Survey protocols for the British herpetofauna

Version 1.0




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IMPORTANT NOTICE

The draft survey protocols contained in this document do not represent official policy, and in particular are not intended to necessarily represent the views of Natural England, Scottish National Heritage or the Countryside Council for Wales. As the protocols represent a distillation of information gleaned from five workshops they also do not necessarily represent the views of the individual authors. Nor is the document intended to provide methodological details such as design and construction of traps or the optimal size of artificial cover objects. This is not an oversight, as some of these matters are the subject of continuing projects elsewhere. In other areas further research is needed before authoritative recommendations can be made.

Introduction

Protocols for surveying the native amphibians and reptiles of Great Britain have been in existence for some years. However, following research and recommendations that emerged before the millennium (e.g. Swan and Oldham 1989, 1993a,b; HGBI 1998; Gent and Gibson (1998), there has been little development of survey protocols in recent years (JNCC 2004 and Gleed-Owen et al. 2005 being the major exceptions), despite and increasing interest in the subject from both volunteer and professional surveyors, and recent advances in methods and statistical tools.

This document combines information from two main sources: (1) recent research, and (2) five regional workshops on survey protocols that were held in 2011-12. The workshops were intended to be a two-way process, with scientists presenting examples of recent research and their potential application to field protocols, and field practitioners highlighting priorities and areas where further research was necessary. The workshops identified the following key issues:

- Current methodologies for assessing amphibian populations can be standardized relatively easily, and there is a general consensus about the effectiveness of different methods.
- Current methodologies for reptiles are less easy to standardize and there is less consensus on the effectiveness of different methods.
- Variation in detectability of individuals, populations and species over time and between sites remains a challenge to standardization of survey protocols.
- Views varied on the usefulness of statistical models in improving the design and analysis of surveys, but the majority of participants agreed that they had the potential to provide more robust population assessments.
- Any modelling software incorporated into revised guidance needs to be user-friendly. The use of such models may require extensive training, with the constraints of budgets, time and end-user resistance. However, in the longer term, such tools may ultimately allow the design of more cost-effective survey protocols.

- Removal (i.e. catch depletion) modelling was regarded as having considerable potential, especially for those involved in mitigation projects.
- Although habitat assessment was beyond the scope of the workshops, the application of spatial and landscape-level modelling to amphibian and reptile surveys can guide survey effort, provide assessments of habitat suitability, and predictions of occurrence.
- In general, surveys in Scotland operate at larger spatial scales than in England and Wales and protocols need to take account of this.
- There is an issue as to whether indices (simple counts) or densities (such as animals per square metre) are best, as both can be misleading in some circumstances. Although they are difficult to defend statistically, peak counts were still regarded as useful measures of the minimum number of animals present.
- For larger scale surveys management of data may be a higher priority than data collection and analysis. For example, in a national survey all analysis could be done by a single specialist rather than individual surveyors. However, resulting issues include data ownership and coordination of effort.
- Specific targets and timescales need to be clearly defined in line with the conservation goals. Changes to survey protocols are unlikely to be accepted unless clearly and unambiguously incorporated into national best practice guidelines.

Some of the issues raised in these workshops are resolved here, particularly where supporting evidence is now available. Others require further research. In particular, the issue of catch depletion (population removal from a site) requires greater attention. Fortunately a number of suitable data sets have been made available, and it should be possible to incorporate guidance into later versions of this document. Habitat assessment is again excluded from this document as it lies outside the scope of the project. However, as stated above, habitat assessment should usually accompany population assessment. For example, the habitat suitability index (HSI) for great crested newts (Oldham *et al.* 2000) demonstrates what can be achieved using a simple habitat assessment approach. Equally, analysing traces of DNA at a site to determine the status of a species has enormous future potential for survey and monitoring (Thomsen et al., 2011).

Type of survey

In this document we make recommendations for completing surveys for both amphibians and reptiles. Although amphibians have different survey requirements to reptiles there are some general principles applying to both groups that stem from the purpose for carrying out the survey. We recognise surveys at four different levels, with increasing amounts of survey effort required:

1. *Presence/Absence surveys*

These are simple surveys, carried out for a number of purposes, but with the common intention of determining the likelihood of whether a species, or number of species, are present or absent on a particular site. Typical uses include determination of the distribution of species and risk assessments in advance of development. Statistical analysis of the data obtained can be carried out at a central point remote from the surveyor if required. Programs to complete analysis, such as PRESENCE, are readily available, and allow the estimation of site occupancy and detectability of the species at a landscape level (MacKenzie et al. 2003; Pellet and Schmidt 2005). Such approaches can therefore determine the likelihood of a species being truly absent, or present but undetected.

