captures of adult, sub-adult and juvenile newts from badly-compacted back-fill along drift fences and during fence removal. In most cases small numbers were involved, but in a small number of instances a combination of clay-rich ‘blocky’ back-fill and proximity to breeding ponds late in the year, led to large captures of juveniles in particular.

Some projects made use of vegetation management (most often grass cutting) in an attempt to increase nocturnal/hand search captures and/or to dissuade newts from using an area. Whilst it is possible that this was effective in altering the newts’ behaviour in avoiding areas, no reliable data were collated to indicate any increases in capture totals or efficiency.

A small number of projects involved the transfer of egg-laden pond vegetation and/or the use of artificial egg-laying media in order to move eggs between donor and receptor ponds. Although these procedures appeared self-evidently to be successful, there were no simple measures of efficiency. In certain situations, particularly in ponds with little submerged or floating vegetation or, when the vegetation had been removed effectively, the use of artificial media certainly was shown to be effective in moving large numbers of eggs. Similarly, transferring aquatic vegetation (particularly floating mats of *Glyceria*) was also reported as being effective in moving eggs. Clearly, the timing of such operations was critical: moving the material (vegetation or artificial media) late enough for it to have accumulated significant numbers of eggs but early enough for the eggs not to have hatched.

5.4.3 The influence of capture 'effort'

In order to further examine the effectiveness of the capture methods, a score for the 'effort' applied to the various methods was calculated for each method, along with a composite variable for each project, measured in terms of the period of trapping; numbers and density of traps; intensity of trapping/searching (see Appendix I).

There was a significant positive correlation between captures (using total captures and total captures excluding larvae) and both the number of capture methods used and the overall project scores for capture effort. Details are presented in Table 5.4.2 along with the equivalent information split by trap/fence configuration. Trap/fence configuration appeared to have a significant effect. Trap/fence configurations involving breeding ponds appeared to be less sensitive to trapping effort than attempts to capture newts away from breeding ponds.

Table 5.4.2 Correlation matrix of numbers of capture methods and capture effort vs capture totals

		Overall numbers caught	**Overall numbers excl. larvae**
Number of Capture Methods	*Correlation Coefficient*	0.506**	0.500**
	Sig. (1-tailed)	0.000	0.000
	N	52	52
Number of capture methods (associated with breeding ponds)	*Correlation Coefficient*	0.057	0.007
	Sig. (1-tailed)	0.414	0.490
	N	17	17
Number of capture methods (<u>not</u> associated with breeding ponds)	*Correlation Coefficient*	0.511**	0.453**
	Sig. (1-tailed)	0.001	0.004
	N	34	34
Capture Effort	*Correlation Coefficient*	0.478**	0.489**
	Sig. (1-tailed)	0.000	0.000
	N	53	53
Capture Effort (associated with breeding ponds)	*Correlation Coefficient*	0.212	0.149
	Sig. (1-tailed)	0.199	0.278
	N	18	18
Capture Effort (<u>not</u> associated with breeding ponds)	*Correlation Coefficient*	0.498**	0.453**
	Sig. (1-tailed)	0.001	0.004
	N	34	34

* Correlation is significant at the 0.05 level   ** Correlation is significant at the 0.01 level

Similar information is presented in Table 5.4.3 for each capture method. This indicates that the relationships between capture effort and numbers caught for each capture method were far less clear. A sequence of correlations of this kind needs to be interpreted with caution, since some relationships would be expected by chance; scatter plots of each of these comparisons are presented in Appendix III to help interpret the data further. Only bottle trapping showed a positive correlation between effort and numbers caught for both totals. The raw data which underpins this relationship were investigated further, along with a small number of other cases which, whilst they could not be included within this particular analysis as a result of one or more missing variables, nevertheless contained valid bottle trapping results. This indicated that the positive correlation between numbers of bottle traps, and periods of trapping and total captures was a valid relationship. The correlation between pitfall trapping effort associated with breeding ponds and capture totals is possibly also valid, but runs counter to the clear relationship illustrated in Table 5.4.2, of capture totals from operations associated with breeding ponds not being correlated with capture effort, whereas there was a relationship for operations not involving breeding ponds.

Table 5.4.3 Correlation matrix of capture effort scores for each method vs capture totals.

		Total No. of Newts	**Total No. of Newts excl. larvae**
Hand Search	*Correlation Coefficient*		0.154
	Sig. (1-tailed)		0.264
	N		19
Destructive Search	*Correlation Coefficient*		0.036
	Sig. (1-tailed)		0.447
	N		16
Pond Drainage	*Correlation Coefficient*	0.707	0.725
	Sig. (1-tailed)	0.091	0.083
	N	5	5
Netting	*Correlation Coefficient*	0.345	0.310
	Sig. (1-tailed)	0.182	0.208
	N	9	9
Nocturnal	*Correlation Coefficient*		0.775
	Sig. (1-tailed)		0.113
	N		4
Refugia	*Correlation Coefficient*		0.095
	Sig. (1-tailed)		0.353
	N		18
Bottle Traps	*Correlation Coefficient*	0.828*	0.866*
	Sig. (1-tailed)	0.021	0.029
	N	6	5
Pitfalls	*Correlation Coefficient*		0.126
	Sig. (1-tailed)		0.211
	N		43
Pitfalls (associated with breeding ponds)	*Correlation Coefficient*		0.496*
	Sig. (1-tailed)		0.043
	N		13
Pitfalls (not associated with breeding ponds)	*Correlation Coefficient*		0.14
	Sig. (1-tailed)		0.471
	N		30

* Correlation is significant at the 0.05 level

5.4.4 Effectiveness of capture methods for each life stage

Figure 5.4.2 indicates the number of projects which involved captures of one, two, three or all life stages.

It is clear from Figure 5.4.2 that the majority of the 87 projects have dealt with adult newts only (where one life stage was involved, these were always adult) and that only a small proportion involved captures of all life stages.

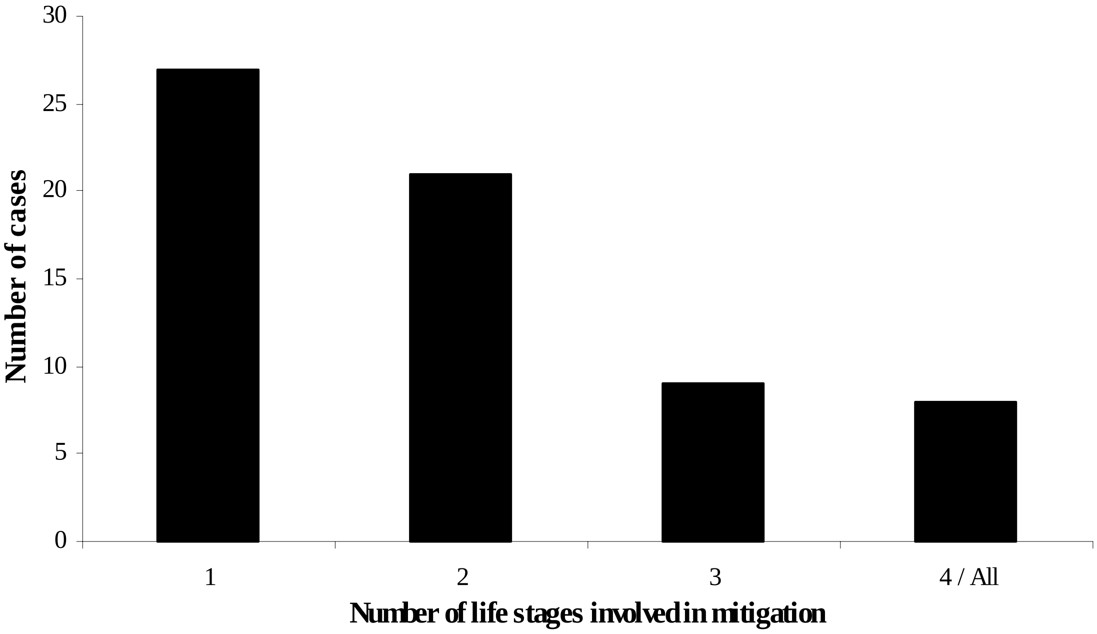


Figure 5.4.2 Numbers of projects involving different life stages

Table 5.4.4 sets out the capture totals recorded for each life stage from the 44 projects for which more detailed information was available. Clearly these data contain a significant amount of variation, but a key feature is the relatively small proportion of sub-adults captured across the majority of projects. Few projects appeared to involve captures of substantial numbers of sub-adults (although for those cases where total captures of each life stage were not recorded, the proportion of sub-adults is obviously unknown). There were two notable exceptions, where substantial numbers of sub-adults were captured:

One was a project which involved captures (using pitfalls and refuges) along a drift fence in the year following a multiple pond exclusion; the other was a pipeline project involving the removal of newts from spoil mounds to which they had access from the autumn of the previous year. Both projects (or project phases) yielded relatively large proportions of sub-adults.

Sub-adult capture totals were, however, similar across different trap configurations: as many (and in some cases more) sub-adults were caught away from breeding ponds as around them, whereas for all other life stages, far more were caught in projects which involved work around breeding ponds.

Table 5.4.4 Capture totals analysed by life stage and fence/trap configuration

Capture totals for each life stage

	N	Range	Median	Mean	± Std. Error
No. of Larvae	43	0-351	0	18.60	9.80
No. of Juveniles	43	0-376	0	14.76	10.02
No. of Sub-Adults	43	0-68	0	6.57	2.31
No. of Adults	45	0-723	4	55.69	20.81

Capture totals for each life stage (fence/trap configuration associated with breeding ponds)

	N	Range	Median	Mean	± Std. Error
No. of Larvae	12	0-351	6.0	65.08	32.24
No. of Juveniles	12	0-221	0	18.50	18.41
No. of Sub-Adults	12	0-60	0	8.92	5.27
No. of Adults	12	0-475	81.50	134.17	43.96

Captures totals for each life stage (fence/trap configuration <u>not</u> associated with breeding ponds)

	N	Range	Median	Mean	± Std. Error
No. of Juveniles	29	0-6†	0	0.76	0.26
No. of Sub-Adults	30	0-68	1	6.04	2.67
No. of Adults	31	0-41 †	2.0	5.55	1.62

Clearly, (as expected), far more adults have been captured than any other life stage. In addition, a comparison of mean and median figures indicates that many more adults have been captured during exclusions of breeding ponds rather than fence/trap configurations which do not involve breeding ponds. This latter sample had been biased by the inclusion of a project which involved a large number of captures (over 700) from exclusion fencing along a pipeline which ran between, and very close to, a cluster of large breeding ponds. This therefore was effectively a hybrid fence/trap configuration, and when it was removed from the analysis (shown by † on Table 5.4.4) a much clearer distinction could be made between adult captures obtained using different fencing configurations.

Juvenile capture totals were heavily influenced by a small number of projects. Where fence/trap configurations involved breeding ponds, large juvenile captures appeared to arise from those few projects which began later in the season and/or which enclosed terrestrial habitats and hibernation sites within fencing, and thus 'permitted' breeding in the ponds in question. Very few juvenile newts were captured in most projects not involving exclusions of breeding ponds. However, a small number of projects which (on the basis of key missing variables or a 'hybrid' trap configuration) were not included in Table 5.4.4, did involve the capture of larger numbers of juveniles (in some cases several hundred). This tended to be where drift fencing and pitfall traps (often excluding newts from pipeline routes or other development sites) were erected very close to breeding ponds and operated during the autumn, but where these ponds were otherwise unaffected.

Larval capture totals were extremely variable. In the vast majority of cases, high larval captures were generated when the timing of fence erection, the effectiveness of the fencing and/or the incorporation of terrestrial habitat features within exclusion fencing, 'permitted' breeding in ponds from which newts were being relocated.

Tables 5.4.5 (a)-(e) set out the captures per unit effort for each life stage using the different capture methods. For ease of interpretation, capture methods have been included within the same sub-table where the effort estimates utilised broadly similar scales. Thus, no direct comparison is possible between the differential efficiency of capturing adults by netting and from beneath refuges, whereas a comparison between the use of refuges and pitfall traps is more valid, as is a comparison between destructive searching and hand searching during daylight. Comparisons within sub-tables are generally valid, although the data are extremely variable.

Notwithstanding the variable nature of the data, it is possible to identify some clear relationships. Bottle trapping produced variable totals but was clearly only efficient in capturing adult newts, and then only in certain situations. Netting appears to be the most effective technique for capturing larvae, and can be useful in capturing adult newts also. As identified in Section 5.4.2, these large capture totals tended to be when netting was combined with some form of pond drainage.

Although slightly more effective at capturing sub-adults, refuges appeared to be generally ineffective at capturing newts in substantial numbers. By contrast, pitfall trapping was more efficient, particularly for some projects and particularly in capturing adult newts.

Few clear trends were discernable with regard to the other techniques: the capture totals for destructive searches were biased by the inclusion of a single project (as explained in Section 5.4.2); similarly two projects to some extent biased the apparent efficiency of daylight hand searching in capturing sub-adults. Destructive searching and hand searching in daylight tended to be equally efficient (or inefficient) in capturing each terrestrial life stage.

As explained in Section 5.4.2, the few occasions that large numbers of newts were captured during nocturnal searches coincided with the use of drift fences, concentrating animals into a particular 'zone'. Thus these capture totals were biased towards adults rather than sub-adults (as were those for pitfall traps associated with breeding ponds); none of these projects happened to involve periods when juvenile newts would be available for capture.

Tables 5.4.5 (a) – (e) Captures per unit effort for each life stage by capture method

(a) Bottle Traps

	N	**Range**	**Median**	**Mean**	**± Std. Error**
Larvae	5	0-1.0	0.0	0.20	0.20
Sub-Adults	5	0-1.25	0.0	0.25	0.25
Adults	5	2.33-57.0	12.67	20.87	9.63
All Life Stages	5	2.33-57.0	12.67	20.87	9.63
All Life Stages except Larvae	5	2.33-58.25	12.67	21.12	9.86

(b) Netting

	N	Range	Median	Mean	± Std. Error
Larvae	9	0-117.00	0.25	24.85	14.38
Sub-Adults	9	0-6.0	0.0	0.70	0.66
Adults	9	0-36.67	1.5	11.42	5.06
All Life Stages	9	0-154.0	15.25	36.97	17.40
All Life Stages except Larvae	9	0-41.00	1.5	12.12	5.50

(c) Pitfalls and Refuges

	N	Range	Median	Mean	± Std. Error
Refuges					
Juveniles	17	0-0.25	0.0	0.02	0.02
Sub-Adults	17	0-3.5	0.0	0.64	0.32
Adults	17	0-1.25	0.0	0.14	0.08
All Life Stages except Larvae	18	0-4.25	0.0	0.75	0.36
Pitfalls (associated with breeding pond)					
Juveniles	10	0	0.0	0	0
Sub-Adults	10	0-5.25	0.0	1.22	0.81
Adults	10	0-120	5.63	18.18	11.52
All Life Stages except Larvae	12	0-120	8.25	21.78	9.73
Pitfalls (not associated with breeding ponds)					
Juveniles	27	0-0.67	0.0	0.06	0.03
Sub-Adults	27	0-21.75	0.0	1.13	0.81
Adults	29	0-20.67	0.0	1.72	0.84
All Life Stages except Larvae	30	0-45	0.42	4.31	1.84

(d) Destructive Search and Hand Search (daylight)

	N	Range	Median	Mean	± Std. Error
Destructive Search					
Juveniles	13	0-1.50	0.0	0.13	0.12
Sub-Adults	13	0-5.33	0.0	1.03	0.53
Adults	14	0-13.50	0.0	1.41	0.97
All Life Stages except Larvae	16	0-42.67	0.92	4.96	2.77
Hand Search					
Juveniles	17	0-1.33	0.0	0.14	0.08
Sub-Adults	18	0-11.50	0.0	1.36	0.69
Adults	18	0-8.5	0.0	1.13	0.53
All Life Stages except Larvae	18	0-12	1.0	2.14	0.73

(e) Nocturnal search

	N	Range	*Median*	*Mean*	± Std. Error
Sub-Adults	5	0-0.33	0.0	0.07	0.07
Adults	4	0-23.67	1.17	6.50	5.76
All Life Stages except Larvae	4	0-23.67	1.67	6.75	5.66

5.4.5 Captures in different seasons

Figure 5.4.3 indicates the different seasons during which mitigation works were undertaken (involving all 87 projects). The most obvious feature is that although a number of projects involved the temporary or permanent relocation of newts from breeding ponds, by no means all of these began the works sufficiently early in the year to prevent newts entering the ponds in question and going on to breed in the year during which the bulk of the relocation operations took place. Very few of the projects selected involved captures over successive years.

