Amphibian and Reptile Conservation

RESEARCH REPORT 19/01B

Development of future reptile and freshwater monitoring schemes in Jersey (Report B)

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States of Jersey

amphibian and reptile conservation

Executive Summary

Based on the Analysis of Jersey National Amphibian and Reptile Recording Scheme (NARRS) Data 2007–2018 (Report A) the following recommendations were proposed:

1. Develop separate monitoring efforts for widespread (western toad, palmate newt, slow worm, green lizard) and restricted or difficult to monitor (agile frog, wall lizard, grass snake) species.
2. Utilise refugia more regularly and in greater numbers for widespread reptile surveys.
3. Employ site-based population monitoring of restricted and rare species.
4. Increase the number of repeat surveys for widespread amphibians to five.
5. Increase the number of repeat surveys for widespread reptiles to six.
6. Reduce the sampling grid from 1 km to 500 m for all lizard species.
7. Carry out water quality monitoring.
8. Carry out amphibian disease screening.

The schemes for monitoring amphibians (and other freshwater biodiversity) and reptiles need to be redesigned with robust and practical data collection in mind, in order to operate effectively in a resource- and volunteer-limited climate, and with future-proofing in mind.

Within this report we have reviewed the existing monitoring efforts for freshwater and reptilian biodiversity in Jersey, and applied a science-based approach to develop two new monitoring schemes for the island; Pondwatch JE and Reptilewatch JE. These schemes have been designed to implement the Analysis of Jersey National Amphibian and Reptile Recording Scheme (NARRS) Data 2007–2018 (Report A) recommendations as well as be accessible and of interest to volunteers with varying levels of experience, skill and time availability. The schemes use robust and repeatable methods to generate data for future analyses of population status and trends, whilst maximising the data collected by volunteers and improving our overall knowledge on many of Jersey's species.

The new schemes provide backwards compatibility with previous survey efforts carried out under the NARRS and Toadwatch schemes, meaning that it may be possible to supplement future analyses with data from these earlier schemes for greater effect.

The recommendations above from Report A gave clear guidance on what should be included in to any future survey scheme in order to maximise chances of detecting species and changes

in their populations. A review of existing monitoring schemes and a set of workshops held with stakeholders, volunteers and species experts also provided useful suggestions for ensuring any new schemes were practical and effective. Following these steps we propose two new volunteer schemes for Jersey:

Pondwatch JE and **Reptilewatch JE**

Both schemes have three different levels of involvement depending on the experience, skill and time commitment of the volunteer surveyor. Where previous monitoring schemes have focused on single taxonomic groups (i.e. amphibians or reptiles), the new schemes offer greater variety in the species that can be recorded and the methods that can be applied. The findings from Report A along with ecological knowledge of the species of interest made it clear that separate schemes were warranted for the two taxonomic groups. The additional species surveyed within these schemes were identified in consultation with species experts and from a review of other monitoring schemes. These species are known to occur within the same ecosystems as our primary target groups (amphibians and reptiles), are relatively easy to identify and require little additional effort to survey. Incorporating other species in to our monitoring efforts may also serve to reduce the negative experiences felt by many surveyors when their survey site yields few, or no, primary target species. A wider selection of species increases the chances that at least one species of interest may be present.

Pondwatch JE

- Pondwatch JE aims to detect changes in the conservation status of Jersey's pondlife, including amphibians, through changes in occupancy (levels 1 and 2) or in order to detect site-level population changes (level 3).
- All Pondwatch JE surveys are to be carried out between January and May.
- **Level 1** volunteers do not require experience or training, and are asked to carry out a single 30-minute visual pond survey, with a focus on garden ponds.
- **Level 2** volunteer surveyors do not require experience but do require training. Surveyors are required to carry out five surveys of the same pond, each lasting 30–60 minutes and using a combination of visual surveys, netting and night-time torching across the five visits. Volunteers are also required to undertake a habitat assessment of their pond. Trained surveyors can opt-in to additionally record aquatic non-native plants and/or Odonates (dragonflies and damselflies).