2. *Population counts*

Population counts aim to go one stage further than presence/absence surveys, and give an idea of the relative abundance of a species without the need of the much greater commitment required for a population estimate. Population counts typically involve a series of surveys, with the peak count of each species being used. Peak counts are difficult to defend statistically, as they do not take account of variations in detectability from site to site. They can therefore be misleading, but many practitioners prefer them to densities and population estimates for ease of data collection.

3. *Population densities*

Population densities provide slightly more detail than population counts, and divide the counts by some measure of effort (e.g. numbers of amphibians per 2 m of shoreline; number of amphibians per trap; number of reptiles per hour of survey effort). Most of the limitations that apply to counts also apply to densities and they are combined in the recommendations specific to either amphibians or reptiles in this document.

4. *Population estimates*

Actual population assessment techniques call for intensive effort using capture-mark-recapture techniques or a complete census over one or more years. For this reason they are carried out at relatively few sites, and usually at a relatively small geographic scale of a single population or metapopulation. It is therefore unlikely that a remote analyst will be available, and analysis of the data gathered will often therefore fall to the person originally collecting the data. Software such as MARK, makes relatively sophisticated analysis possible, and allows estimates of survival and detectability, as well as population sizes (White and Burnham 1999; Griffiths et al. 2010). Open models such as the Cormack-Jolly-Seber model in MARK account for deaths and recruitment in the population, but require at least three capture-release occasions (i.e. usually three years of data). Within-season methods of population estimation, such as program CAPTURE (White et al. 1982) and the Schnabel method (Schnabel, 1938) are more limited in that they assume populations are closed to gains and losses over the survey period. Such methodologies do, however, allow a relatively rapid estimate of populations if they can be carried out over a short timeframe.

5. *Population depletion*

This category is very different to the other four, although it has some features in common with population estimates. It is of particular interest to those who are involved in mitigation projects or translocation projects, as it is concerned with estimating whether removal of animals from a site is actually depleting the population. If the removals are shown to significantly deplete the population, then it may be possible to estimate how many animals were on the site originally.

Scales of survey

As well as the purpose of survey, it is necessary to consider the scale of the survey. This may be in terms of the geographical area covered, or the intensity of effort required. Generally, as the level of a survey increases, so will the costs, whether they are counted in terms of cash or volunteer time. There will also be increases in costs as the geographical scale of a survey increases.

Training and competency

This document does not provide information on training and competency levels for surveying for reptiles and amphibians. However, we do endorse the core competencies laid out by the IEEM (Institute of Ecology and Environmental Management). These may be found at http://www.ieem.net/competency-framework.

Survey protocols for amphibians

There are many recognised methods of detecting, and capturing, amphibians in the aquatic stage of their life cycles, but only five in widespread use in the UK – bottle trapping, netting, pitfall trapping, torching and visual searches. Searches of suitable terrestrial refugia may also be made (Froglife, 2003). These may yield useful results, especially in autumn, but we are unaware of any work quantifying their effectiveness. In areas outside the UK call surveys are often used for frogs or toads, but as the majority of species in most areas of the UK are

Figure 1. Bottle trapping can be a highly effective method for great crested newts

newts, which do not vocalise, call surveys are not considered further here. Calls of natterjack toads may, however, be useful to determine their presence and may give some indication of numbers. Pitfall traps are effective, but are expensive to set up and require regular checking. For great crested newts, and some other species, an additional licence is required before the methodology can be used. In any case, the cost implications have tended to mean that pitfall trapping is normally used in conjunction with mitigation projects, and, to a lesser extent, for scientific research.