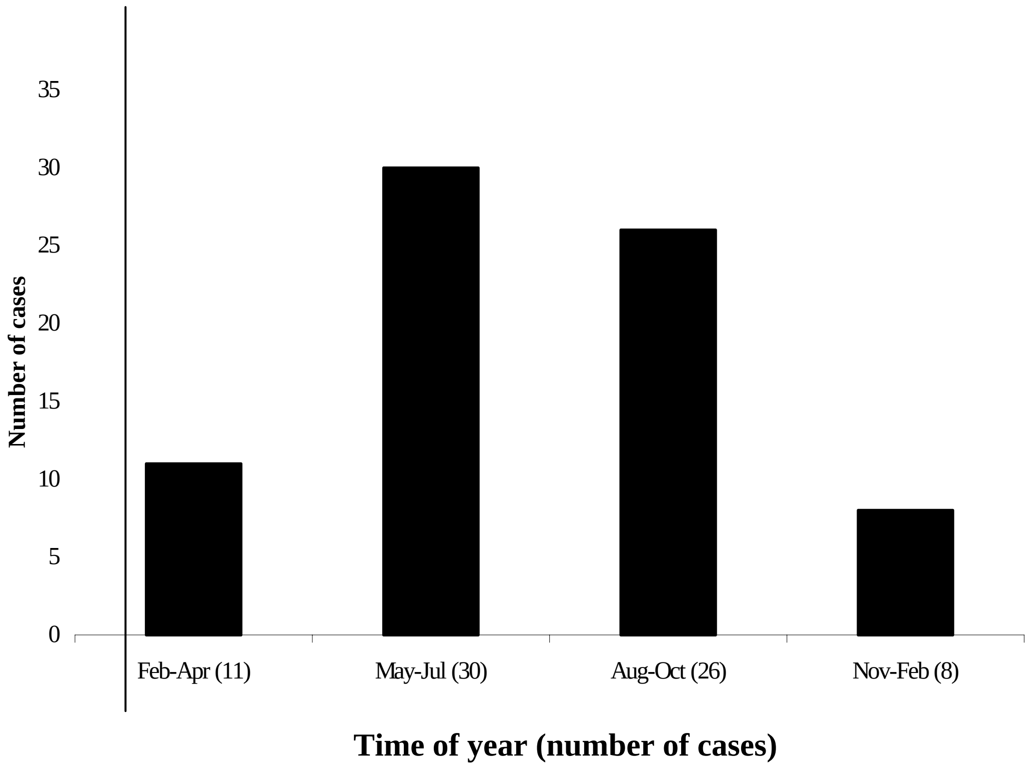


Figure 5.4.3 Time of year mitigation works were undertaken

The capture totals for the different life stages in each season (presented in Table 5.4.6) are largely as expected: very few captures of any life stage over winter; very few larvae captured outside the main breeding period; a peak of juvenile captures around emergence from the pond during the autumn; no particular difference in sub-adult captures between spring and autumn, but with a slight increase during the summer; and consistent adult captures outside the winter, with a peak in spring, coinciding with animals captured *en route* to breeding ponds.

Table 5.4.6 Capture totals for different life stages in each season

		N	Range	Median	Mean	± Std. Error
Number of Larvae	Feb-Apr	8	0	0.0	0	0.0
	May-Jul	24	0-351	0.0	18.00	14.75
	Aug-Oct	17	0-228	0.0	15.71	13.45
	Nov-Jan	6	0-15	0.0	2.67	2.47
Number of Juveniles	Feb-Apr	8	0-2	0.0	0.25	0.25
	May-Jul	24	0-6	0.0	0.63	0.30
	Aug-Oct	16	0-221	0.0	22.94	15.89
	Nov-Jan	5	0-2	0.0	0.8	0.49
Number of Sub-Adults	Feb-Apr	8	0-18	0.5	3.88	2.35
	May-Jul	24	0-68	1.0	8.83	3.40
	Aug-Oct	16	0-20	0.0	2.38	1.37
	Nov-Jan	5	0	0.0	0.0	0.0
Number of Adults	Feb-Apr	8	0-360	34.0	89.88	45.09
	May-Jul	25	0-411	2.0	25.56	16.38
	Aug-Oct	18	0-164	5.0	24.11	9.97
	Nov-Jan	6	0-9	2.5	3.33	1.26
Total Numbers excluding larvae	Feb-Apr	10	0-360	70.0	89.6	35.64
	May-Jul	28	0-453	13.0	40.54	16.50
	Aug-Oct	22	0-308	9.5	48.23	19.04
	Nov-Jan	7	0-9	5.0	4.29	1.27

Some of the small sample sizes which underpin the capture per unit effort figures presented in Table 5.4.7 mean that these data should be interpreted with caution. The only valid relationships appear to be that pitfall trapping and nocturnal searches are more productive in the spring and that (not unexpectedly) netting is more effective in spring and summer.

Table 5.4.7 Combined captures per unit effort for all life stages except larvae by method in each season

		N	Range	Median	Mean	± Std. Error
Hand Search	Feb-Apr	1	0	0	0	0
	May-Jul	13	0-12	1.75	2.53	0.94
	Aug-Oct	4	0-4.7	0.5	1.42	1.11
Destructive Search	Feb-Apr	2	0-1.3	0.63	0.63	0.63
	May-Jul	7	0-17.5	0.5	3.70	2.41
	Aug-Oct	4	0-4.0	0.88	1.44	0.95
	Nov-Jan	2	0-1.5	0.75	0.75	0.75
Netting	Feb-Apr	2	4-21.5	12.75	12.75	8.75
	May-Jul	3	1.5-33	19.5	18.00	9.13
	Aug-Oct	3	0-1.3	0.25	0.53	0.41
	Nov-Jan	2	0	0	0	0
Nocturnal	Feb-Apr	2	1.3-23.7	12.5	12.50	11.17
	May-Jul	3	0-1.0	0.33	0.44	0.29
	Aug-Oct	1	0	0	0	0
Pitfalls	Feb-Apr	8	0-120.00	3.79	19.31	14.53
	May-Jul	22	0-16.5	0.25	1.44	3.54
	Aug-Oct	17	0-28.0	0.63	6.15	2.66
	Nov-Jan	3	0.3-3.0	1.67	1.64	0.79
Refugia	Feb-Apr	2	0-1.8	0.88	0.88	0.88

		N	Range	Median	Mean	± Std. Error
	May-Jul	12	0-4.3	0.17	0.95	0.45
	Aug-Oct	5	0-0.3	0.0	0.05	0.05
Bottle Traps	Feb-Apr	2	6.3-15	10.63	10.63	4.38
	May-Jul	4	2.3-52	8.67	17.92	11.46
Pond Drainage	May-Jul	4	0.3-1.7	0.93	0.97	0.29
	Nov-Jan	1	0.7	0.67	0.67	0.67

5.4.6 The influence of weather conditions on capture success

Few projects recorded details of nocturnal temperatures or other weather conditions, and where these data were recorded, the recording methodologies and/or descriptions of weather conditions were rarely directly comparable. As a result no statistical analysis was possible. Only the most basic trends and relationships could be discerned from the weather data:

a. Very few newts were captured at temperatures below 6°C. Above that temperature no clear relationships could be discerned.

b. Very few newts were captured in terrestrial habitats during extended periods of dry weather in June, July and the first half of August.

c. The largest captures of adult newts tended to be on wet nights during March; the largest captures of juvenile newts on wet nights in late August and early September.

5.4.7 The influence of different fencing and trapping configurations

In order to maintain reasonable sample sizes, for the purposes of each of the preceding analyses the original fence configuration categories that were assigned to each project were combined to form a composite variable. This variable identified (i) projects which involved some element of captures from around breeding ponds and (ii) those which did not. Those projects for which fence/trap configuration was unclear were coded as missing values. The influences of this most basic variation in fencing and trapping configuration have been highlighted as appropriate in the preceding analyses. However, whilst the following data were not suitable for a robust, statistical analysis, detailed investigations of trapping returns from particular fence arrangements where the locations of captures were also recorded, did yield some valuable information:

(a) The effectiveness of drift fencing located at a distance from breeding ponds in capturing newts as part of a relocation operation.

A number of projects made use of drift fencing away from breeding ponds, both as a means of trapping and removing newts from prescribed areas and as an adjunct to a relocation operation involving breeding ponds. In the majority of cases no more than small numbers of newts were captured on drift fences in any of these situations.

There was a clear inverse relationship between distance from the breeding pond and captures along drift fences, for those projects which used drift fencing away from ponds as part of an exclusion and relocation project. Captures were greatest within 50m of a pond and few captures were recorded greater than 100m from a pond (although for some projects the proximity of the works to breeding ponds was not identified). Although the numbers of newts captured still appeared to be dependent upon distance from breeding ponds, there also appeared to be a relationship between the number and length of drift fence 'panels' and their degree of 'overlap' or the density of compartmentalisation, and the capture totals. None of these projects caught large numbers of newts per unit effort. However, each of the projects with higher capture totals utilised substantial lengths of drift fencing, in some cases arranged in lengths which 'overlapped'. Appendix IV presents selected examples of different fence arrangements and capture locations. Very few of the projects fully 'compartmentalised' exclusion areas as described in *the Guidelines*.

A small number projects recorded some captures on drift fences across linear features at distances up to 150-200m from breeding ponds.

(b) The effectiveness of drift fencing and traps in excluding newts from prescribed areas.

A number of the projects used drift fencing (usually accompanied by pitfall traps) to exclude newts from particular areas or features. Variations in the extents and configurations of this fencing and the numbers and locations of pitfall traps made direct comparisons difficult, but there were certain principles which held true for most projects. As with the use of drift fences and traps in other situations, the over-riding influence appeared to be the proximity to breeding ponds. Once again, by far the most captures were recorded within 50m of ponds and few animals were captured at distances greater than 100m. In addition, most of the other factors which have been shown to influence capture totals, for example low captures during mid-summer, appeared to have even greater effects on trap success in these situations. An example of the distribution of captures along a drift fence used to exclude newts from a pipeline development is presented in Appendix IV, which illustrates some of these principles.

5.4.8 The relationship between population estimates and capture totals

Some of the 44 projects subject to more detailed analysis calculated population size class estimates from their initial survey data (as set out in *the Guidelines*) and others came up with numerical estimates. In some cases there were attempts to base these numerical estimates on population capture models, however in the majority a relatively basic estimate of the likely proportion seen or captured was used as a conversion factor. Some projects simply presented initial survey results without further analysis. Figure 5.4.4 presents the numbers of projects which dealt with small, medium or large populations respectively. Where no size class was quoted, these size class estimates were derived from an analysis of whatever pre-mitigation survey data were available. Figure 5.5.5 presents the range of numerical population estimates produced by the different projects.

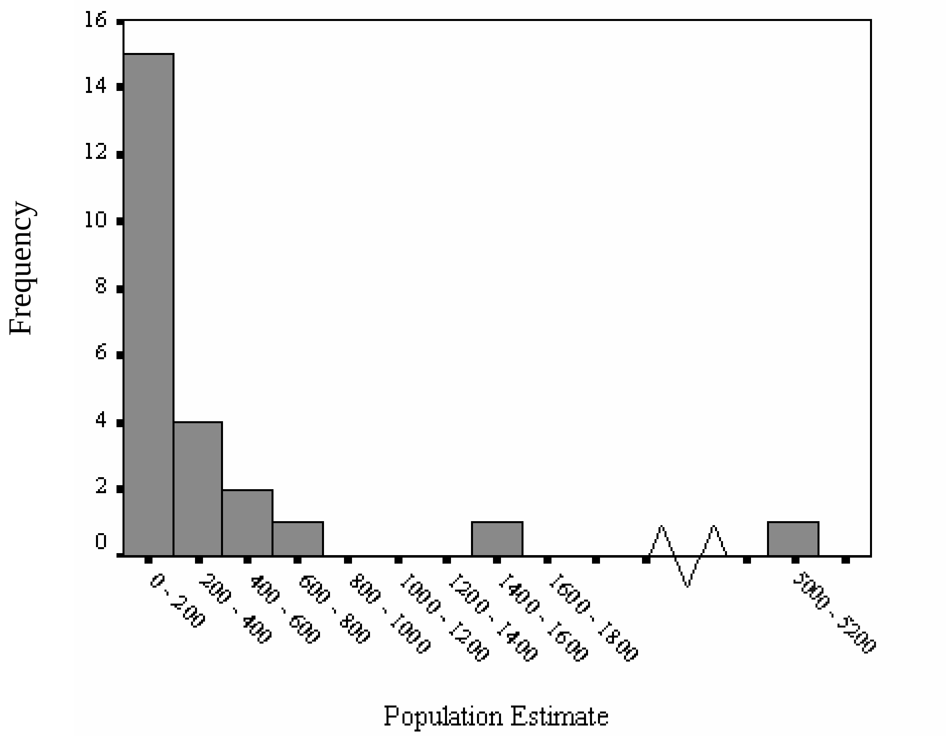


Figure 5.4.4 Numerical population estimates quoted

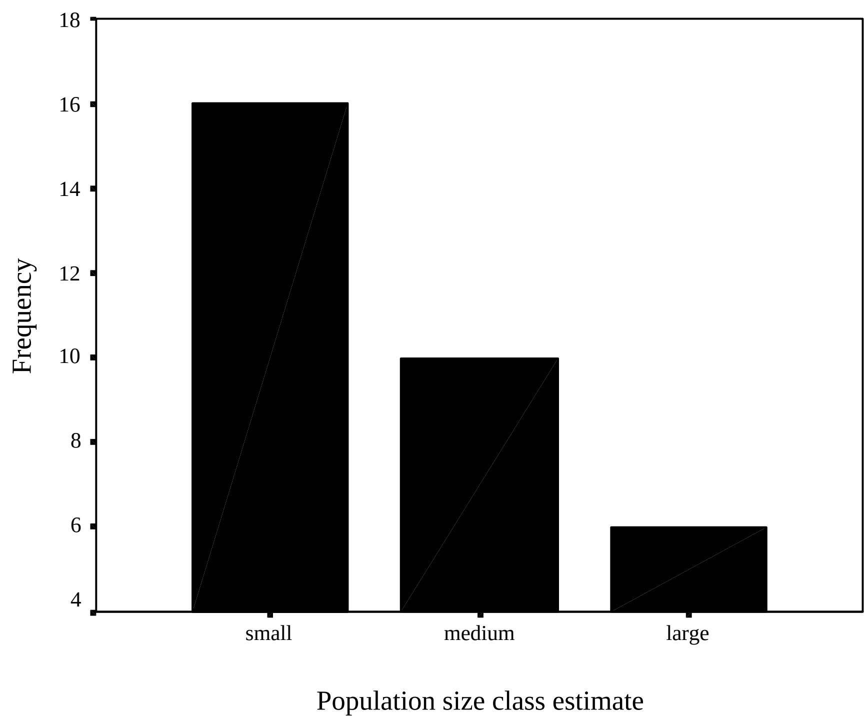


Figure 5.4.5 Population size class estimates derived for the 44 projects involved in the more detailed analysis

Significant positive correlations were found between population size class estimates and capture totals across all projects and for all of those involving breeding ponds (details are presented in Table 5.4.8). No relationship was found for those projects not involving breeding ponds.