- **Level 3** requires volunteers to be experienced in freshwater surveys and to undergo training. This level requires intensive population monitoring following existing agile frog monitoring guidelines. Volunteers are also required to undertake a habitat assessment of their pond. Trained level 3 surveyors will also carry out disease screening of Jersey's amphibians; collecting swabs every three years which will be tested for the fungal diseases *Batrachochytrium dendrobatidis* and *B. salamandrivorans*.
- All surveyors can request to carry out water quality monitoring at their survey pond, consisting of a simple kit for assessing nitrate and phosphate nutrient pollution levels.

Reptilewatch JE

- Reptilewatch JE aims to detect changes in the conservation status of Jersey's reptiles, through changes in occupancy (levels 1 and 2) or in order to detect site-level population changes (level 3).
- All Reptilewatch JE surveys are to be carried out between March and October.
- **Level 1** volunteers do not need training or experience, and are asked to carry out a single 30-minute visual survey for reptiles.
- **Level 2** volunteer surveyors do not need to have survey experience but are required to undergo training. This level consists of two survey options:
    - ***Widespread reptile surveys*** – surveyors are required to carry out six surveys, each lasting 1–2 hours using both visual surveys and artificial refugia. Surveyors can also opt-in to record small mammals, cockroaches, beetles and/or butterflies and moths following appropriate training. Volunteers are also required to undertake a habitat assessment at their survey site.
    - ***Wall lizard surveys*** – surveyors are required to carry out six surveys, spending 30 minutes at each visually searching (either walking or looking from a fixed vantage point) for wall lizards at known and suspected wall lizard sites
- **Level 3** requires surveyors to be experienced in reptile surveying. This level requires intensive population monitoring, directed towards grass snakes at known or suspected grass snake sites in order to detect site-level population changes. Volunteers are also required to undertake a habitat assessment at their survey site.

For both schemes, we provide all necessary forms, guides and training materials.

After the launch of these two new scheme we propose the following is needed to modify and check the schemes effectiveness;

- Scheme performance should be reviewed after a pilot year to trial the methods.

- Level 1 surveys should be advertised widely to the general public, including local community groups and schools.
- A greater sense of community needs to be fostered among volunteers involved in biodiversity monitoring. We suggest this is done through the use of social media and regular updates on scheme findings.
- The water quality testing kits being used measure up to 10 ppm for nitrates. However, the Jersey Water stream nitrate map suggests levels may be much higher in Jersey. Preliminary sampling should therefore determine the appropriate range before ordering additional kits.

Acknowledgements

We are grateful to those that have contributed to previous monitoring efforts in Jersey particularly as part of the National Amphibian and Reptile Recording Scheme (NARRS) and Toadwatch. We also wish to thank those that participated in workshops, the Jersey Biodiversity Centre, Natural Environment and Jersey Amphibian and Reptile Group.

SUGGESTED CITATION: Ward, R.J. and Wilkinson, J.W. (2019) Development of future reptile and freshwater monitoring schemes in Jersey. ARC Research Report 19/01B.

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Additional documentation

The following support documents are available on the Jersey Amphibian and Reptile Group website (https://groups.arguk.org/jarg):

- Pondwatch JE handbooks
- Pondwatch JE survey forms
- Pondwatch JE species ID guides
- Pondwatch JE training presentation
- Reptilewatch JE handbooks
- Reptilewatch JE survey forms
- Reptilewatch JE species ID guides
- Reptilewatch JE training presentation

1. Study objectives

Following the Analysis of Jersey National Amphibian and Reptile Recording Scheme (NARRS) Data 2007–2018 (Report A) report, we review Jersey's monitoring schemes for assessing population data for amphibians and reptiles. The following recommendations need to be incorporated when designing a new scheme;

1. Develop separate monitoring efforts for widespread (western toad, palmate newt, slow worm, green lizard) and restricted or difficult to monitor (agile frog, wall lizard, grass snake) species.
2. Utilise refugia more regularly and in greater numbers for widespread reptile surveys.
3. Employ site-based population monitoring of restricted and rare species.
4. Increase the number of repeat surveys for widespread amphibians to five.
5. Increase the number of repeat surveys for widespread reptiles to six.
6. Reduce the sampling grid from 1 km to 500 m for all lizard species.
7. Carry out water quality monitoring.
8. Carry out amphibian disease screening.