Of the remaining four methods, bottle trapping is highly effective for both adult and larval newts, but is less effective for adult frogs (although tadpoles are sometimes caught in large numbers), and is of little or no value for common toads. An advantage of bottle trapping is that difficult identification problems can be quickly resolved (for example distinguishing between female palmate and smooth newts). Disadvantages include the need for double visits, once to set and once to open the traps, and animal welfare issues including the risk of newts drowning or expiring in traps in hot weather. The double visit necessary for bottle trapping may, of course, increase the likelihood of detection of frogs and toads due to the additional time spent at each site. Bottle traps should be laid along the shoreline at 2 m intervals (Griffiths et al. 1996; English Nature 2001).

Figure 2. Netting is useful but may be less effective than other methods

Unless carried out in conjunction with torching, netting is generally less effective than other methods for detecting newts, and there may be concerns over damage caused to the gills of larval newts in particular. Netting is therefore recommended as a back-up to the other, more effective, methods listed here, or where the alternative methods are impractical.

Torching after dark can be highly effective for certain species, in particular adult great crested newts, and has the advantage that a survey can be completed in a single visit, rather than the two required to complete a single survey by bottle trapping. However, female palmate and smooth newts are difficult to separate by this method, as are larvae of the two species. Frog and toad tadpoles may also be surprisingly hard to separate by torchlight. Torching may be a very effective method for obtaining peak counts of toads, but is dependent on hitting the relatively short breeding season. The season may, however, sometimes be protracted during poor weather conditions, making repeat counts essential.

Figure 3. Daylight visual surveys are useful for some species. The folded grass stem here is characteristic for newt eggs.

Visual surveys are defined as daytime observational searches for any stages of the amphibian life cycle. They are less effective than night time torching for newts, but can be useful for adult frogs and toads at breeding times. They are also useful for spawn counts, and detecting frog and toad tadpoles under suitable conditions. A particular use has been to detect great crested newt eggs, for which the technique is highly effective. A description of the advantages and disadvantages of each method is given in Gent and Gibson (1998). As no single survey method is ideal, we recommend a combination of methods for each type of survey as follows:

Presence/Absence surveys

In a recent study (Sewell et al. 2010) it was found that for presence/absence surveys for amphibians four surveys were usually sufficient for most species (but not great crested newt – see below), to be 95% certain that if a species was not detected it was truly absent. This was providing a combination of methods were used (bottle trapping, torching, netting and visual searches) and the surveys are carried out under appropriate conditions and timeframes. English Nature (2001) makes similar recommendations for great crested newt survey methods. There are, however, differences in the recommended timings. The English Nature (2011) guidelines recommend mid March-mid June for surveys, with a preference for mid April to mid May. Sewell et al. (2010), in contrast, recommend one survey in March followed by three between mid April and the end of May. There is only a slight difference between these two studies. The Sewell et al. (2010) study was examining all common British amphibian species, whilst the English Nature (2011) guidelines were examining great crested newts only. The Sewell et al. (2010) March survey was primarily intended to pick up the timings when adult frogs and/or toads were likely to be in ponds. The choice of timings for presence/absence surveys for amphibians will therefore depend on how many species are of interest. Where the presence of great crested newts is suspected, an increase in the number of surveys to reliably determine presence/absence to six is recommended. This higher number of surveys is especially important at sites where the detectability is low (Sewell et al., 2010). Four surveys per pond can be sufficient within the core range of the species and at sites where detectability is likely to be high, for example at peak season at small-medium sized ponds with high water clarity. Six surveys would be needed on the edge of range (Zone B in Oldham *et al.* 2000), at upland sites, at the start or end of the season, or at sites where detectability is expected to be lower than normal (e.g. large, turbid or vegetation-covered ponds). Equally, the number of surveys may need to be increased at sites where populations are likely to be small. It may be possible to avoid bottle trapping within the core range of great crested newts, but bottle trapping may be essential at the edge of range. The Sewell et al. (2010) study examined a number of sites in Wales where the presence of great crested newts was only confirmed by bottle trapping, whilst torching, visual searches and netting all failed to detect the species. In core areas of the range, where population densities are often higher, torching may be the more effective method. However, we do emphasise the need of multiple detection methods both for great crested newts and other species.

In any area, it is not necessary to continue with presence/absence surveys once the species has been located at a site. The full number of surveys only needs be completed to increase certainty that non-detection reflects true absence, rather than just undetected amphibians. Searches of terrestrial refugia may also be made (Froglife, 2003), but as newt species are cryptic, non-detection should not be taken as providing evidence of absence.