The relationship between capture totals and numerical estimates was similar, but less clear with regard to fencing/trap configurations associated with breeding ponds.

Table 5.4.8 Correlation matrix of population size classes + estimates vs total captures and total captures excluding larvae

		Population Size Class Estimate	**Population Estimate**
All Fencing/Trap Configurations			
All Life Stages	*Correlation Coefficient*	0.483**	0.583**
	Sig. (1-tailed)	0.003	0.001
	N	31	24
All Life Stages excluding larvae	*Correlation Coefficient*	0.478**	0.608**
	Sig. (1-tailed)	0.003	0.004
	N	31	24
Fencing/Trap Configurations associated with breeding ponds			
All Life Stages	*Correlation Coefficient*	0.643*	0.460
	Sig. (1-tailed)	0.012	0.066
	N	12	12
All Life Stages excluding larvae	*Correlation Coefficient*	0.616*	0.573*
	Sig. (1-tailed)	0.017	0.036
	N	12	12
Fencing/Trap Configurations <u>not</u> associated with breeding ponds			
All Life Stages excluding larvae	*Correlation Coefficient*	0.315	0.493
	Sig. (1-tailed)	0.101	0.062
	N	18	11

* Correlation is significant at the 0.05 level
** Correlation is significant at the 0.01 level

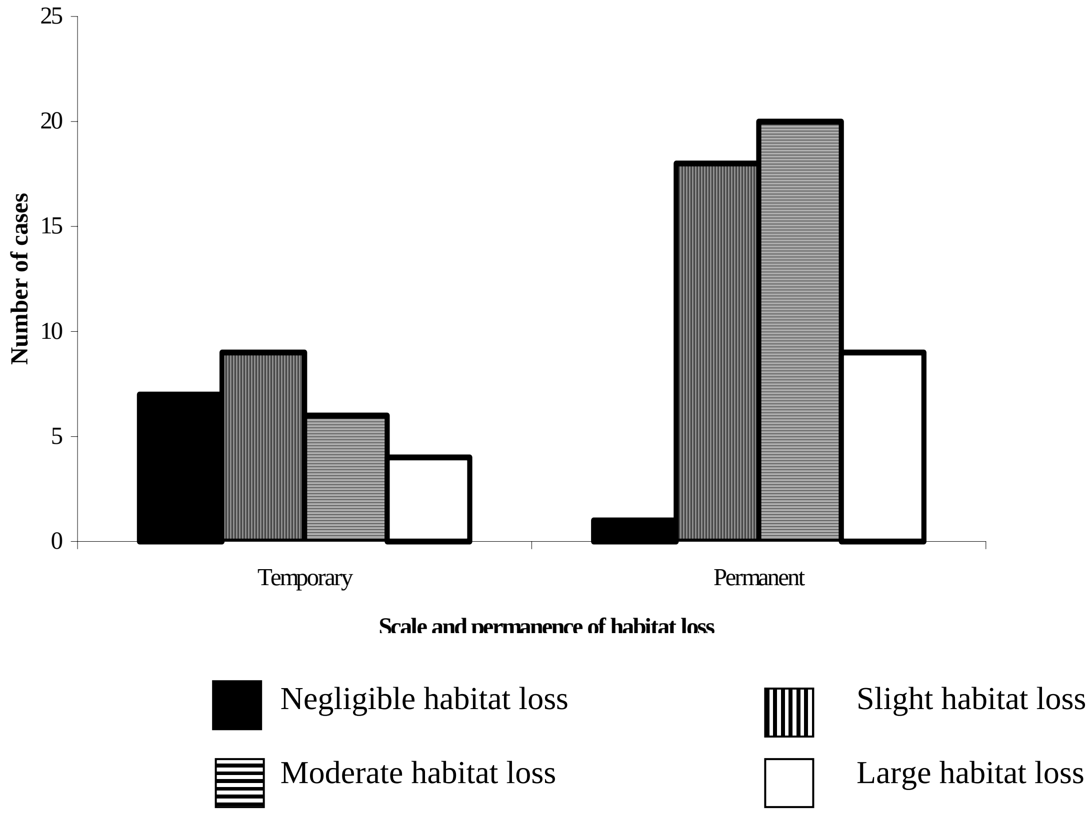


Figure 5.4.6 Scale and permanence of habitat losses

5.4.9 The relationship between impact and capture effort

Figure 5.4.6 presents the scale and permanence of habitat losses for each of the 87 projects which recorded appropriate details. These data were then combined to create a variable representing the overall impact involved in each of the projects for which more detailed information was available. The relationship between impact and the overall capture effort score for each project was compared using a simple non-parametric correlation, and no significant relationship was revealed. A measure of impact significance was also obtained by creating a combined variable of impact scale and population size class. However, there was also no correlation between this new variable and capture effort. This indicates that, in some cases at least, inappropriate levels of capture effort had been applied, with regard to the scale of the likely impact on newts.

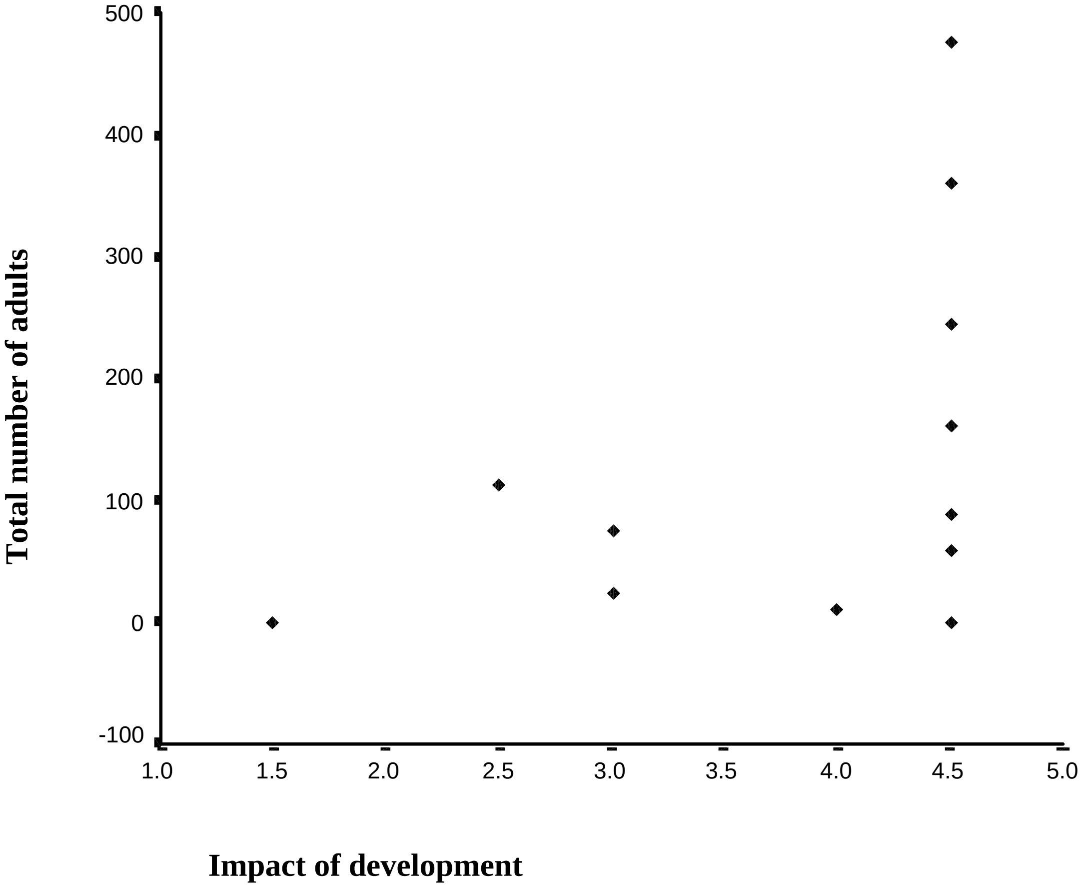


Figure 5.4.7 The relationship between impact of development and total number of adults caught

5.4.10 The relationship between impact of development and adult capture totals

The scatter plot in figure 5.4.7 presents the relationship between the impact of development and adult capture totals. There appeared to be a positive trend between total numbers of adults caught and impact of development, although this relationship was found not to be statistically significant. A significant relationship was revealed when numbers caught at all life stages were correlated with impact of development, however the high numbers of larval captures associated with several of their larger-scale developments appeared likely to have biased this result.

6. Discussion and recommendations

6.1 Can habitat type be used to predict newt density and distribution, and appropriate mitigation effort?

Although it has been possible to account for a substantial proportion of the variation in numbers of newts captured by deriving regression equations using selected habitat variables, the apparent relationships revealed by these analyses are subtle and cannot be converted into simple recommendations with regard to the scope and scale of mitigation in different habitats. Clearly, where the selected habitats (woodland, hedgerows, post-industrial habitats and, in some cases, arable land) occur in conjunction with breeding ponds, it is necessary to consider a comprehensive mitigation programme. However, it would be misleading to use these findings as a reason to undertake less comprehensive mitigation in other habitats, particularly if associated with breeding ponds.

The selection of woodland and hedgerow habitats as predictors of newt numbers is generally consistent with the literature. (Beebee, 1977; Beebee, 1981; Latham *et al,* 1996; Malmgren, 2002). The finding that the presence of arable land was positively correlated with total great crested newt captures was somewhat surprising, since it is well reported in the literature that it represents poor terrestrial habitat for newts (Laan and Verboom,1990; Swan and Oldham 1993, 1994). This is likely to have been, to some extent, an artefact of the selection process: licensed operations are only likely to be taking place in situations where newts have been found or predicted to occur, so if the majority of the habitat involved in some of the projects is arable farmland, this represents, to some degree, a self-selected sample. In addition, those projects which contributed most to the perceived relationship between capture totals and arable land were associated within a high pond density. This strengthens the metapopulation structure and reduces the chance of long-term declines and local extinctions, otherwise likely to occur within a sub-optimal habitat (Froglife, 2001). Thus, whilst the results do not necessarily indicate the active selection of arable habitats by newts, they do indicate that arable farmland with a high density of ponds can support substantial great crested newt populations.

It should also be considered that there are opportunities for great crested newts within the arable landscape. Hedges and ditches have been shown to be significant positive determinants of great crested newt occurrence in arable habitats, since they increase habitat diversity and provide stable refugia in a landscape prone to massive change (Swan and Oldham, 1994). In addition, certain points during the arable rotation, such as set-aside and post-cropping habitats, may also increase the structural diversity of the vegetation and substrate, and constitute a valuable intermittent habitat. The occurrence and abundance of newts within pasture has been found to be related to the presence and width of uncultivated sectors (Oldham *et al,* 2000). Some of these habitat features are also likely to have been present within the arable land which formed part of the current analysis.

More research on newt habitat associations is required in order to investigate a more useful means of predicting newt density and distribution on the basis of habitat variables.

A strong relationship was demonstrated between the proximity of breeding ponds, and capture totals and capture efficiency, throughout the analyses. In contract to the effects of habitat, it is possible to give definitive advice with regard to trapping effort in different distance ‘zones’ away from breeding ponds. The most comprehensive mitigation, in relation to avoiding disturbance, killing or injury is appropriate within approximately 50m of a breeding pond. It will also almost always be necessary actively to capture newts 50-100m away. However, at distances greater than 100m, there should be careful consideration as to whether attempts to capture newts are necessary or the most effective option to avoid incidental mortality (this is dealt with in more detail along with related considerations below). At distances greater than 200-250m, capture operations with hardly ever be appropriate.

These recommendations are also broadly consistent with findings in the literature, since although a maximum routine migratory range has been estimated as approximately 250m from a breeding pond (Franklin, 1993; Oldham and Nicholson, 1986; Jehle, 2000), Jehle (2000) determined a terrestrial zone of 63m, within which 95% of summer refuges were located. In addition, following the breeding season, (Jehle and Arntzen, 2000) recorded 64% of newts within 20m of the pond edge.

6.2 What are the most effective capture methods?

In general, the results of the various analyses support the recommendations presented in *the Guidelines*. For projects involving the exclusion and relocation of newts from breeding ponds, pitfall traps set on an encircling drift fence are clearly the most important element. The results suggest that the critical features are establishing the fencing sufficiently early and installing the fencing sufficiently well to be effective in preventing as many adult newts as possible returning to the water. The use of multiple capture methods has also been shown to be important, particularly (i) if attempting to catch newts away from breeding ponds, and (ii) where, for whatever reason, the early-season elements of an operation to exclude and relocate newts from a breeding pond have been less effective at keeping adult newts out of the pond.

A small number of other, minor, modifications to *the Guidelines* may also be appropriate: It would be helpful to stress the significantly better performance of netting as a technique when associated with draining-down operations. It may also be helpful to recognise the increased effectiveness and usefulness of nocturnal searching of terrestrial habitat in the zone beside drift fences, both during the first warmer, wet nights of the season (primarily during March), for adults; and during similar climatic conditions from mid-August to the end of September for juveniles.

6.3 Capturing differing life stages

It was clear from the data that, consistently, sub-adult life stages were captured less effectively than the others. The main reason appeared to be that few mitigation projects took place over successive seasons, and none appeared to have taken place over the three-year period recommended in *the Guidelines.*

This means that under these circumstances it is necessary to attempt to capture sub-adults in terrestrial habitats away from ponds, and the analysis of capture results shows clearly that in almost all cases catching newts at a distance from breeding ponds is labour-intensive and inefficient. The inability to capture non-breeding newts, which constitute a significant proportion of the population, probably represents the single most important limitation on most mitigation projects.

The inefficiency of capturing non-breeding individuals some distance from the pond is partially attributable to inadequacies in the terrestrial capture methods for this life stage. There have been suggestions that sub-adult newts are more capable of climbing out of pitfall traps (Kemp, 2001). In addition, with increasing distance from breeding ponds the issues of scale in relation to lengths of drift fencing and numbers of pitfall traps required, along with the problems of low trap returns per unit effort, multiply to the extent that these techniques become less practicable to employ. A substantial degree of effort is also required to capture significant numbers of sub-adult newts away from breeding ponds using artificial refugia. As an approach to reptile translocation this technique is labour-intensive and can be very time consuming. Since non-breeding newts away from ponds are often likely to be present at much lower densities than reptiles and, as non-heliotherms, are less attracted to such refugia, this technique is a very inefficient.

One way of improving sub-adult captures, if captures on a drift fence around a breeding pond is not possible in the following spring (because, for example, it has been destroyed to permit development), is to install some form of drift fence on the development boundary in the direction of nearby suitable terrestrial habitat and hibernation features, and operate pitfall traps during the most critical periods in an attempt to catch newts returning in the direction of the old ponds in subsequent years.

In addition, a suggested design modification to pitfall traps to prevent sub-adult and juvenile newts from escaping is to cut out the centre of the lids to form a 10mm overhang (Kemp, 2001).

It would also be appropriate to investigate the possibility of designing passive multiple live capture 'traps' for newts, which can be used in terrestrial habitats (possibly used in conjunction with drift fences or channels) and which can be checked less frequently than pitfalls, offering the opportunity for cumulative captures.

One of the reasons underlying the inability to capture non-breeding newts appears to be the need to complete capture operations in shorter time periods. This is often as a result of the need to have a detailed planning consent in place prior to undertaking mitigation. Thus the poor performance of projects in capturing non-breeding newts is likely to have worsened considerably as a result of the changes in responsibility for licensing which took place in 2000, moving the responsibilities for licensing development activities from English Nature (originally for 'conservation purposes'), to Defra ('for imperative reasons of overriding public interest').