Our main objective is to design schemes for monitoring amphibians (and other freshwater biodiversity) and reptiles with robust and practical data collection in mind. This is necessary in order to operate effectively in a resource- and volunteer-limited climate, and with future-proofing in mind.

2. Introduction / Background

Ensuring effective and efficient ecological monitoring of Jersey's wildlife is an essential component of maintaining and supporting Jersey's natural environment; enabling the Government of Jersey's strategic objectives to be implemented. Volunteer-based survey schemes can be extremely cost-effective, as well as providing opportunities to promote biodiversity and deliver wider benefits in the forms of health and well-being.

In order to effectively design new recording schemes for Jersey's freshwater wildlife and reptiles, we carried out the following steps:

1. A review of current monitoring efforts in Jersey
2. A stakeholder workshop with volunteer surveyors and scheme coordinators in Jersey
3. A review of Jersey's species and habitats that may be suitable for inclusion in freshwater and terrestrial (reptile) monitoring
4. A review of survey approaches suitable for the species reviewed in step 2
5. A review of freshwater and terrestrial monitoring schemes within the UK and mainland Europe
6. Training session in both schemes

We use the findings from these throughout this report, with references given where applicable.

2.1. Why monitor?

Monitoring species provides valuable information on their status and of the wider environment, and allows appropriate action to be taken to ensure they are in favourable conservation status. A number of species are protected by law, or are the subject of Biodiversity Action Plans (BAPs). Furthermore, monitoring is an important component for meeting the various Multilateral Environmental Agreements (MEAs) to which the Government of Jersey are a signatory. Jersey's terrestrial and freshwater fauna and flora are currently monitored through several schemes and via independent recording efforts of local groups and individuals. Limitations in available resources and volunteers for monitoring means that efforts should be optimised to make best use of those resources and volunteers available. Therefore, in this report, we set out to review monitoring efforts for terrestrial and freshwater systems within Jersey, the UK and elsewhere in Europe to provide informed recommendations for new and improved monitoring schemes from these domains.

There is currently insufficient data for many of Jersey's species, meaning that their conservation status and population trends cannot be adequately assessed. Previous attempts to analyse trend datasets have shown that many more 1-km squares (monads) need to be surveyed to understand trends in reptile and amphibians based on current protocols (Ward et al. 2017). However, for widespread species at least, appropriately designed schemes should be capable of detecting population changes. Volunteer monitoring schemes can also be useful in detecting wildlife disease outbreaks. A previous study evaluated the presence of the fungal pathogen *Batrachochytrium dendrobatidis* in Jersey by sampling 97 toads from Grosnez and Les Landes, and no positive samples were detected (Cunningham and Minting 2008).

2.2. Tracking changes in populations and their causes

Biological monitoring aims to detect changes in populations, and to determine their causes so that remedial action can be taken in the case of declines or to inform best practice in improving the species status (e.g. through reintroduction efforts). The metrics most commonly used are changes in occupancy and abundance. Simply, this requires data on the presence or absence of a species at a given location at a single moment in time, or similarly the number of individuals (counts) of a species. The structure in which this data is collected can influence subsequent analysis. Data collection typically ranges from ad-hoc recording through to carefully structured repeat sampling of the same locations to allow a more detailed picture to be constructed.

Presence/absence information (occupancy) is far 'cheaper' to record than abundance in terms of survey effort. For instance, a survey targeted toward a single species would only need to be carried out at a site until a single specimen of that species was recorded or the surveyor felt that they had used enough effort that the species should have been detected, if present. By comparison, raw counts of a species may not be a true representation of local abundance and becomes more 'costly' as efforts to improve accuracy require repeated counts at the same location. Alternatively, they may involve recording individuals based on their unique patterns (known as mark-recapture) to develop a clearer picture of the population. Overall, datasets including repeated visits allow for more statistically robust analyses to be carried out.