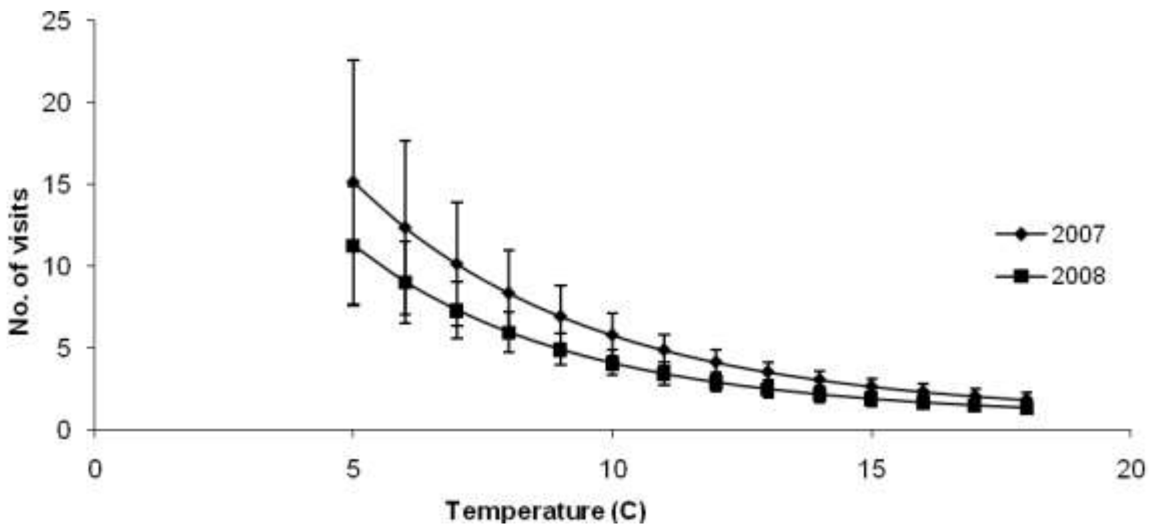

Fig. 4. The relationship between water temperature and survey effort required to detect great crested newts over two years from Sewell et al. (2010).

Sewell et al. (2010) demonstrated a relationship between mean overnight water temperature and detectability of great crested newts. As survey effort required is directly related to detectability, more surveys will be required at lower water temperatures (Fig. 4).

It is worth emphasising that Fig. 4 is for surveys carried out during the peak season of mid-April to late May. Unseasonally warm weather earlier in the year, or cool weather later in the year, will not yield the same changes in detectability. It can be seen from Fig. 4 that for water temperatures of 10^{o} C or lower the number of survey visits needs to be progressively increased as water temperature declines. Therefore we recommend that water temperature be recorded on each survey (preferably when traps are laid), and the number of survey visits increased if the temperature is 10^{o}C or lower. We do appreciate that many surveyors work by air rather than water temperature, but models that incorporated water rather than air temperature as a covariate of detection accounted for >99% of model weight.

Population counts and densities

For great crested newts the recommendations by English Nature (2001) suggest six surveys in suitable weather conditions using both bottle trapping and torch surveys. Our own experience is that the optimum number of surveys for maximum counts is 7-8 (Sewell *et al*. 2005), although the timing of the surveys to include peak season may be more important than the number of repeats. Populations are classed on the maximum count from repeated surveys, with up to 10 newts being classed as small, 11-100 as medium, and 100+ as large. Alternatively, populations can be categorised as low, good or exceptional using a system originally created for the selection of biological SSSIs by the Nature Conservancy Council in 1989 (Gent and Gibson, 1998; Langton et al. 2001). The density system classifies populations as below average, average, above average, good or excellent based on densities calculated using different methods at a random sample of ponds (Griffiths et al. 1996). The English Nature (2001) mitigation guidelines for great crested newts prefer peak total counts to densities as a means of population assessments. This is because large populations may exist at low densities and vice versa, although Lewis et al. (2007) showed that when sites are scored by peak counts and densities are scored by pond there is often a high correspondence between the two methods. Having at least one count early or late in the season, even though numbers can be expected to be lower, will help emphasise that the peak count is the ‘true’ peak rather than an artefact of inappropriate timing of the survey. Such a count may also help establish if the main season is unusually early or late in that particular year.