Prior to 2000 it was possible, for those development projects that were clearly going to proceed, to begin capture and relocation operations as advance works, prior to the granting of detailed planning consent. In this way projects had a chance of approaching English Nature's best practice guidance that such relocation operations should take place over successive seasons (ideally three breeding periods). However, in practice, and for most housing developments in particular, a detailed consent is rarely granted any more than weeks (even days) in advance of the commencement of site clearance, and thus the need to delay licence application and mitigation works until this is received, tends unavoidably to compress the time available for mitigation. It is often the efficacy of the mitigation operations which has suffered, particularly the ability to capture the non-breeding element of the population. It is possible that any subsequent transfer of responsibilities for determining derogations from Council Directive 92/42/EEC to, for example, Local Planning Authorities, may improve the situation, but only if any licensing procedures could incorporate more time for advance mitigation.

Other issues were also identified which would usefully inform future mitigation design (and which could be incorporated within *the Guidelines*):

It has been possible clearly to identify netting as the most efficient means of capturing larval newts, particularly when associated with draining-down operations.

It has also been possible to identify a clear relationship between ‘effort’ and capture success for bottle traps, meaning that the more traps employed the more newts will be caught. Thus, recommended trap densities could be increased to accelerate captures in key periods (for example, early in the season, to minimise successful breeding in ponds to be cleared).

It might also be helpful to include reference to the use of artificial egg-laying media as an adjunct to relocation operations.

It has also been possible to identify that the efficient capture of juvenile newts relies on rather ‘narrow’ and potentially very important ‘windows’ in late summer/early autumn. In addition, because of the size and behaviour of juveniles, the details of some mitigation techniques (particularly the quality of installation of drift fences and pitfall traps) are more critical and these methods can be much less successful than for adult newts. It is likely that other measures, for example, the careful re-excavation and supervised removal of fencing, or very labour-intensive ‘bursts’ of trapping and nocturnal hand searching during wet conditions, would need to be undertaken to ‘back-up’ the more routine techniques.

6.4 Additional effects of weather and season

Generally the results of the various investigations supported the details and advice presented in *the Guidelines.* In particular, the results support not attempting to capture newts in terrestrial habitats at temperatures below 5-6^{o}C.

The key finding with regard to the influence of weather patterns, is that it is seldom worth attempting to capture newts away from ponds during spells of dry weather between June and mid-August inclusive.

6.5 Fencing and trapping configurations

Clearly, when dealing with the relocation of newts from breeding ponds, the vast majority of captures come along encircling drift fences. To capture newts effectively at distances up to 100m from a pond requires significant lengths of drift fencing with pitfall traps, laid out to create sequential barriers for newts to negotiate. There were also some indications that for long lengths of drift fencing, including those around breeding ponds, trapping efficiency was increased by the addition of short lengths of fencing, with pitfalls, at 90^{o} to the main fence. There were also some tentative indications that orientating ‘panels’ of drift fencing at 90^{o} to potentially important habitat features, which might represent ‘movement corridors’ increased the effectiveness of the fences, when installed some distance away from breeding ponds.

Very few of the projects provided a clear test of the comprehensive ‘compartmentalisation’ recommended in *the Guidelines*. Whilst newts were caught in these circumstances, including, in one case, a large proportion of sub-adults, and in another, relatively large numbers of sub-adults or juveniles, overall small numbers were caught compared to the lengths of fencing and numbers of traps employed. In addition, the risk of incidental mortality associated with installing relatively dense fencing compartments within terrestrial habitat also needs to be considered when evaluating this method as an effective capture technique.

Where there were no obvious features to ‘target’ with fencing, capture success along drift fences declined sharply with distance from ponds and captures within the 50-100m zone were generally inefficient.

Captures on fences (and by other methods) at distances between 100m and 200-250m from breeding ponds tended to be so low as to raise serious doubts about the efficacy of this as an approach, although a small number of projects did report captures on significant linear features at distances of approximately 150-200m from ponds.

6.6 The relationships between capture effort, mitigation success, impact magnitude and population status

On the basis of the projects included in this investigation, it appears that there have, in the past, been imbalances between the extent of mitigation (particularly in relation to capture effort), and the magnitude of impact and the status of the newt population concerned.

It is important that mitigation design is based upon a carefully considered risk assessment, with regard to the likelihood of the development-related activities resulting in disturbance, killing or injury of newts and interference with population processes; for example reducing breeding success, or impeding seasonal mitigation. The scale of the mitigation and the resources allocated to it also needs to take account of the likely outcomes of different mitigation options in relation to these potential impacts, the numbers of newts involved and the likelihood of success of the various mitigation options.

Based on comprehensive, high quality surveys and a sound impact assessment, certain aspects of any mitigation method statement need to be ‘fixed’; for example the number of breeding sites that would be affected and the amounts of different types of terrestrial habitats (and key habitat features) that would be lost. The overall design needs to be founded on the principles and details set out in *the Guidelines* and could also usefully be informed by the relevant findings in this study.

However, any risk assessment also needs to be an iterative process, continually reviewed and re-modelled on the basis of the emerging capture results. To limit the need for repeated requests for licence amendments, a flexible approach may therefore have to be incorporated within licence application method statements, with regard to capture methods and intensity, dependent upon emerging capture results. Notwithstanding this need for an iterative approach to some aspects of the capture operations, it should be noted that in the sample of licensed operations reviewed in this study, those with more robust and comprehensive pre-mitigation surveys required fewer licence amendments or changes to be made during the mitigation period.

Some examples of important elements that should be included in a risk assessment/mitigation design are given below:

(a) Exclusions and relocations from breeding ponds

For exclusions and relocations of newts from breeding ponds, the most critical element is to install an encircling drift fence early in the season, to a high standard, and as close to the pond as possible. It is then an advantage to focus extra capture effort (in addition to routine pitfall trapping) on key ‘windows’ to take advantage of favourable weather conditions in the early stages.

If it is obvious that adult newts remain within (or have penetrated) the fence in anything more than very low numbers, it is necessary to react quickly, adopting multiple additional capture methods, with the aim of capturing most adults before they have bred and moving most eggs before they have hatched. It is then necessary to plan carefully an additional bottle-trapping and netting programme, in concert with a draining-down exercise.

It is also necessary to make a reasonable attempt to capture the non-breeding elements of the population. Ideally this should take place over subsequent years, taking advantage of seasonal migrations. It is rarely feasible to rely just upon a single ‘bout’ of drift fencing and pitfall trapping away from the pond during the summer to achieve this.

(b) Clearance of prescribed areas

For clearing newts from areas of terrestrial habitat away from breeding ponds, the proximity to the breeding pond is key:

Within a zone up to approximately 100m from the pond, the following measures can be effective in capturing newts: comprehensive drift fencing and pitfall trapping, involving substantial lengths and using layouts which create a series of overlapping barriers across features most likely to be used as movement corridors, combined with a ‘compartmentalising’ approach. However, in all cases, and particularly when only small areas of suitable habitat are involved, care needs to be taken to avoid the incidental mortality of newts during fence installation: it is important not to destroy substantial amounts of the valuable habitat concerned by installing the fences themselves. Because of the likely reductions in capture efficiency pitfall trapping should be suspended during periods of dry summer weather. This approach should be combined with the use of as many other measures as possible, but only when these are ‘targeted’ to take advantage of particularly weather and seasonal ‘windows’.

At distances between 100 and 200-250m from breeding ponds careful consideration should be given to whether attempts to capture newts are appropriate. This will depend upon the magnitude, type and duration of impacts, what habitat types and features would be affected, the proportions of habitats within this ‘zone’ which would be affected and, crucially, the timing of the development activities. If the habitats within the zone are largely homogenous and there is no way of ‘targeting’ capture effort, a comprehensive attempt to capture newts throughout this zone is rarely likely to be feasible or cost effective. However, targeting particular habitat features may be worthwhile, using similar capture protocols as described for the within 100m zone.

Existing information on habitat preferences (reviewed in Section 3) and the results of this study could be used to help design such targeted capture measures. However, it is important to highlight that more information is urgently required on resource utilisation and selection, how great crested newts move within different habitat types, and their use of different habitat features in the UK, in order to improve this element of mitigation design.

(c) **Exclusions from prescribed areas**

For exclusions from, for example, a pipeline development, the example guidance presented in Example 4 in *the Guidelines* was generally supported by the results from this investigation. However, it would rarely be appropriate to extend exclusion fencing for greater than 100m to either side of a breeding pond, and then only if the pond itself is within 100m of the route. It is also appropriate to critically evaluate the need for, or cost effectiveness of, pitfall trapping, (i) to make shorter lengths of fencing effective, and (ii) to help reduce the effects of fragmentation. It would certainly be appropriate to move adults across the pipeline toward ponds in the early spring (however most pipelines will not be established during this period). It will often be less appropriate (or necessary) to relocate adults and juveniles across the pipeline away from ponds in the summer and autumn. It is also necessary to critically evaluate the need for exclusion fencing at all. Fencing is almost certainly necessary in the proximity of breeding ponds pre- mid-April and post- mid-August, but many pipelines are completed between these dates. Unless the works have to take place very close to the ponds, in some cases it may be possible to avoid fencing, given careful consideration of the likelihood, in practice, of incidental mortality.

For each of these elements it is helpful, when undertaking the detailed mitigation design, to ‘de-couple’ the aims of maintaining or enhancing the favourable conservation status of the local population, through mitigating losses of habitat and breeding sites; from measures to avoid the incidental mortality of individual newts. Assessments of the importance and likely success of such measures and the amount of resources allocated to each, referring back to the risk assessment, can then be made objectively.

7. Acknowledgements

This research was founded by English Nature. We are indebted to Jim Foster, whose idea the project was, for his help and support throughout, and critical appraisal, constructive comments and helpful additions to various drafts of this document. Thanks also to his colleagues at English Nature for helping to extract the various items of background information from the licensing files. We would also like to express our gratitude to the various workers whose licence return information was included within the different levels of analysis.

Various members of staff at Cresswell Associates contributed to different aspects of the project: Tom Clarkson, Kay Hawkins, Robin Jones, James Latham, Paola Reason, Stephanie Wray, Eleanor Weir.

8. References

ARNTZEN J.W. & TEUNIS S.F.M., 1993. A six year study on the population dynamics of the crested newt (*Triturus cristatus*) following the colonisation of a newly created pond. *Herpetological Journal,* **3**: pp. 99-110.

ARNTZEN J.W., OLDHAM R.S. & LATHAM D.M., 1995). Cost effective drift fences for toads and newts. *Amphibia-Reptilia,* **16**, pp. 137-145.

BEEBEE, T.J.C., 1977. Habitats of the British Amphibians (1): Chalk Uplands. *Biological Conservation,* **12** (4), 279-293.

Beebee, T.J.C., 1980. Habitats of the British Amphibians (3): River Valley Marshes. *Biological Conservation,* **18** (4), 281-287.

BEEBEE, T.J.C., 1981. Habitats of the British Amphibians. *Biological Conservation,* **21**, pp. 127-139.

COOK, E A.S., 1995. A comparison of survey methods for crested newts (*Triturus cristatus*) and night counts at a secure site, 1983-1993. *Herpetological Journal,* **5**, pp. 221-228.

FRANKLIN, P.S., 1993. The migratory ecology and terrestrial habitat preferences of the great crested newt (*Triturus cristatus*) at Little Wittenham Nature Reserve. De Montford University unpublished thesis.

FROGLIFE, 2001. *Great Crested Newt Conservation Handbook.* Suffolk: Froglife.

GRIFFITHS, R.A., 1985. A simple funnel trap for studying newt populations and an evaluation of trap behaviour in smooth and palmate newts *Triturus vulgaris* and *Triturus helveticus*. *Herpetological Journal,* **1,** pp. 5-10.

GRIFFITHS, R.A., RAPER, S.J. & BRADY, L.D., 1996. Evaluation of a standardised method for surveying common frogs (*Rana temporaria*) and newts (*Triturus cristatus, T. helveticus* and *T. vulgaris*). *JNCC Report,* **259.**

HALLEY, J.M., OLDHAM, R.S. & ARNTZEN, J.W., 1996. Predicting the persistence of amphibian populations with the help of a spatial model. *Journal of Applied Ecology,* **33**, pp. 455-470.

JEHLE, R., 2000.. The terrestrial summer habitat of radio-tracked great crested newts (*Triturus cristatus*) and marbled newts (*T. marmoratus*). *Herpetological Journal,* **10**, pp. 137-142.

JEHLE, R. & ARNTZEN, J.W., 2000. Post-breeding migrations of newts with contrasting ecological requirements. *J. Zool., Lond.,* **251**, pp. 297-306.

KEMP, B., 2001. Amphibian pitfall trapping at a site in Newhaven, East Sussex. *In Practice,* **34,** pp. 12-14.

KUPFER, A. & KNEITZ, S., 2000. Population Ecology of the great crested newt (*Triturus cristatus*) in an agricultural landscape: dynamics, pond fidelity and dispersal. *Herpetological Journal,* **10,** pp. 165 – 171.

LAAN, R. & VERBOOM, B., 1990. Effects of pool size and isolation on amphibian communities. *Biological Conservation,* **54**, pp. 251-262.

LATHAM, D.M., OLDHAM, R.S., STEVENSON, M.J., DUFF, R., FRANKLIN, P. & HEAD, S.M., 1996. Woodland management and the conservation of the great crested newt (*Triturus cristatus*). *Aspects of Applied Biology,* **44**, pp. 451-459.

MALMGREN, J.C., 2002. How does a newt find its way from a pond? Migration patterns after breeding and metamorphosis in great crested newts (*Triturus cristatus*) and smooth newts (*T. vulgaris*). *Herpetological Journal,* **12**, pp. 29-35.

OLDHAM, R.S. & NICHOLSON, M., 1986. *Status and ecology of the warty newt* Triturus cristatus. Report to the Nature Conservancy Council (Contract HF 3/05/123), Peterborough.

OLDHAM, R.S., KEEBLE ,J., SWAN, M.J.S. & JEFFCOTE, M., 2000. Evaluating the suitability of habitat for the great crested newt (*Triturus cristatus*). *Herpetological Journal,* **10,** pp. 143-155.

SWAN, M.J.S. & OLDHAM, R.S., 1993. National amphibian survey. Peterborough: *English Nature Research Reports*, No. 38.

SWAN, M.J.S & OLDHAM, R.S., 1994. Amphibians and landscape composition. *In:* J.W. DOVER, ed. *Fragmentation in agricultural landscapes.* Proc. 3rd annual International Association of Landscape Ecology (UK) Conference, Preston, pp. 176-183.

Appendix I. Variable name definitions and glossary of technical terms

Variable names	
Capture techniques:	
Drift fence	An amphibian-proof fence, generally an upright barrier formed by some form of plastic membrane or similar, used to exclude/deflect/guide newts moving within terrestrial habitats. Often used as a capture technique in conjunction with pitfall traps.
Pitfall trap	A sunken plastic bucket or similar into which newts tend to fall and from which they cannot easily escape. With damp cover material, drainage holes to prevent flooding, means for small mammals to escape and, in some circumstances a partial lid to increase capture efficiency.
Destructive/hand search	A method by which the first stages of site clearance proceed with care, under close supervision by suitably experienced ecologists. This can involve the demolition/excavation of structures and substrates by hand alone or in combination with a mechanical excavator or similar. The intention is, wherever possible, to identify and capture newts unharmed during this process. It usually takes place as the final stage in a capture and relocation process, in order to safely 'rescue' any remaining animals, once captures fall (reliably) to zero.
Netting	The careful use of hand-held pond nets or, in some cases static nets, to capture adult newts and larvae from standing water and the surface layers of pond sediment. This technique is far more efficiently employed in parallel with pond drainage. As with destructive searching, this is often undertaken as part of the latter stages of a capture and relocation operation, having been preceded by bottle trapping and terrestrial capture methods.
Funnel traps/bottle traps	Underwater traps usually constructed from 2 litre plastic bottles which adult newts and larvae enter but find difficulty in escaping from.
Nocturnal searches	A technique of torchlight searching of terrestrial habitat features and the hand investigation of vegetation and natural refuges during the night. This is a generally inefficient technique but under certain weather conditions can be helpful, particularly if focussed along drift fences.
Grass cutting/other vegetation manipulation	Simply the careful removal of vegetation to facilitate finding newts or increasing the effectiveness of artificial refuges.
Refuges/artificial cover objects	The placing of artificial refuges which provide newts with small areas of artificial cover and places of protection and relatively high humidity. Captures from beneath refuges can be helpful but this tends to be a relatively inefficient process.
Newt age classes:	
Adults	Animals which have reached sexual maturity
Sub-adults	Immature animals from the beginning of their second year onwards (newts usually reach sexual maturity in 2 to 4 years).
Juveniles	Newly land-adapted newts which have recently emerged from the breeding pond (newts usually emerge during the period August-September). Juveniles are also called 'efts'.
Larvae	The term used to describe the newts' developmental phase after hatching from eggs (laid between mid-March and mid-May) and until metamorphosis and emergence from the breeding pond (larvae take approximately 2-3 months to complete development).
Pond drainage/'draining-down'	The process of removing water from a breeding pond as part of a destructive search and the removal of a pond. Should be combined with netting. Precautions needed to avoid incidental mortality.
Other technical terms:	
Metapopulation	A series of sub-populations that are linked by the relatively frequent dispersal of individuals. Usually relates to 'pond clusters'.