Basic knowledge of distribution (e.g. the development of atlases) and changes in that distribution is useful, but is a coarse representation of underlying changes in populations. Improvements in statistical methods now allow for more accurate estimates of species occupancy, abundance and distribution to be constructed. Different factors may affect changes in occupancy and abundance, and changes in abundance may not be immediately represented by changes in occupancy. There is therefore a trade-off between sensitivity in detecting trends and the resources required to collect relevant data. Statistical approaches also allow us to calculate the amount of survey effort required so that we can adequately detect population changes.

2.3. Who should conduct monitoring?

Limited resources and staff within the environmental sector and government agencies means that monitoring cannot be carried out by so-called professionals. Volunteers, also referred to as citizen scientists, are often driven by their interests in the natural world and a desire to become upskilled. Though they may not have the same expertise as paid professionals, well-trained citizen scientists can become highly competent and achieve similar identification

accuracy as experts (Austen et al. 2016). The ability and willingness of volunteers to partake in monitoring efforts is dependent upon a number of factors, including their experience, the resources available to them, access to training and materials, the required time and travel commitments and the sense of community and contribution they may receive from participating.

2.4. Which species to monitor

Not all species are equal in their suitability for monitoring due to a multitude of factors. These include the detectability of species (e.g. due to size, rarity, behaviour or camouflage), their distribution (e.g. occurring on private lands or in inaccessible or dangerous habitats) and their suitability as a representative of the wider ecosystem (e.g. as indicator, umbrella or flagship species). Furthermore, biases in personal preferences and monitoring locations can influence the willingness of citizen scientists to monitor particular species or wildlife groups.

Schemes that intend to monitor multiple species must be aware of the variances in traits among the species being targeted. Habitat preferences, aggregation (dispersed or clumped), movement and other behaviour (e.g. seasonality) and ultimately, detectability are especially of importance. Therefore, different strategies may need to be used to optimise detection and data collection on each species (Guillera-Arroita et al. 2010; Guillera-Arroita and Lahoz-Monfort 2012; Ficetola et al. 2017).

2.5. Where to monitor?

Approaches to monitoring can either take (i) a census approach, where every location/site within the region of interest is surveyed, or (ii) seek to take a representative sample by selecting a subset of sites, perhaps using some sort of random stratified sampling approach. Achieving either of these rarely occurs without incident due to land-access issues (e.g. due to lack of permission or remoteness (Ficetola et al. 2017)), availability of surveyor effort in particular areas or other unforeseen challenges. Within Jersey, gaining permission for access to survey particular areas is likely to be the greatest challenge.

2.6. Scale of monitoring

Monitoring can be undertaken at a range of scales relevant to the aims of the scheme. Regular approaches are to use monads (1-km squares), transects, habitat features (e.g. ponds) or species features (e.g. nests, roosts) as the area of interest. Importantly, the area and scale of surveying should be standardised across the scheme to enable comparison across locations and seasons.

2.7. Expertise and training

Providing appropriate skills training is essential in ensuring reliable data recording and in engaging and retaining surveyors. Often, the volunteers involved in a recording scheme will represent a range of experience and skills; from first timers to experienced volunteers, as well as the inclusion of individuals with professional experience. Local capacity can be improved by providing training in a number of forms. Some schemes opt to 'train the trainers'; whereby experienced recorders receive additional training in order to then act as local coordinators that provide support and training to less experienced volunteers. Similarly, recording schemes may rely on local experts (e.g. professional ecologists or experienced amateur naturalists) to act in a similar capacity. Training may often be in the form of a workshop involving desk-based and practical elements, or the use of printed or online training materials. Such training requires logistical and financial support in order to ensure participants are appropriately trained and remain engaged with regular communication.

2.8. Data storage

Biological monitoring data in Jersey is primarily collated by the Jersey Biodiversity Centre (JBC) (http://jerseybiodiversitycentre.org.je/). The recent development of a new recording interface using Indicia (http://www.indicia.org.uk/) and Drupal (https://www.drupal.org/) allows for better data management and easier input. Though some monitoring data is stored locally by government departments and recording groups, it is intended that eventually all data will flow in to this single repository at the JBC. Collation of records in to this single database also ensures records are validated consistently, and streamlines data access for future analyses.