Population estimates

English Nature (2001) suggests two methods of estimating a population. Firstly, a pond may be drift fenced in conjunction with pitfall traps, with a survey effort of at least 100 days. Secondly they suggested capture-mark-recapture using bottle traps and netting, in which case at least 20 visits were suggested. In both scenarios timings were suggested as early February, and continuing through to late May. Such methods are especially suited to great crested newts amongst the amphibians, as the belly pattern on these is unique to the individual. In other species, where individuals are less easy to recognise, some form of individual or batch marking may be essential (Dodd 2010). This is only possible in small populations, and may require Home Office licensing depending on the exact methodology used.

In 2005 we compared drift fencing with capture-mark-recapture at a site with a known great crested newt population. Some newts lived their entire lives in or close to the pond, and thus never had to pass through the drift fence, whilst others paid short visits to the ponds and were never caught in the bottle traps. Long term population estimation is probably best achieved by annualising capture data from bottle traps over a multi-year period and using statistical software, such as MARK, to estimate the annual capture rates. Population estimates for each year can then be obtained. Such estimates are likely to be restricted to a long-term studies (e.g. Griffiths et al. 2010). The recommendation for the number of nights of operation for the drift fence for great crested newts is 60 nights (English Nature 2001), with the emphasis that this refers to nights with suitable weather conditions only. The recommendation also refers to presence/absence surveys and is therefore probably insufficient for either population estimates or catch depletion.

Figure 5. The individual belly patterns of great crested newts make them an ideal subject for capture-mark-recapture studies

For common frogs it is possible to gain an estimate of the number of females in a population by measuring the area of the spawn mat and reading off the number of clumps from a chart (Griffiths et al. 1996). For common toads a head count during the breeding season may be the most effective means of estimating the population, but may underestimate the true population size. Counts should include the animals around the breeding site as well as animals actually in the water. Practically this may be difficult to achieve, as the breeding aggregation at a pond may be only a few days, and timing can be difficult to predict.

For studies based on short-term data, collected within a single survey season for closed populations, we recommend the Schnabel method, or program CAPTURE (White et al. 1982).

Population depletion

As removal is usually intended to relocate an entire population from a site it has much in common with the previous category, especially the need to use both bottle trapping and drift fencing in order to reach an entire population of newts. To maximise the catch it is important to have the drift fence in place before newts migrate into the pond at the start of the breeding season. Exact timing will depend on weather conditions, but is usually between mid January and early April, with males tending to migrate earlier than females. There are relatively few data on how long such systems should be left in operation to reliably remove an entire population and existing practice appears largely based on the HGBI guidelines (1998). The few datasets that do exist show that after the initial migrations at the start of the breeding season there can be gaps of up to 10 days between captures for great crested newts. Checking should continue for at least this long after the last capture, although we do expect this recommendation to be extended as further information becomes available. It should be noted that such methods may not capture sub-adults, which may not return to the pond during the breeding season, or adults that may skip breeding in a given year. Pond perimeter fences therefore need to be combined with habitat specific fences around key habitat features (hedges, woodland etc).

In addition to captures during the immigration period, described above, captures during the period when animals are leaving the pond are also possible. Removal may also incorporate captures during a pond drain-down and terrestrial captures away from a pond. Again, further guidance will be incorporated as it becomes available.

Survey protocols for reptiles

Compared to amphibians, there are fewer methods of detecting and capturing reptiles and protocols rely more heavily on fieldcraft. Fundamentally, only two methods are used commonly in the UK, directed visual transects and refugia searching. In the case of the latter, refugia may be natural, man-made (usually discarded rubbish), or laid deliberately for the survey. In the case of the latter, tins or roofing felts (at least 0.5 m x 0.5 m) are the most popular materials, but other types can also be used effectively and the most effective size is also debateable. These are often referred to as artificial cover objects (ACOs).

Figure 6. Discarded rubbish can make good refugia for reptiles. Up to eight slow-worms at once were found underneath this old car bonnet.

Considerations over which material(s) to use are governed by cost, target species, and portability as well as the personal preference of the surveyor. As felt and tin react differently to solar radiation, with tin warming more quickly but cooling faster than felt, we recommend a combination of materials in most situations. Siting of ACOs is important. To increase the likelihood of detections, ideally they should be laid in a south-facing position, and preferably partially concealed in – or adjacent to – vegetation cover. ACOs that do not receive direct solar radiation, at least for part of the day, are unlikely to be used. With the increase in metal theft it may not be practical to use tins at urban, or semi-urban, sites, but a mix of materials should be maintained wherever possible. In many cases, judicious siting of an ACO may avoid unwanted detection by people.