First level of analysis database
File number
Total number of newts captured
Capture method used and numbers of traps
Trapping period
Habitat types present
Season
Geographic location
Type and size of development
Number of life stages involved
Level of detail in methods statement
Level of detail in licence return
Climate details provided
Population estimate
Population size class estimate
Monitoring carried out
Fencing configuration plan/comments

Project database	
File identification number	
Magnitude of development	1 = Temporary, very small area of habitat loss (<0.01ha) 1.5 = Temporary, small area of habitat loss (0.01-0.25ha) 2 = Permanent, very small area of habitat loss (<0.01ha) 2.5 = Temporary, medium area of habitat loss (0.25-1ha) 3 = Permanent, small area of habitat loss (0.01ha – 0.25ha) 3.5 = Temporary, large area of habitat loss (>1ha) 4 = Permanent, medium area of habitat loss (0.25 - 1ha) 4.5 = Permanent, large area of habitat loss (>1ha)
Population size class estimate	1 = Small 2 = Medium 3 = Large
Sum total of capture effort per method scores per file (maximum = 45)	See Capture Method database for scales of capture effort per method scores.
Latitude	
Longitude	
Number of different capture methods used	1 - 9
Types of capture method	1 = Only trap method used 2 = Only non trap method used 3 = Both trap and non-trap method used
Number of seasons in which mitigation took place	1 - 4
Population estimate	
Overall number of newts caught	
Overall number of newts caught excluding larvae	
Overall: captures/unit effort	Overall number of newts caught / overall subjective effort for all capture methods
Excl. larvae: captures/unit effort	Overall number of newts caught excluding larvae / overall subjective effort for all capture methods
Proximity to Breeding Ponds	1 = Breeding pond greater than 1km away 2 = Breeding pond 500-1000m away 3 = Breeding pond 200-500m away 4 = Breeding pond 50-200m away 5 = Single breeding pond less than 50m away 6 = Multiple breeding ponds less than 50m away 7 = Work within breeding pond
Number of larvae	
Number of juveniles	
Number of sub-adults	
Number of adults	
Total numbers at different life stages	
Number of newts caught at -0 Degrees C	
Number of newts caught at 0 - 1.9 Degrees C	
Number of newts caught at 2 - 3.9 Degrees C	
Number of newts caught at 4 - 5.9 Degrees C	
Number of newts caught at 6 - 7.9 Degrees C	
Number of newts caught at 8 - 9.9 Degrees C	
Number of newts caught at 10 - 11.9 Degrees C	
Number of newts caught at 12 - 13.9 Degrees C	
Number of newts caught at 14 - 15.9 Degrees C	
Number of newts caught at 16 + Degrees C	

Rough Grassland Present/Absent	0 Absent; 1 Present
Scrub Present/Absent	0 Absent; 1 Present
Arable Present/Absent	0 Absent; 1 Present
Grassland Present/Absent	0 Absent; 1 Present
Deciduous Woodland Present/Absent	0 Absent; 1 Present
Ditch Present/Absent	0 Absent; 1 Present
Garden Present/Absent	0 Absent; 1 Present
Hedgerow Present/Absent	0 Absent; 1 Present
Marsh Present/Absent	0 Absent; 1 Present
Meadow Present/Absent	0 Absent; 1 Present
Pasture Present/Absent	0 Absent; 1 Present
Rubble Present/Absent	0 Absent; 1 Present
Tall Herbs Present/Absent	0 Absent; 1 Present
Treatment Works Present/Absent	0 Absent; 1 Present
Woodland Present/Absent	0 Absent; 1 Present
Quarry Present/Absent	0 Absent; 1 Present
Building Present/Absent	0 Absent; 1 Present
Size in m^2 of Rough Grassland	
Size in m^2 of Scrub	
Size in m^2 of Arable	
Size in m^2 of Grassland	
Size in m^2 of Deciduous Woodland	
Size in m^2 of Ditch	
Size in m^2 of Garden	
Size in m^2 of Hedge	
Size in m^2 of Marsh	
Size in m^2 of Meadow	
Size in m^2 of Pasture	
Size in m^2 of Rubble	
Size in m^2 of Tall herb	
Size in m^2 of Water treatment works	
Size in m^2 of Woodland	
Size in m^2 of Quarry	
Size in m^2 of Building	
Distance of Rough grassland from Breeding Pond	1 = Breeding pond greater than 1km away 2 = Breeding pond 500-1000m away 3 = Breeding pond 200-500m away 4 = Breeding pond 50-200m away 5 = Single breeding pond less than 50m away 6 = Multiple breeding ponds less than 50m away 7 = Work within breeding pond
Distance of Scrub from Breeding Pond	
Distance of Arable from Breeding Pond	
Distance of Grassland from Breeding Pond	
Distance of Deciduous Woodland from Breeding Pond	
Distance of Ditch from Breeding Pond	
Distance of Garden from Breeding Pond	
Distance of Hedgerow from Breeding Pond	
Distance of Marsh from Breeding Pond	
Distance of Meadow from Breeding Pond	
Distance of Pasture from Breeding Pond	
Distance of Rubble from Breeding Pond	
Distance of Tall herb from Breeding Pond	
Distance of Water Treatment Works from Breeding Pond	
Distance of Woodland from Breeding Pond	
Distance of Quarry from Breeding Pond	
Distance of Building from Breeding Pond	
Total Newt Captures within Rough Grassland	
Total Newt Captures within Scrub	
Total Newt Captures within Arable	
Total Newt Captures within Grassland	
Total Newt Captures within Deciduous Woodland	
Total Newt Captures within Ditch	
Total Newt Captures within Garden	
Total Newt Captures within Hedge	
Total Newt Captures within Marsh	
Total Newt Captures within Meadow	
Total Newt Captures within Pasture	
Total Newt Captures within Pasture	
Total Newt Captures within Tall herb	

Total Newt Captures within Water Treatment Works		
Total Newt Captures within Woodland		
Total Newt Captures within Quarry		
Total Newt Captures within Building		
Rough Grassland Subjective Effort	Insufficient data to calculate subjective effort for habitats	
Scrub Subjective Effort		
Arable Subjective Effort		
Grassland Subjective Effort		
Deciduous Woodland Subjective Effort		
Ditch Subjective Effort		
Garden Subjective Effort		
Hedgerow Subjective Effort		
Marsh Subjective Effort		
Meadow Subjective Effort		
Pasture Subjective Effort		
Rubble Subjective Effort		
Tall herb Subjective Effort		
Water Treatment Works Subjective Effort		
Woodland Subjective Effort		
Quarry Subjective Effort		
Building Subjective Effort		
Pasture, meadow or grassland present	0 Absent; 1 Present	
Rough grassland or tall herbs present	0 Absent; 1 Present	
Any woodland present	0 Absent; 1 Present	
Ditch or marsh present	0 Absent; 1 Present	
Hedgerow present	0 Absent; 1 Present	
Post-industrial habitats present	0 Absent; 1 Present	
Arable present	0 Absent; 1 Present	
Scrub present	0 Absent; 1 Present	
Weighted grassland by distance	Presence or absence x proximity to breeding pond	
Weighted rough grass by distance		
Weighted woodland by distance		
Weighted wet habitats by distance		
Weighted hedgerow by distance		
Weighted post-industrial by distance		
Weighted arable by distance		
Weighted scrub by distance		
Adult captures per unit effort	Number of adult newts caught / total subjective effort for all capture methods	
Overall fencing configuration	0 = Ring fenced breeding pond 1 = Fencing other than ring fenced breeding pond 2 = Both of the above 3 = Neither	
Pond or not pond mitigation	1 = Mitigation excluding the breeding pond 2 = Mitigation including the breeding pond	
Transformation of habitat variables for all subsequent databases	Deciduous Woodland	Woodland
	Woodland	
	Improved Grassland	Grassland
	Meadow	
	Pasture	
	Grassland	
	Amenity Grassland	
	Rough Grassland	Rough Grassland/Tall Herbs
	Tall Herbs	
	Ditch	Wet Habitats
	Marsh	
	Hedgerow	Hedgerow
	Arable	Arable
	Scrub	Scrub
	Quarry	Post Industrial
	Water Treatment Works	
	Rubble	
	Garden	
	Building	

Capture method database	
File identification number	
Numerical population estimate	
Total number of newts caught	
Proximity to breeding ponds	1 = Breeding pond greater than 1km away 2 = Breeding pond 500-1000m away 3 = Breeding pond 200-500m away 4 = Breeding pond 50-200m away 5 = Single breeding pond less than 50m away 6 = Multiple breeding ponds less than 50m away 7 = Work within breeding pond
Fencing configuration	0 = Ring fenced breeding pond 1 = Fencing other than ring fenced breeding pond 2 = Both of the above 3 = Neither
Mitigation inc/excl pond	1 = Excluding pond 2 = Including pond
Trapping effort estimate pitfalls and refuges	1 = Less than 30 trap nights, less than 1 trap every 15m+ 2 = Less than 30 trap nights, 1 trap every 10 – 14.99m 3 = 30 trap nights, 1 trap every 10m 4 = More than 30 trap nights, 1 trap every 5 - 9.9m 5 = More than 30 trap nights, 1 trap every 4.99m or less
Trapping effort estimate for bottle traps	1 = Less than 20 trap nights, very low trap density 2 = 20-30 trap nights, less than 1 trap every 2m 3 = 30 trap nights, 1 trap every 2m 4 = More than 30 trap nights, 1 trap every 1 – 1.99m 5 = More than 30 trap nights, very high trap density
Trapping effort estimate for non trap methods	Destructive/Hand Search 1-5 scale based on time per area, whether a machine was involved, type of terrain. Where there was insufficient information, a score was estimated dependent on the level of detail provided for that technique compared to other capture methods. The approximate scale, taking these factors into account is based on covering 20m^2 per day. 1 = Less than 1 day 2 = Less than 4 days 3 = 5/6 days 4 = Up to 10 days 5 = More than 10 days Netting and Nocturnal Searches Loosely based on time per area 1 = Inadequate 2 = Poor 3 = Good 4 = Very good 5 = Excellent Drainage Scale of 1-5 as for netting and nocturnal searches, but taking into account, for example, whether preliminary mitigation was used (e.g. netting) and how comprehensive the approach was.
Combined effort scores	Total of all trapping effort scores
Capture method	1 = Hand search; 2 = Destructive search; 3 = Netting; 4 = Nocturnal; 5 = 5 = Grass cutting; 6 = Pitfall traps; 7 = Refuges; 8 = Funnel traps; 9 = Pond drainage
Is the capture method a trap or not?	1 = Trap; 2 = Non trap
Number of traps	
Area of traps	
Trap density	Number of traps / area of traps
Number of trapping nights	
Capture effort for traps	Number of traps x number of trapping nights
Duration of non-trap mitigation (days)	
Non trapping effort value	Duration of non-trap mitigation x area of mitigation
Number of larvae	
Number of juveniles	
Number of sub-adults	
Number of adults	

Capture method database	
Total numbers at different life stages	
Total numbers excluding larvae	
Captures/unit effort larvae	Captures of newt larvae / subjective effort score for that capture method
Captures/unit effort juveniles	Captures of newt juveniles / subjective effort score for that capture method
Captures/unit effort sub-adults	Captures of newt sub-adults / subjective effort score for that capture method
Captures/unit effort adults	Captures of adult newts / subjective effort score for that capture method
Captures/unit effort/all life stages	Total captures of newts / subjective effort score for that capture method
Number of newts caught at -0 Degrees C	
Number of newts caught at 0 - 1.9 Degrees C	
Number of newts caught at 2 - 3.9 Degrees C	
Number of newts caught at 4 - 5.9 Degrees C	
Number of newts caught at 6 - 7.9 Degrees C	
Number of newts caught at 8 - 9.9 Degrees C	
Number of newts caught at 10 - 11.9 Degrees C	
Number of newts caught at 12 - 13.9 Degrees C	
Number of newts caught at 14 - 15.9 Degrees C	
Number of newts caught at 16 + Degrees C	
Total numbers of newts at different temperatures	
Rough Grassland Present/Absent	0 Absent; 1 Present
Scrub Present/Absent	0 Absent; 1 Present
Arable Present/Absent	0 Absent; 1 Present
Grassland Present/Absent	0 Absent; 1 Present
Deciduous Woodland Present/Absent	0 Absent; 1 Present
Ditch Present/Absent	0 Absent; 1 Present
Garden Present/Absent	0 Absent; 1 Present
Hedgerow Present/Absent	0 Absent; 1 Present
Marsh Present/Absent	0 Absent; 1 Present
Meadow Present/Absent	0 Absent; 1 Present
Pasture Present/Absent	0 Absent; 1 Present
Rubble Present/Absent	0 Absent; 1 Present
Tall Herbs Present/Absent	0 Absent; 1 Present
Treatment Works Present/Absent	0 Absent; 1 Present
Woodland Present/Absent	0 Absent; 1 Present
Quarry Present/Absent	0 Absent; 1 Present
Building Present/Absent	0 Absent; 1 Present
Size in m^2 of Rough Grassland	
Size in m^2 of Scrub	
Size in m^2 of Arable	
Size in m^2 of Grassland	
Size in m^2 of Deciduous Woodland	
Size in m^2 of Ditch	
Size in m^2 of Garden	
Size in m^2 of Hedge	
Size in m^2 of Marsh	
Size in m^2 of Meadow	
Size in m^2 of Pasture	
Size in m^2 of Rubble	
Size in m^2 of Tall herb	
Size in m^2 of Water treatment works	
Size in m^2 of Woodland	
Size in m^2 of Quarry	
Size in m^2 of Building	