2.9. Reptile and amphibian monitoring

A number of challenges are present in surveying herpetofauna (Griffiths et al. 2015; Ward et al. 2017), with a 'one size fits all' approach unlikely to be sufficient to gather appropriate data. This is exacerbated by low detectability of many species and some exhibiting restricted distributions (Ficetola et al. 2017). Within the UK, much of the national monitoring of amphibians and reptiles (herpetofauna) has been directed by Amphibian and Reptile Conservation (ARC) (previously known as the Herpetological Conservation Trust). Further efforts are managed by local recording groups such as those under the auspices of the Amphibian and Reptile Groups of the UK (ARG-UK). Another organisation, Froglife, has also coordinated monitoring of toads during their migrations across roads. In all instances, volunteers (or citizen scientists) are responsible for the majority of data collection. In 2007, ARC launched the National Amphibian and Reptile Recording Scheme (NARRS). This

scheme utilises volunteers to conduct structured surveys and collect data to contribute to status assessments for reptiles and amphibians (Wilkinson and Arnell 2013).

2.10. Monitoring in Europe

Biodiversity monitoring occurs throughout Europe, focusing on both habitats and species. Many of these schemes are listed on the EuMon website (http://eumon.ckff.si/monitoring/), which at the time of writing lists 649 monitoring schemes, of which 472 focus on habitats. However, the number of schemes is likely to be considerably larger. At the same time, 200 surveys or monitoring schemes are listed by the National Biodiversity Network (NBN) in the UK (https://nbn.org.uk/tools-and-resources/useful-websites/database-of-wildlife-surveys-and-recording-schemes/).

3. Methods

In order to effectively design new recording schemes for Jersey's freshwater wildlife and reptiles, we carried out the following steps:

1. A stakeholder workshop with volunteer surveyors and scheme coordinators in Jersey
2. A review of Jersey's species and habitats that may be suitable for inclusion in freshwater and terrestrial (reptile) monitoring
3. A review of survey approaches suitable for the species reviewed in step 2
4. A review of freshwater and terrestrial monitoring schemes within the UK and mainland Europe

We use the findings from these throughout this report, with references given where applicable.

3.1. Definitions

Throughout this document we use the following definitions. We define freshwater habitats based on the following descriptions given by the Freshwater Habitats Trust:

- **Pond**: Standing or still waters between 1 m^2 and 2 ha in area which may be permanent or temporary, but that holds water for at least four months of the year. Includes both man-made and natural waterbodies.
- **Garden Pond**: As above, but within a garden or within the boundary of your curtilage.
- **Lake**: A body of still water >2 ha in area, includes reservoirs and gravel pits.
- **River**: Larger running waters, created mainly by natural processes. Marked as a double blue line on 1:25,000 OS maps and defined by the OS as greater than 8.25 m in width.

- **Stream**: Small running waters, created mainly by natural processes. Marked as a single blue line on 1:25,000 OS maps and defined by the OS as being less than 8.25 m in width. Streams differ from ditches by usually having a sinuous outline and following natural landscape features, e.g. valleys. They include the headwaters or tributaries of larger rivers.
- **Ditch**: Man-made channels created primarily for drainage, they often (i) follow a straight line, (ii) follow boundaries e.g. field or road edges, (iii) turn at right angles, and (iv) show little relationship with natural landscape contours.

4. Current monitoring in Jersey

Species and habitat monitoring is primarily coordinated by the Natural Environment team within the department of Growth, Housing and Environment, Government of Jersey. Further monitoring, particularly pertaining to water quality, agricultural pests and diseases, disease surveillance and management of marine resources is undertaken by other Government departments (e.g. Water Resource Management and Regulation). These efforts to monitor Jersey's species and habitats align with a number MEAs that the Government of Jersey is signatory to. Locally, ecological monitoring data has relevance to a number of environmental objectives laid out in the Revised Island Plan including objective NE 1 (States of Jersey 2011). Further details on the Government of Jersey's monitoring commitments are outlined in the Biodiversity Strategy (States of Jersey: Planning and Environment Committee 2002).