It should be noted that directed transect walks that take in potentially important reptile basking areas are required in addition to ACO searches. Sand lizards use ACOs comparatively rarely, whilst adders may use them at some sites, but not others. Thus, failure to carry out transect walks may result in under-recording of these species.

It should be noted that the following recommendations are aimed at surveyors of medium to high experience. Inexperienced surveyors will require training in fieldcraft, especially on visual transects, and the number of surveys may need to be increased to allow for experience.

Presence/Absence surveys

For presence/absence purposes, a recent study (Sewell et al. 2012) has shown that 4-5 survey visits (depending on species) are usually sufficient to detect 95% of occupied sites, at least for the widespread British species, providing a combination of both tins and other artificial ACOs are used in addition to transects. However, the Sewell *et al.* (2012) study has a number of important caveats, which must be taken into consideration when arriving at a suitable number of surveys performed for mitigation purposes. Firstly, the study was undertaken on behalf of NARRS (the National Amphibian and Reptile Recording Scheme). Within a randomly generated survey square, surveyors on this scheme are able to pick the sites most likely to contain reptiles, which means that detection rates are higher than in the more marginal habitats that are often surveyed as part of mitigation studies. At such sites, the number of survey visits may consequently need to be increased to account for lower detectability. Also NARRS sites are more likely to have ACOs that have been laid for longer periods of time than mitigation sites. Therefore, we recommend increasing the number of surveys to at least seven unless it can be proved that refugia have been in place for a sufficiently long period, and that the area is one where reptile detectability is high.

Figure 7. Checking for slow-worms under felt refugia

If the area is likely to support sand lizards, however, the Sewell *et al.* (2012) study suggests that up to seven surveys will be needed for NARRS purposes, and as many as 11 for surveys on marginal reptile sites. The same study suggested that at least 30 refugia should be laid for presence/absence purposes, but this number applied regardless of the size of site as long as the ACOs were appropriately positioned. We have not reviewed the number of ACOs required for other purposes, and therefore make no recommendations. Instead, examination of existing literature on this topic is recommended (e.g. Reading 1997). However, it is clear from the consultation process that the size, type, numbers and location of refugia remains a controversial issue and more research and evaluation is urgently required in this area from different parts of the country before definitive recommendations can be made.

As with amphibians, there is no need to continue surveys once the species of interest has been located on a site. However, the full number of surveys should be carried out before it is assumed that non-detection can be interpreted as true absence of the species from the site.

Previous studies in continental Europe (Kéry 2002; Kéry and Schmidt 2008) – but examining most of the species found in the UK - found lower detection rates than those reported in the Sewell et al. (2012) study, but only used transects as a single method of detection. Therefore, if ACOs are not included in the surveys, the number of survey visits needs to be increased. Equally, if transects were excluded from a programme and the surveyor merely moved from refuge to refuge without checking the survey route for basking animals, the number of survey visits would also need to be increased in to compensate. However, at some sites, there remains a risk that some species (e.g. adders, grass snakes, sand lizards) may be missed altogether if refugia surveys are conducted without directed transect walks.

Surveys should ideally be spread across the survey season. Detectability can be lower in March, and some species, such as smooth snakes may not have emerged from hibernation. On the other hand, as reptiles become more active later in the year the growth of vegetation (e.g. bracken, bramble) may hinder detectability. As a compromise – and depending on the weather in a given year – we recommend presence/absence surveys for reptiles to be timed to start from April onwards. However, we do recognise that warm days in March can be useful for reptile surveys, especially for finding animals emerging from hibernation sites. Indeed, at sites containing hibernacula the highest counts may occur in March, even in relatively northern parts of the UK.

Population counts and densities

Many of the comments given above for amphibian counts and densities apply equally to reptiles. Indeed, site delimitation may not be clearly known, and as many species can be highly cryptic, it is even more difficult to interpret data comprised of counts and densities. Given these caveats – and until more informative data are available – population class assessments may be carried out using the guidance given by HGBI (1998). This system calls for peak counts, with size classes varying from species to species. The need to use ACOs in varies from species to species. While slow-worms and smooth snakes can occasionally be found without using ACOs, this method radically improves the detectability of both species. At the other extreme, sand lizards use refugia of any sort.