Capture method database	
Distance of Rough grassland from Breeding Pond	1 = Breeding pond greater than 1km away 2 = Breeding pond 500-1000m away 3 = Breeding pond 200-500m away 4 = Breeding pond 50-200m away 5 = Single breeding pond less than 50m away 6 = Multiple breeding ponds less than 50m away 7 = Work within breeding pond
Distance of Scrub from Breeding Pond	
Distance of Arable from Breeding Pond	
Distance of Grassland from Breeding Pond	
Distance of Deciduous Woodland from Breeding Pond	
Distance of Ditch from Breeding Pond	
Distance of Garden from Breeding Pond	
Distance of Hedgerow from Breeding Pond	
Distance of Marsh from Breeding Pond	
Distance of Meadow from Breeding Pond	
Distance of Pasture from Breeding Pond	
Distance of Rubble from Breeding Pond	
Distance of Tall herb from Breeding Pond	
Distance of Water Treatment Works from Breeding Pond	
Distance of Woodland from Breeding Pond	
Distance of Quarry from Breeding Pond	
Distance of Building from Breeding Pond	
Total Newt Captures within Rough Grassland	
Total Newt Captures within Scrub	
Total Newt Captures within Arable	
Total Newt Captures within Grassland	
Total Newt Captures within Deciduous Woodland	
Total Newt Captures within Ditch	
Total Newt Captures within Garden	
Total Newt Captures within Hedge	
Total Newt Captures within Marsh	
Total Newt Captures within Meadow	
Total Newt Captures within Pasture	
Total Newt Captures within Pasture	
Total Newt Captures within Tall herb	
Total Newt Captures within Water Treatment Works	
Total Newt Captures within Woodland	
Total Newt Captures within Quarry	
Total Newt Captures within Building	
Rough Grassland Subjective Effort	
Scrub Subjective Effort	Insufficient data to calculate a subjective effort score for each habitat
Arable Subjective Effort	
Grassland Subjective Effort	
Deciduous Woodland Subjective Effort	
Ditch Subjective Effort	
Garden Subjective Effort	
Hedgerow Subjective Effort	
Marsh Subjective Effort	
Meadow Subjective Effort	
Pasture Subjective Effort	
Rubble Subjective Effort	
Tall herb Subjective Effort	
Water Treatment Works Subjective Effort	
Woodland Subjective Effort	
Quarry Subjective Effort	
Building Subjective Effort	

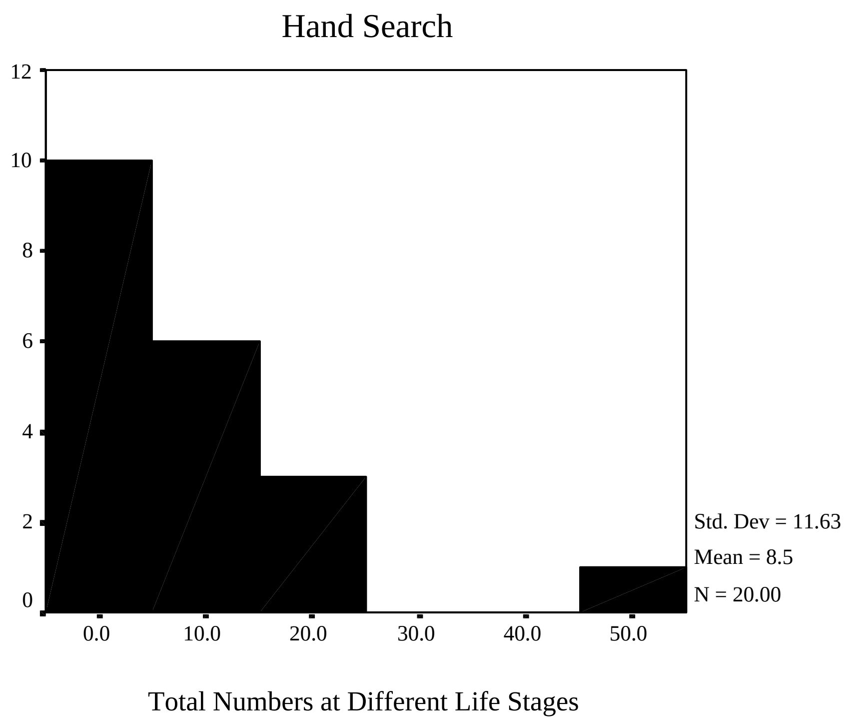
Capture method database	
Capture effort per Rough Grassland	Insufficient data to calculate a capture effort score for each habitat
Capture effort per Scrub	
Capture effort per Arable	
Capture effort per Grassland	
Capture effort per Deciduous Woodland	
Capture effort per Ditch	
Capture effort per Garden	
Capture effort per Hedgerow	
Capture effort per Marsh	
Capture effort per Meadow	
Capture effort per Pasture	
Capture effort per Rubble	
Capture effort per Tall herb	
Capture effort per Water Treatment Works	
Capture effort per Woodland	
Capture effort per Quarry	
Capture effort per Building	

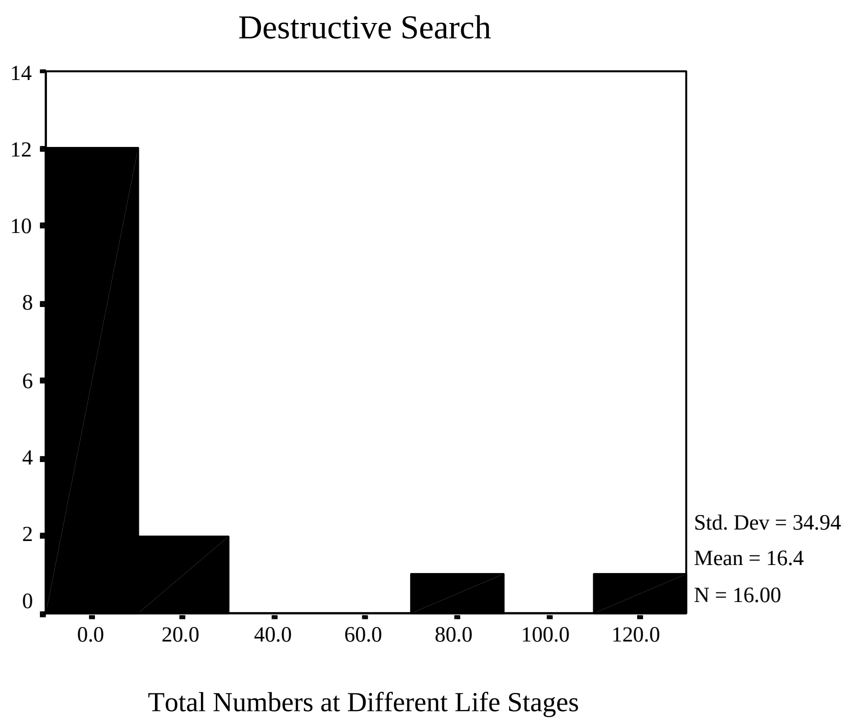
Seasonal database	
Variable	**Values**
File identification number	
Estimate of effort per capture method	*Pitfalls and Refuges* 1 = Less than 30 trap nights, less than 1 trap every 15m+ 2 = Less than 30 trap nights, 1 trap every 10 – 14.99m 3 = 30 trap nights, 1 trap every 10m 4 = More than 30 trap nights, 1 trap every 5 - 9.9m 5 = More than 30 trap nights, 1 trap every 4.99m or less *Bottle Traps* 1 = Less than 20 trap nights, very low trap density 2 = 20-30 trap nights, less than 1 trap every 2m 3 = 30 trap nights, 1 trap every 2m 4 = More than 30 trap nights, 1 trap every 1 – 1.99m 5 = More than 30 trap nights, very high trap density *Destructive/Hand Search* 1-5 scale based on time per area, whether a machine was involved, type of terrain. Where there was insufficient information, a score was estimated dependent on the level of detail provided for that technique compared to other capture methods. The approximate scale, taking these factors into account is based on covering $20m^2$ per day. 1 = Less than 1 day 2 = Less than 4 days 3 = 5/6 days 4 = Up to 10 days 5 = More than 10 days *Netting and Nocturnal Searches* Loosely based on time per area 1 = Inadequate 2 = Poor 3 = Good 4 = Very good 5 = Excellent *Drainage* Scale of 1-5 as for netting and nocturnal searches, but taking into account, for example, whether preliminary mitigation was used (e.g. netting) and how comprehensive the approach was.
Numerical population estimate	
Total number of newts caught	
Proximity to breeding ponds	1 = Breeding pond greater than 1km away 2 = Breeding pond 500-1000m away 3 = Breeding pond 200-500m away 4 = Breeding pond 50-200m away 5 = Single breeding pond less than 50m away 6 = Multiple breeding ponds less than 50m away 7 = Work within breeding pond
Fencing configuration	0 = Ring fenced breeding pond 1 = Fencing other than ring fenced breeding pond 2 = Both of the above 3 = Neither
Capture method	1 = Hand search; 2 = Destructive search; 3 = Netting; 4 = Nocturnal; 5 = Grass cutting; 6 = Pitfall traps; 7 = Refuges; 8 = Funnel traps; 9 = Pond drainage
Is the capture method a trap or not?	1 = Trap; 2 = Non trap
Season	1 = Feb-April; 2 = May-Jul; 3 = Aug-Oct; 4 = Nov-Jan
Number of traps	
Area of traps	
Trap density	Number of traps / area of traps
Number of trapping nights	
Capture effort for traps	Number of traps x number of trapping nights
Duration of non-trap mitigation (days)	

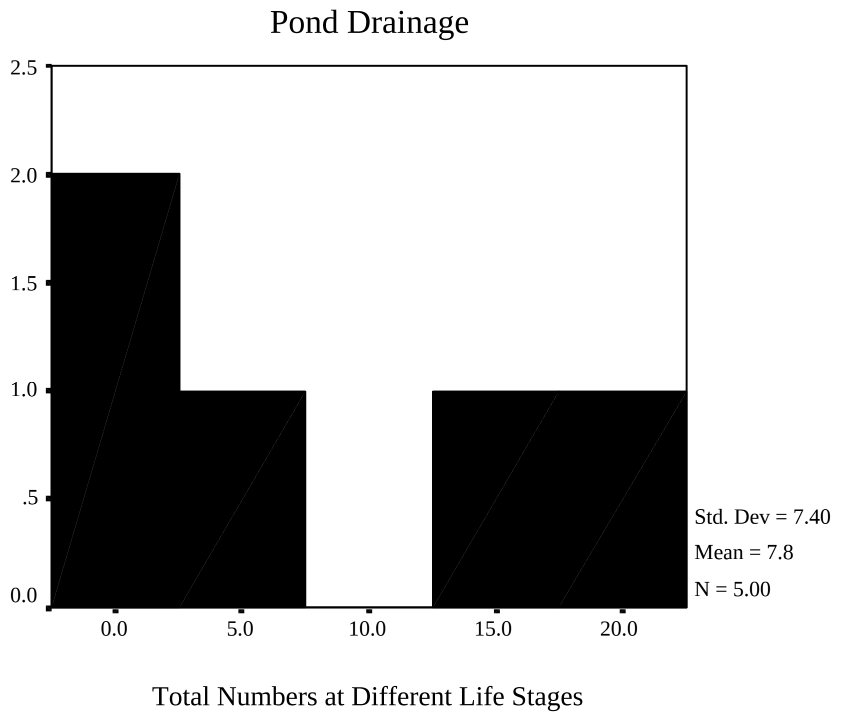
Seasonal database	
Non trapping effort value	Duration of non-trap mitigation x area of mitigation
Number of larvae	
Number of juveniles	
Number of sub-adults	
Number of adults	
Total numbers at different life stages	
Number of newts caught at -0 Degrees C	
Number of newts caught at 0 - 1.9 Degrees C	
Number of newts caught at 2 - 3.9 Degrees C	
Number of newts caught at 4 - 5.9 Degrees C	
Number of newts caught at 6 - 7.9 Degrees C	
Number of newts caught at 8 - 9.9 Degrees C	
Number of newts caught at 10 - 11.9 Degrees C	
Number of newts caught at 12 - 13.9 Degrees C	
Number of newts caught at 14 - 15.9 Degrees C	
Number of newts caught at 16 + Degrees C	
Total numbers of newts at all temperatures	
Rough Grassland Present/Absent	0 Absent; 1 Present
Scrub Present/Absent	0 Absent; 1 Present
Arable Present/Absent	0 Absent; 1 Present
Grassland Present/Absent	0 Absent; 1 Present
Deciduous Woodland Present/Absent	0 Absent; 1 Present
Ditch Present/Absent	0 Absent; 1 Present
Garden Present/Absent	0 Absent; 1 Present
Hedgerow Present/Absent	0 Absent; 1 Present
Marsh Present/Absent	0 Absent; 1 Present
Meadow Present/Absent	0 Absent; 1 Present
Pasture Present/Absent	0 Absent; 1 Present
Rubble Present/Absent	0 Absent; 1 Present
Tall Herbs Present/Absent	0 Absent; 1 Present
Treatment Works Present/Absent	0 Absent; 1 Present
Woodland Present/Absent	0 Absent; 1 Present
Quarry Present/Absent	0 Absent; 1 Present
Building Present/Absent	0 Absent; 1 Present
Size in m^2 of Rough grassland	
Size in m^2 of Scrub	
Size in m^2 of Arable	
Size in m^2 of Grassland	
Size in m^2 of woodland	
Size in m^2 of Ditch	
Size in m^2 of Garden	
Size in m^2 of Hedge	
Size in m^2 of Marsh	
Size in m^2 of Meadow	
Size in m^2 of Pasture	
Size in m^2 of Rubble	
Size in m^2 of Tall herb	
Size in m^2 of Water treatment works	
Size in m^2 of Woodland	
Size in m^2 of Quarry	
Size in m^2 of Building	
Distance of Rough grassland from Breeding Pond	1 = Breeding pond greater than 1km away 2 = Breeding pond 500-1000m away 3 = Breeding pond 200-500m away 4 = Breeding pond 50-200m away 5 = Single breeding pond less than 50m away 6 = Multiple breeding ponds less than 50m away 7 = Work within breeding pond
Distance of Scrub from Breeding Pond	
Distance of Arable from Breeding Pond	
Distance of Grassland from Breeding Pond	
Distance of Deciduous Woodland from Breeding Pond	
Distance of Ditch from Breeding Pond	
Distance of Garden from Breeding Pond	
Distance of Hedgerow from Breeding Pond	
Distance of Marsh from Breeding Pond	
Distance of Meadow from Breeding Pond	
Distance of Pasture from Breeding Pond	
Distance of Rubble from Breeding Pond	
Distance of Tall herb from Breeding Pond	
Distance of Water Treatment Works from Breeding Pond	
Distance of Woodland from Breeding Pond	
Distance of Quarry from Breeding Pond	
Distance of Building from Breeding Pond	

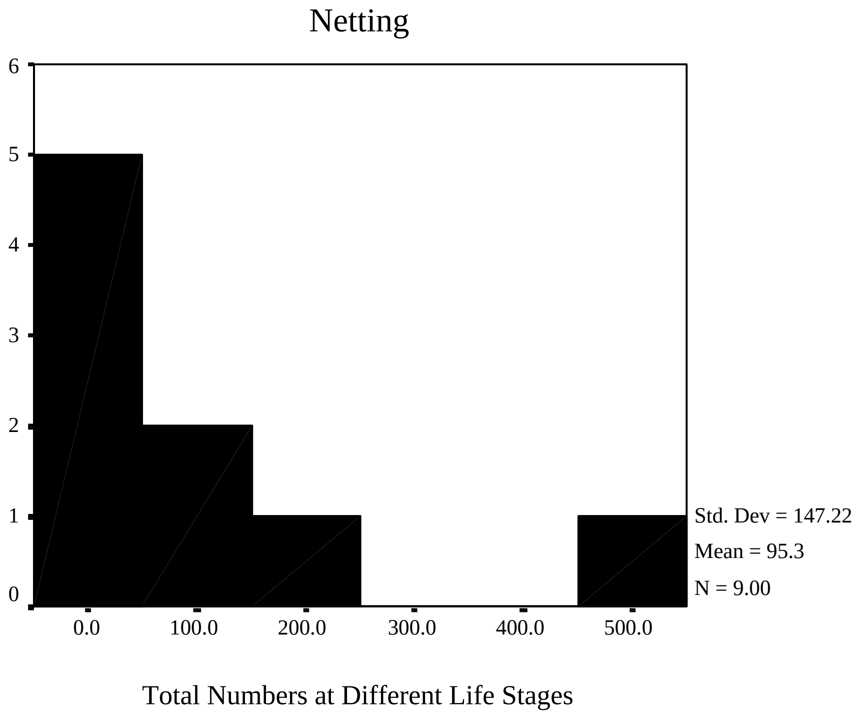
Seasonal database	
Total Newt Captures within Rough Grassland	
Total Newt Captures within Scrub	
Total Newt Captures within Arable	
Total Newt Captures within Grassland	
Total Newt Captures within Deciduous Woodland	
Total Newt Captures within Ditch	
Total Newt Captures within Garden	
Total Newt Captures within Hedge	
Total Newt Captures within Marsh	
Total Newt Captures within Meadow	
Total Newt Captures within Pasture	
Total Newt Captures within Pasture	
Total Newt Captures within Tall herb	
Total Newt Captures within Water Treatment Works	
Total Newt Captures within Woodland	
Total Newt Captures within Quarry	
Total Newt Captures within Building	
Rough Grassland Subjective Effort	Insufficient data to calculate a subjective effort score for each habitat
Scrub Subjective Effort	
Arable Subjective Effort	
Grassland Subjective Effort	
Deciduous Woodland Subjective Effort	
Ditch Subjective Effort	
Garden Subjective Effort	
Hedgerow Subjective Effort	
Marsh Subjective Effort	
Meadow Subjective Effort	
Pasture Subjective Effort	
Rubble Subjective Effort	
Tall herb Subjective Effort	
Water Treatment Works Subjective Effort	
Woodland Subjective Effort	
Quarry Subjective Effort	
Building Subjective Effort	
Capture effort per Rough Grassland	Insufficient data to calculate a capture effort for each habitat
Capture effort per Scrub	
Capture effort per Arable	
Capture effort per Grassland	
Capture effort per Deciduous Woodland	
Capture effort per Ditch	
Capture effort per Garden	
Capture effort per Hedgerow	
Capture effort per Marsh	
Capture effort per Meadow	
Capture effort per Pasture	
Capture effort per Rubble	
Capture effort per Tall herb	
Capture effort per Water Treatment Works	
Capture effort per Woodland	
Capture effort per Quarry	
Capture effort per Building	