Jersey's amphibian and reptile species (referred to as herpetofauna) have been primarily monitored as part of the Jersey National Amphibian and Reptile Recording Scheme (NARRS). Further details on these efforts are given in Report A (Ward and Wilkinson, 2019). Further amphibian recording efforts have also taken place as part of Toadwatch, which began in 2005, and as part of the agile frog recovery monitoring since 1987. These efforts have generated considerable data which have been extremely useful in understanding the conservation status of Jersey's native amphibians and reptiles as well as having a number of other applications.

4.1. The freshwater environment

Water resources in Jersey are protected under the Water Resources (Jersey) Law 2007, which includes the promotion and conservation of wildlife and their habitats that have a reliance on freshwater. Under the Jersey Water Framework Directive, water quality monitoring is carried out by the States of Jersey Environmental Protection Water Resource team. However, the number of freshwater sources that are monitored is limited, being primarily restricted to flowing

water and reservoirs. The number and distribution of freshwater ponds and reservoirs in Jersey is presented in Ward and Wilkinson (2019).

4.1.1. Monitoring amphibians with NARRS

Survey protocol

Amphibian surveyors were assigned a monad within Jersey and asked to identify the most south-westerly pond within it. They were then required to survey the pond up to four times, though sometimes more (or less) surveys were conducted. Survey methods included visual searches, netting and torching. However, bottle-trapping has been scarcely used in Jersey. By using a combination of methods the chance of detecting the species is improved Sewell et al. (2010). No additional taxa were requested to be recorded, but space was provided for such records.

Assessing habitat quality

As part of amphibian monitoring, surveyors were asked to assess habitat suitability using the Habitat Suitability Index (HSI). This was devised by Oldham et al. (2000) for great crested newts (*Triturus cristatus*). Efforts have also been undertaken to develop an agile frog HSI in Jersey (Radiguet 2012; Masters et al. 2018). HSIs provide a numerical index on which the suitability of a site can be assessed ranging between 0 (unsuitable) and 1 (suitable). The amphibian HSI developed by Oldham et al. (2000) consists of 10 indices considered to influence the presence and abundance of great crested newts. Since its inception, a modified HSI has been developed to improve its ease of use (ARG UK 2010). Though the HSI was developed specifically for great crested newts, it may have wider applicability to other amphibian species.

The HSI is calculated as the geometric mean of the following 10 indices: (1) location, (2) pond area (m^2), (3) how frequently the pond dries out, (4) water quality, (5) pond shading, (6) water fowl impact, (7) fish presence, (8) the number of ponds within 1-km of the study pond, (9) terrestrial habitat quality and (10) macrophyte cover. Note that the HSI in Jersey is calculated using nine indices, as location is not a consideration.

4.1.2. Monitoring amphibians with Toadwatch

The Toadwatch scheme ran in Jersey between 2005 and 2018, recording distribution and phenology data from members of the public to inform data analyses and conservation actions. This scheme required a low level of involvement with no training, with many participants reporting on amphibian activity in their own gardens.

4.1.1. Monitoring agile frog recovery efforts

Agile frog monitoring has taken place since 1987, generally focusing on a handful of occupied sites in the south-west of the island; some of which have been the focus of translocation and reintroduction efforts. The monitoring utilises visits in the day and night, with intensive recording at some ponds. The number of adults and spawn are carefully recorded, and at the intensively monitored ponds, the pond and each spawn within it is tracked throughout the season to monitor their progress. This dataset has proven useful in assessing successful conservation strategies and providing information on the species' phenology.

4.2. Reptiles and the terrestrial environment

4.2.1. Monitoring reptiles with NARRS

Survey protocol

Reptile surveyors were asked to identify the most suitable reptile habitat within their assigned monad and arrange permission with the landowner(s) to conduct a survey. If permission was granted, surveyors laid out artificial refugia (often corrugated bitumen). Surveyors were then required to record information about the area being surveyed (e.g. connectivity and habitat types). Four surveys between March and June in optimal weather conditions were preferred in order to maximise detection; though this period can be extended throughout the summer and in to the autumn. More than four surveys could also be conducted. On each survey visit, surveyors followed their survey route trying to encompass all appropriate habitats and features. Along the route, surveyors used visual surveys to try and spot reptiles in combination with artificial refugia that either they have placed for the purposes of the survey, or that may be pre-existing. A set of survey-specific variables were also recorded on each survey, including weather conditions and measures of survey effort (time spent surveying and the number of refugia checked). Generally, it was recommended that surveys do not exceed three hours. No additional taxa were requested to be recorded, but space was provided for such records.