Population estimates

Capture-mark-recapture techniques are recommended for population estimation. Whilst individual recognition is relatively easy for adders (using head patterns) and grass snakes (using belly patterns), individual recognition is more problematical for most lizard species (but see Dent 1986; Smith 1990; Riddell, 1996) although, with care, it does seem to be workable in small populations of slow-worms. For viviparous and sand lizards head and back patterns offer a degree of individual recognition, but may be prohibitive with large populations. There are also licensing issues if a protected species, such as the sand lizard, has to be handled as part of a study. However, it is possible to carry out such studies using photographs of sand lizards taken of the animals in the wild (Fearnley, 2009).

Figure 9. Head patterns of adders are unique to individuals and are useful for population estimates.

As with amphibian studies above, long term population estimation is probably best achieved by annualising capture data over several years and using statistical software, such as MARK, to estimate the annual capture rates. Population estimates for each year can then be obtained. For studies based on closed populations collected within a single survey season, we again recommend the Schnabel method, or program CAPTURE.

Surrogate population estimates based on habitat extent and a theoretical population density may be highly unreliable, and their use is not recommended until the relationships have been validated statistically.

Population depletion

The remarks above relating to amphibians apply similarly to reptiles. Again, existing practice is largely based on the HGBI (1998) guidelines. In some respects reptiles are even more difficult. With amphibians the boundary of the site, at least in the breeding season, is clear. For reptiles the site boundary may be highly indistinct, at least to human eyes, and the animals are less easy to capture than most amphibians. There are few published studies on the removal of reptiles from a site. Platenberg and Griffiths (1999) is an exception, but a key message from consultants involved in the workshops that formed a part of this programme is that current guidance on this subject is inadequate. Removals are likely to be needed over a period of several weeks to deplete a population, and can be confounded by animals becoming undetectable during periods of hot or cold weather, yielding ‘false depletions’. A number of reptile data sets from previous mitigation projects are currently being evaluated, and guidance will be added as analysis is completed.

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Amphibian survey protocols

Purpose	Methods	Materials & Design	Minimum no. Surveys required	Timings	Analysis methods
Presence/Absence	Bottle trapping, netting, torching and visual surveys required, Within the core range torching may be the most effective method for great crested newts if water clarity is good. Outside the core range, all four methods should be used before it is concluded that newts are absent from the site	Bottle traps along pond shoreline at 2 metre intervals; torching using a torch of >500,000 candle power; Daylight visual surveys searching for frog and toad spawn, tadpoles and newt eggs according to timings.	4-6 For 95% confidence that non-detection of great crested newts means the species is absent, use 6 surveys. In particular for sites where detection rates are low e.g. edge of range and upland areas.	Surveys should be split between March (frogs, toads and spawn) and mid-April – end May (tadpoles, newts, newt eggs).	At a landscape level occupancy analysis can be carried out for areas with multiple sites using programs such as PRESENCE.
Counts and Densities	Bottle trapping, netting, torching and visual surveys, all required according to species.	For newt species bottle traps along pond shoreline at 2 metre intervals, torching using a torch of >500,000 candle power. For frogs a daylight visual survey counting spawn clumps or mats may be more productive.	6-8 For great crested newts 7-8 counts recommended, timed during peak season. 7 in core areas, 8 in others.	Peak season, according to species, March for frogs and toads, mid April – end May for newts. A count outside peak season may help establish that most counts have occurred around the peak	Both peak counts and mean densities should be prepared, as either can be misleading in some circumstances. Neither is easy to defend statistically, but they may be useful when a rapid population assessment is required.
Population estimates	Bottle trapping and drift fence/pitfall traps. Either or both required.	Captured individuals should be 'marked' (i.e. have belly patterns	Minimum of 3 for species that breed explosively, i.e. frogs	If drift fences and pitfall traps are being used, start late February to	Ideally continue over at least three years for a population estimate