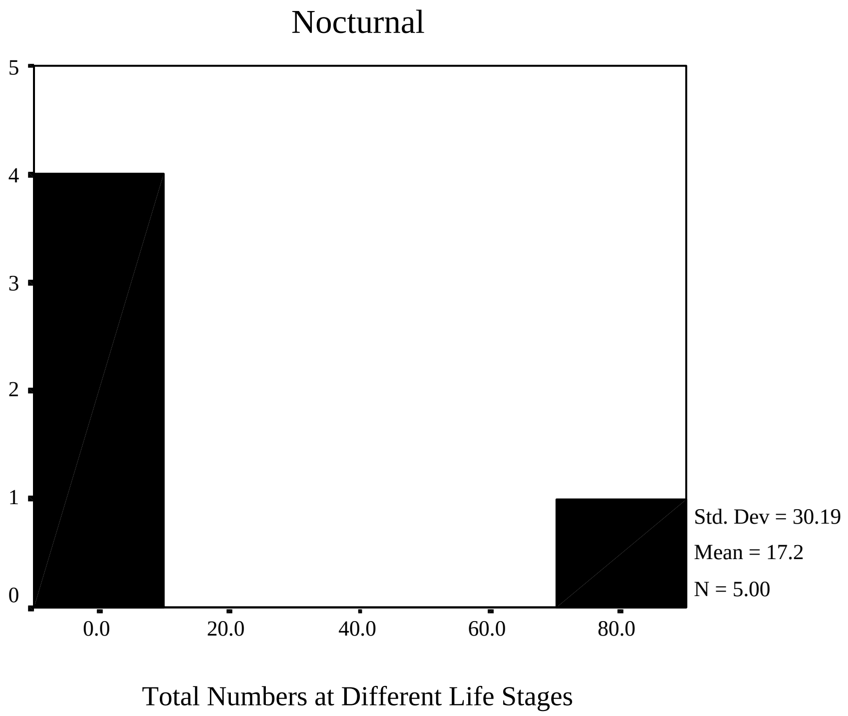
Appendix II. Histograms of total captures using different capture methods

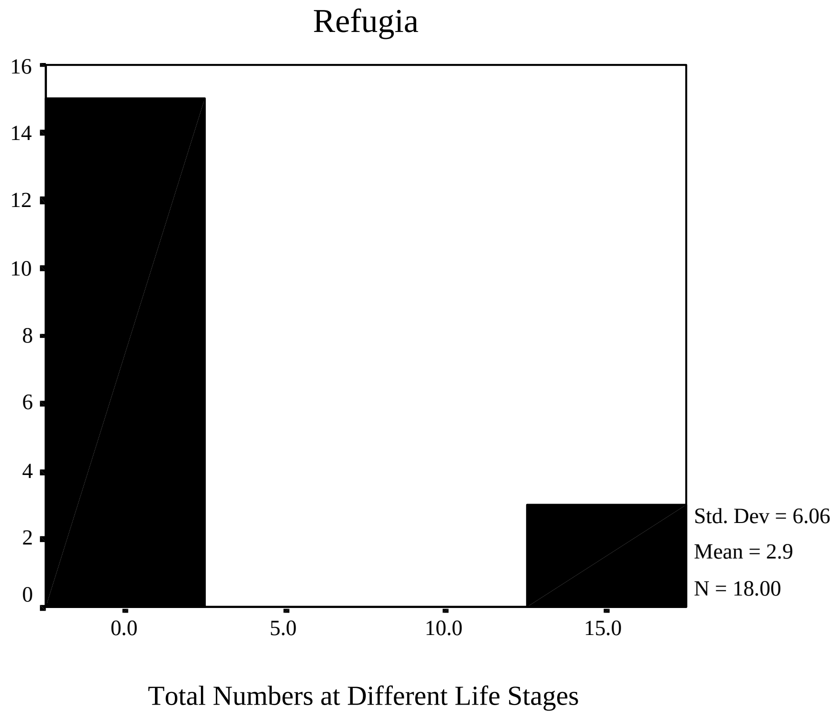




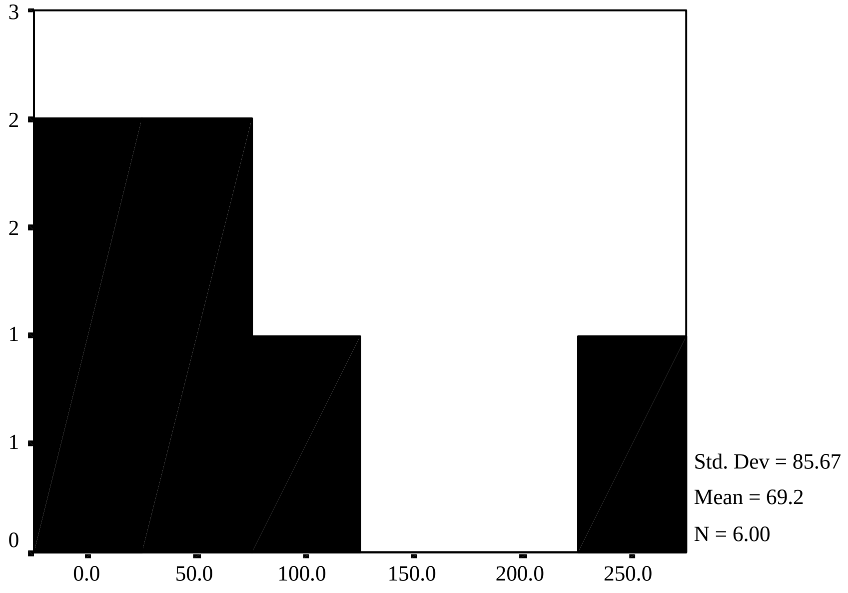

Pond Drainage
2.5
2.0
1.5
1.0
.5
0.0
0.0
5.0
10.0
15.0
20.0
Std. Dev = 7.40
Mean = 7.8
N = 5.00
Total Numbers at Different Life Stages


Netting
6
5
4
3
2
1
0
0.0
100.0
200.0
300.0
400.0
500.0
Std. Dev = 147.22
Mean = 95.3
N = 9.00
Total Numbers at Different Life Stages


Nocturnal
5
4
3
2
1
0
Std. Dev = 30.19
Mean = 17.2
N = 5.00
0.0
20.0
40.0
60.0
80.0
Total Numbers at Different Life Stages

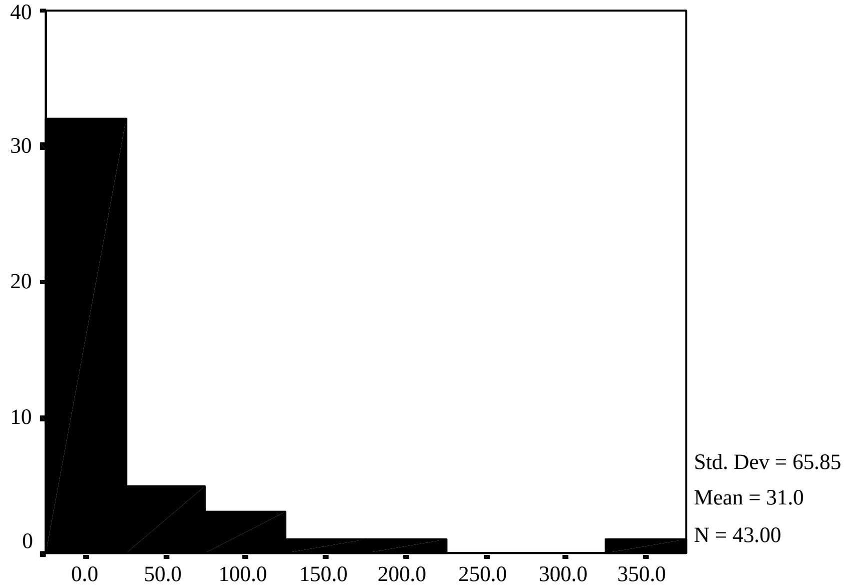

Refugia
16
14
12
10
8
6
4
2
0
Std. Dev = 6.06
Mean = 2.9
N = 18.00
0.0
5.0
10.0
15.0
Total Numbers at Different Life Stages