4.3. Limitations

Though NARRS has seen relatively good uptake in Jersey (Ward and Wilkinson 2019), there are a number of limitations recognised by both the scheme coordinators and the volunteers undertaking the surveys. Primarily, these issues are associated to NARRS being designed for widespread species, but several species in Jersey are restricted in their distributions and/or habitat preferences (Table 1). Indeed, NARRS is poorly suited to wall lizards which are often

arboreal and are restricted to fortifications, dry stone walls and other rocky features that are exposed to the sun. Furthermore, there are limitations in detecting some species. For instance, research has shown the grass snake to require considerable survey effort for detection or a strong assumption of absence (Ward et al. 2017), and the presence of slow-worms and palmate newts was only detected in some squares (2007–2012 period) due to additional focal species efforts (Wilkinson et al. 2014). There are also separate but concurrent monitoring efforts for the agile frog (Ward et al. 2016).

Other concerns over NARRS' suitability include the season beginning too late (particularly for amphibians which can be active in January) and annual changes in which sites are being surveyed. The latter increases the workload for surveyors and degrades morale. A lack of Government staff time means that there is a lack of support, and no development of a 'community' sense among surveyors further hindered by a lack of regular feedback. One of the greatest obstacles is arranging landowner permission for access to sites. This can be time consuming and delay surveys, and is strongly tied to the issue of changing sites every year. From a statistical standpoint, a major challenge for volunteer-dependent monitoring schemes the world over is achieving a suitable sample size for appropriate analyses to be undertaken. This is based on several factors including the recruitment and retention of volunteers and consequently the numbers of sites surveyed and surveys carried out at those sites. The longevity of these schemes also has a bearing on which analyses can be carried out and to what degree the results can be considered as being robust.

Table 1 Native reptile and amphibian species of Jersey, with details on their distributions. Distribution is shown as the number of 1-km squares the species was recorded in during NARRS between 2007–2018 (Ward and Wilkinson 2019).

Common name	Species name	No. squares
Amphibians		
Western toad / Crapaud	*Bufo spinosus*	33
Palmate newt	*Lissotriton helveticus*	25
Agile frog	*Rana dalmatina*	3
Reptiles		
Slow worm	*Anguis fragilis*	33
Green lizard	*Lacerta bilineata*	33
Grass snake	*Natrix helvetica*	6
Wall lizard	*Podarcis muralis*	6

5. Jersey's species and habitats – priorities for monitoring

5.1. Species

We review the different taxonomic groups and species in Jersey that may fall within the remit of either freshwater or terrestrial monitoring schemes. We discuss their suitability for inclusion in monitoring based on the likelihood they will be encountered, ease of identification and ecological importance. Species data were requested from the Jersey Biodiversity Centre (JBC) to compose a list of species. Furthermore, we consulted the text of the Conservation of Wildlife (Jersey) Law 2000, the Conservation of Wildlife (Protected Plants) (Jersey) Order 2009, the Draft Wildlife (Jersey) Law 201- and Biodiversity Action Plans (BAPs) to identify species listed as having conservation concern.

5.1.1. Amphibians

Jersey's three native amphibian species are all protected under the Conservation of Wildlife (Jersey) Law 2000. They have been monitored under NARRS between 2007 and 2018, with specific efforts to record toads via Toadwatch, and additional intensive agile frog monitoring also carried out. Disease screening at two sites has been carried out for the chytrid fungus *Batrachochytrium dendrobatidis*, with no samples testing positive (Cunningham and Minting 2008). All three species are encountered in ponds, and also occasionally on land. Toads especially are encountered during the terrestrial phase resting under artificial and natural refugia. Detectability of all three species is reasonably high, though is lowest in the palmate newt (Ward and Wilkinson 2019).