		recorded in case of great crested newts) for capture-mark-recapture estimates.	and toads. Ideally more for newts, spread through the breeding season. For detailed estimates 20+ surveys per annum may be required for capture-mark-recapture estimates.	catch animals returning to a pond. Continue to at least late April. If ring fences are not being used, bottle trapping can take place over an extended period from late February to end June.	based on the live recaptures model in program MARK. For estimates based on captures within a single season use the Schnabel method, or program CAPTURE.
Population removal	Bottle trapping and ring fence/pitfall traps. Netting and other capture methods may also be required during pond drain down period.	It is assumed that captured animals are removed from the site. Therefore it is only necessary to record markings if the animal population is being monitored at the release site.	Under review	Should include the entire 'active' phase in the habitat, in the case of amphibians in ponds from at least mid February through to the end of June.	Catch removal software currently under evaluation.

Note: Where a category calls for more than one method (for example bottle trapping *and* torching), then all recommended methods must be used together, or the number of surveys increased. Note that for great crested newts the use of ring fence/ pitfall traps may have additional licensing implications in addition to those required for bottle trapping.

Reptile survey protocols

Purpose	Methods	Materials	No. Surveys required	Timings	Analysis methods
Presence/Absence	Visual surveys by transect, searches of natural refugia and artificial cover objects. All methods required, if some are not possible additional surveys required. In practice there may be variation according to species and time of year.	For artificial cover objects a mixture of corrugated tin and roofing felt maximises the chances of detection in variable weather conditions, although tin is often better for snakes. A minimum of 30 artificial cover objects should be used.	For NARRS type surveys 3-5, depending on which species are anticipated. For mitigation surveys on more marginal land for reptiles 7 surveys (11 if sand lizards are possible) required due to lower detection rates.	Main effort in April – May, surveys carried out at other, sub-optimal, times of year require additional effort. September is also a good time in most years. March may be useful for hibernation sites.	At the landscape level occupancy analysis can be carried out for areas with multiple sites using programs such as PRESENCE.
Counts and Densities	Visual surveys by transect, searches of natural refugia and artificial cover objects. All methods required, if some are not possible additional surveys required.	For artificial cover objects a mixture of corrugated tin and roofing felt maximises the chances of detection in variable weather conditions. However, be aware that in some situations snakes prefer tins to felts and larger counts are therefore likely when all refugia are metallic. Transects are also essential, sand lizards rarely use refugia,	6-10, spread over the periods when highest counts are likely	Highest counts are likely in April-May (adults) and September (adults plus young of the year). If comparing counts from these two periods young should be considered separately from adults.	Both counts and densities should be prepared, as either can be misleading in some circumstances. Neither is easy to defend statistically, but they may be useful when a rapid population assessment is required. For reptiles, a count is probably less misleading than a density estimate. Counts can be classified using the HGBI (1998) guidelines for reptiles.

		adders may not do so.			
Population estimates	Searches of natural refugia and artificial cover objects. Surveys best restricted to cooler conditions when animals are easier to capture. Visual surveys without capture may be adequate for adders if head patterns can be photographed.	It is necessary to have some form of marking to identify recaptured individuals. For grass snakes the markings on the underside may be used, for adders the patterns on and near the head. Lizards may be difficult to recognise as individuals.	Minimum of three (spaced across season) if using Schnabel method, but more (at least 6) better to reduce confidence intervals of estimates. For capture-mark recapture studies up to 20 per annum ideal.	Spread across season when each species is active, March – early October for most species. For adders and common lizards from late February in the south, especially near known hibernacula.	Ideally continue over at least three years for a population estimate based on the live recaptures model in program MARK. For estimates based on captures within a single season use the Schnabel method.
Population removal	Exclusion fencing to stop new and returning animals entering the site. Animals captured under refugia and, where possible, whilst basking.	It is assumed that captured animals are removed from the site; therefore it is only necessary to record markings if the population is being monitored at the release site.	Under review. Is likely to show high variation according to population size and site character.	Should include the entire 'active' phase in the habitat. In the case of reptiles from March to early October, especially for species exhibiting sexual seasonality such as slow-worms.	Catch removal software currently under evaluation.

Note: Where a category calls for more than one method (for example refugia searches *and* transects or felts *and* tins), then all recommended methods must be used together, or the number of surveys increased.

Numbers of surveys recommended are for an experienced surveyor, who knows where to correctly site refugia. Number of refugia and transects both need to be increased if work is carried out by an inexperienced person