Bottle Traps



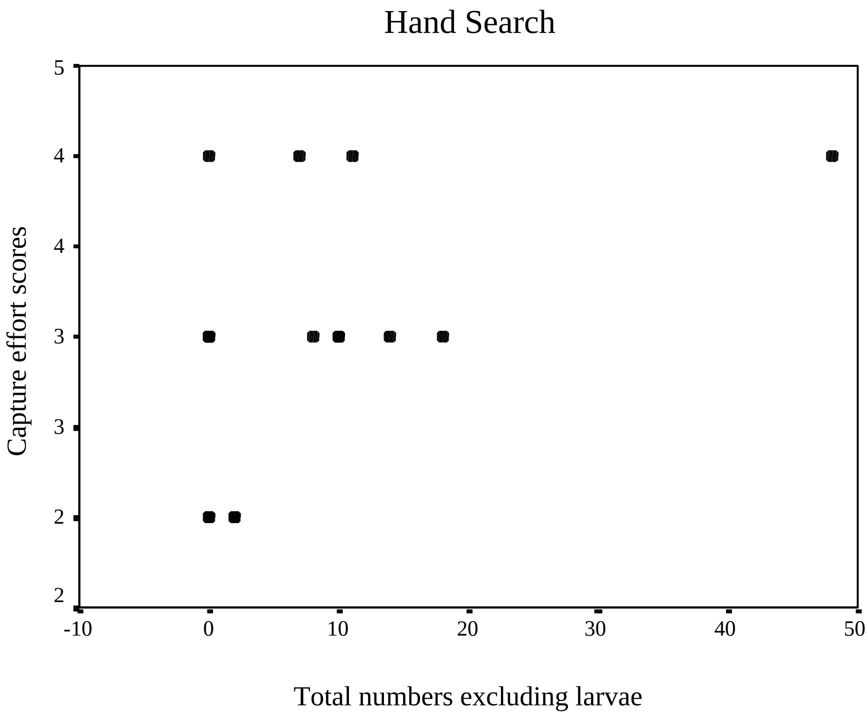
Total Numbers at Different Life Stages

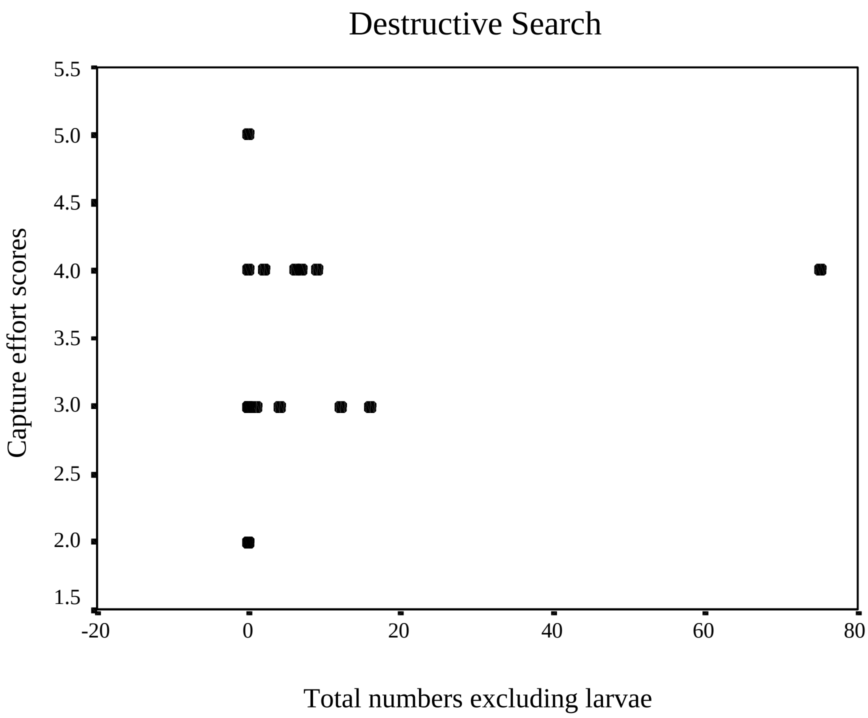
Pitfalls

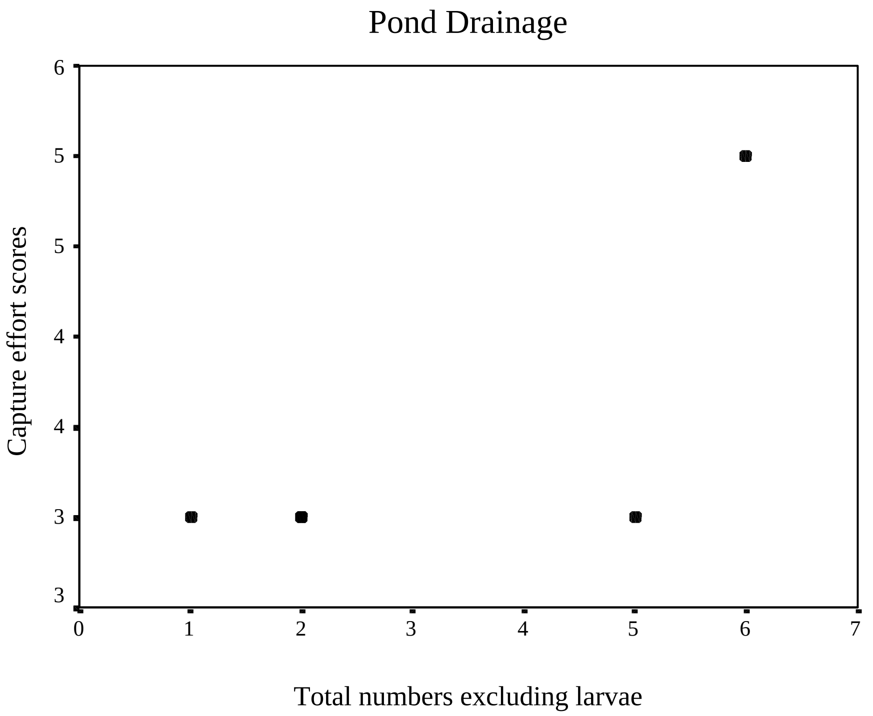


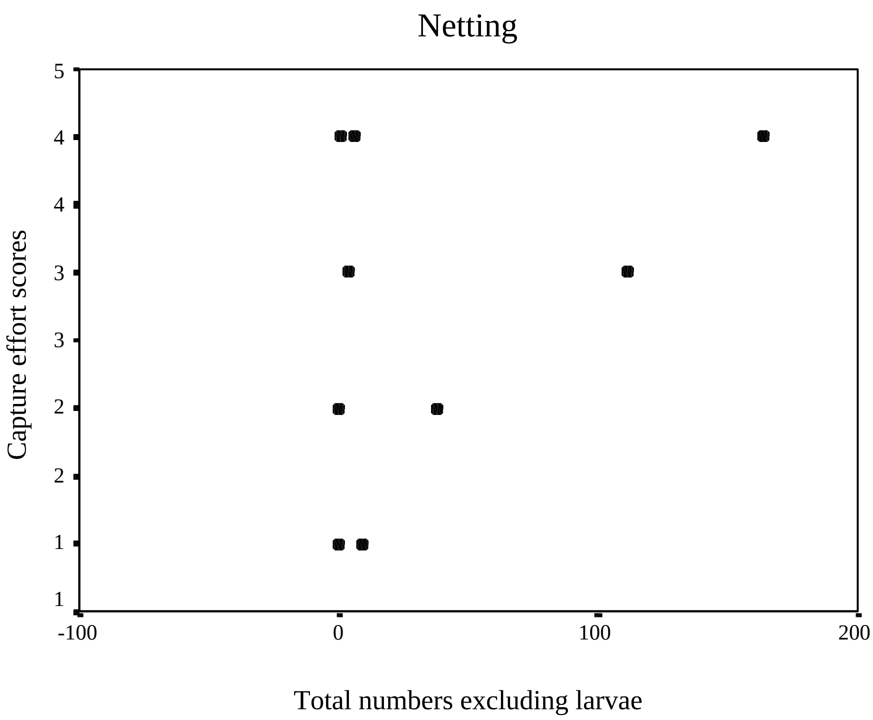
Total Numbers at Different Life Stages

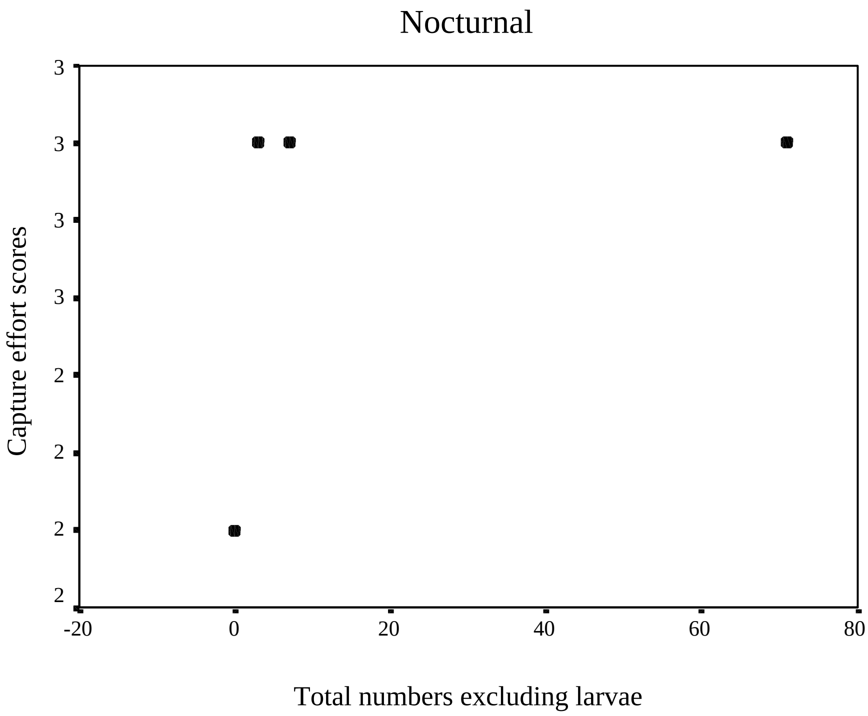
Appendix III. Scatter plots of Effort Scores against total numbers of newts caught, excluding larvae for different capture techniques

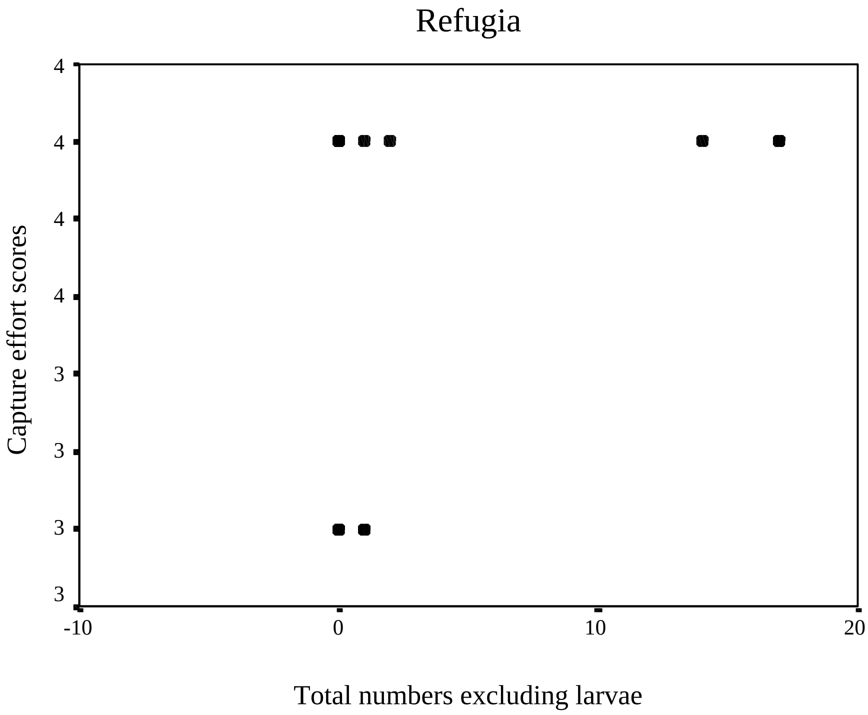




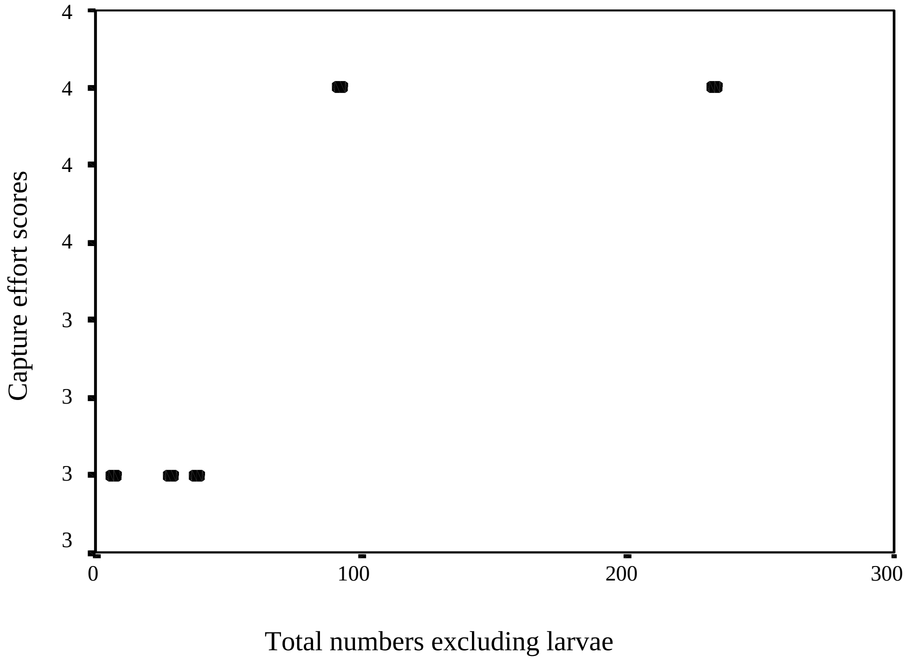

Pond Drainage
Capture effort scores
6
5
5
4
4
3
3
0
1
2
3
4
5
6
7
Total numbers excluding larvae


Netting
Capture effort scores
5
4
4
3
3
2
2
1
1
-100
0
100
200
Total numbers excluding larvae

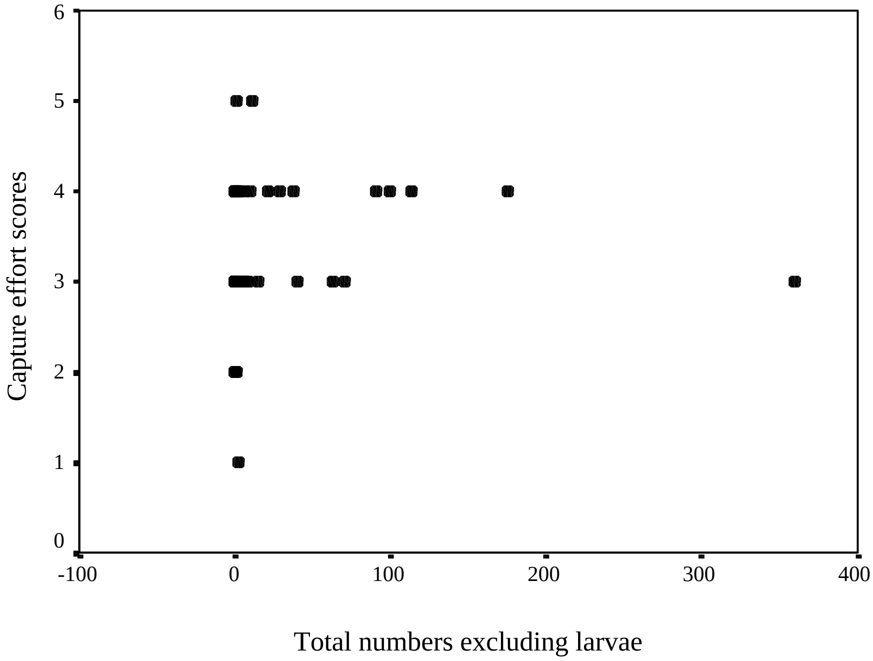

Nocturnal
3
3
3
3
2
2
2
2
-20
0
20
40
60
80
Capture effort scores
Total numbers excluding larvae


Refugia
4
4
4
4
3
3
3
3
-10
0
10
20
Capture effort scores
Total numbers excluding larvae

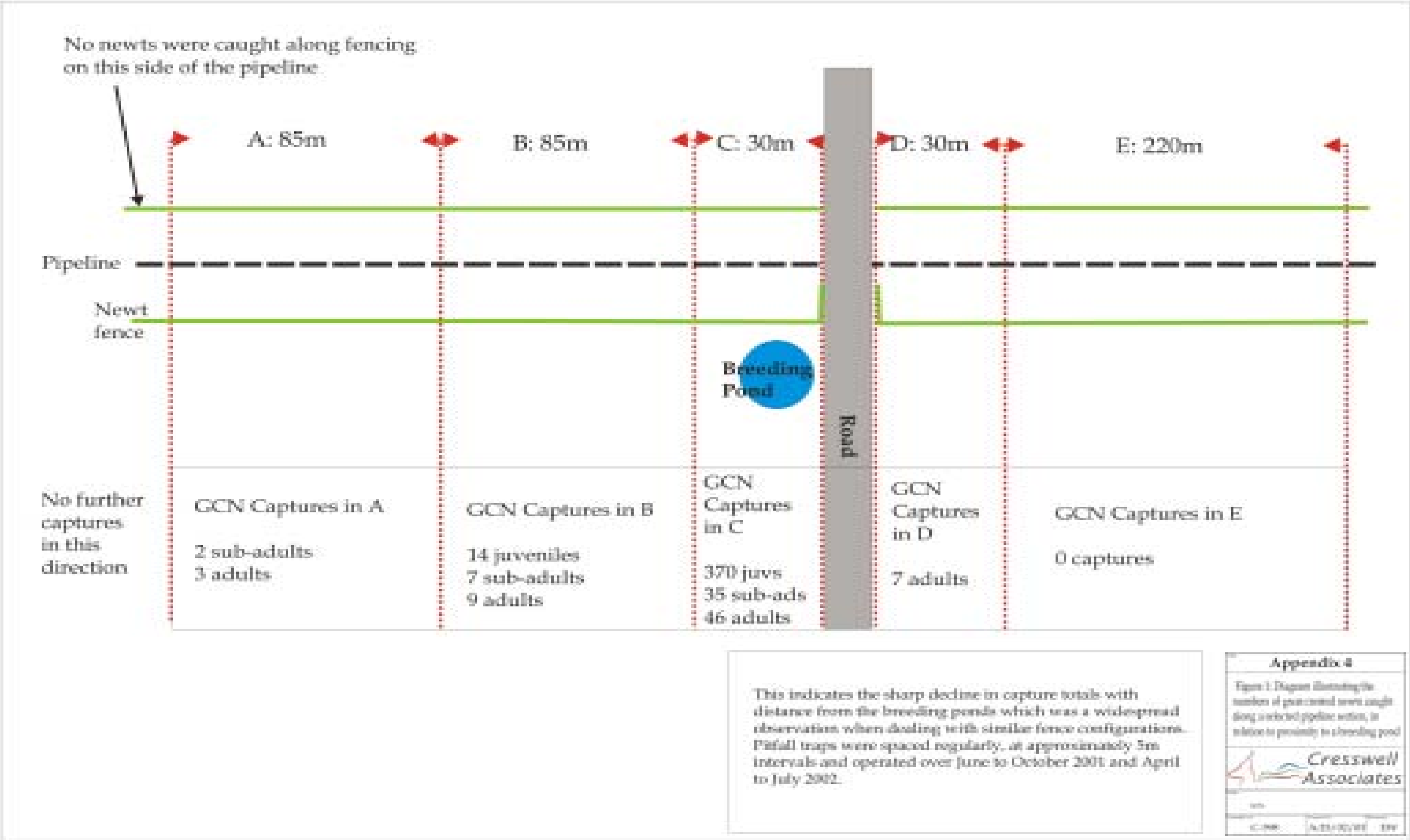
Bottle Traps



Pitfalls



Appendix IV. Examples of fence configurations and capture results




Key
Active development
Perimeter fence
Pitfalls @ 10m one side
Internal drift fence
Pitfalls @ 10m both sides
Other amphibian-proof boundaries
Ponds containing great crested newts
A
B
C
D
E
F
G
H
I
J
Numbers of great crested newts captured in each compartment
Compartment A: 24
Compartment B: 5
Compartment C: 22
Compartment D: 3
Compartment E: 5
Compartment F: 16
Compartment G: 18
Compartment H: 2
Compartment I: 10
Compartment J: 10
This indicates an apparently successful compartment-style fence arrangement in clearing newts from a future development area.
Newt captures, as expected, were highest in Compartment A (very close to a pond and hedge line) and Compartments F and G (enclosing a central hedge leading away from pond areas). Using compartments, trapping effort can be maximised in areas predicted to be used most frequently by newts. However, during installation care needs to be taken to avoid incidental mortality.
Appendix 4
Figure 2: Example of the use of compartment-style fence alignment in a successful newt capture operation
Cresswell Associates
EW

ENGLISH NATURE

English Nature is the Government agency that champions the conservation of wildlife and geology throughout England.

This is one of a range of publications published by:
External Relations Team
English Nature
Northminster House
Peterborough PE1 1UA

www.english-nature.org.uk

Cover printed on Character Express, post consumer waste paper, ECF.

ISSN 0967-876X

Cover designed and printed by Status Design & Advertising, 2M, 5M, 5M.

Front cover photographs:
Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888

CHARTER MARK
Awarded for excellence