5.1.1. Reptiles

All four native reptiles are protected under the Conservation of Wildlife (Jersey) Law 2000, and have been monitored as part of NARRS between 2007 and 2018. Non-native reptiles (e.g. red-eared sliders *Trachemys scripta elegans*) have been recorded on an ad-hoc basis. Detectability of slow worms, green lizards and wall lizards is reasonably high, whereas grass snakes show much lower detection rates (Ward et al. 2017; Ward and Wilkinson 2019).

5.1.1. Small mammals

Small terrestrial mammals (excluding bats) are monitored via periodic trapping efforts by the Natural Environment team and local specialists. Bats are well monitored through schemes managed by the Jersey Bat Group and the Natural Environment team. Further records for

most small mammal species are contributed through casual observations, from research and from ecological consultancy work. In addition to live-trapping, field signs (i.e. faeces, burrows, nests and food remains) can be a useful resource for monitoring small mammals. Sibbald et al. (2006) noted a single respondent to have used artificial refugia to detect small mammals alongside reptile monitoring efforts, but with limited value compared to traditional trapping approaches and a bias towards field vole (*Microtus agrestis*) detection in the UK.

Table 2 Extant terrestrial mammal species in Jersey. Note that bats are excluded for the purposes of this report and that some species are introduced non-natives. (Source: Jersey Biodiversity Centre)

Common name	Species	Monitoring methods
Wood mouse	*Apodemus sylvaticus*	Small mammal survey
Lesser white-toothed shrew	*Crocidura suaveolens*	Small mammal survey
Hedgehog	*Erinaceus europaeus*	
Feral cat	*Felis catus*	
House mouse	*Mus musculus*	
European polecat	*Mustela putorius*	
Jersey bank vole	*Myodes glareolus ssp. caesarius*	Small mammal survey
European rabbit	*Oryctolagus cuniculus*	
Brown rat	*Rattus norvegicus*	
Red squirrel	*Sciurus vulgaris*	(i) Mortality (JSPCA) (ii) Supplementary feeding
Common or French shrew	*Sorex coronatus*	Small mammal survey
Mole	*Talpa europaea*	

5.1.2. Freshwater fish

Freshwater fish (Table 3) are not monitored under any scheme at present, with knowledge of their distribution largely attributed to information from Jersey Freshwater Angling Association and research carried out by the University of Exeter in 1985. A number of the species recorded have been introduced for angling purposes.

Table 3 Extant freshwater fish species in Jersey. Note that we include some species that occur in both marine and freshwater environments. (Sources: Jersey Freshwater Angling Association, Jersey Water, University of Exeter 1985, Baal 1955)

Common name	Species name
Indigenous	
Brown trout	*Salmo trutta*
Common eel	*Anguilla anguilla*
Three-spined stickleback	*Gasterosteus aculeatus*
Lamprey	*Lampetra planeri*
Stone loach	*Barbatula barbatula*
Introduced	
Bream	*Abramis brama*
Common carp	*Cyprinus carpio*
Crucian carp	*Carassius carassius*
Mirror carp	*Cyprinus carpio*
Perch	*Perca fluviatilis*
Roach	*Rutilus rutilus*
Common rudd	*Scardinius erythrophthalmus*
Tench	*Tinca tinca*
Atlantic salmon	*Salmo salar*
Rainbow trout	*Oncorhynchus mykiss*
Brook trout	*Salvelinus fontinalis*
Canadian brook trout	*Salvelinus fontinalis*

5.1.3. Invertebrates

As is often the case, Jersey's invertebrates are relatively understudied. Several species are proposed for legal protection. Butterflies and bees are monitored as part of the Jersey Butterfly Monitoring Scheme (JBMS). This scheme requires volunteers to carry out visual transects between April and September. The timing of butterfly and moth larva, and subsequently pupa, occurs after emergence. However, the time of year at which these stages occur is variable across species. Aside from those that may be observed free-flying during visual surveys, several species of moth may be encountered when checking artificial refugia. This particularly pertains to the larva and cocoons of species in the Lasiocampidae family and the Arctiinae subfamily (tiger and ermine moths), as well as adults of the shoulder stripe moth (*Earophila badiata*) (K. Le Feuvre, pers. comm.). The Lasiocampidae includes drinker moths (*Euthrix potatoria*), the fox moth (*Macrothylacia rubi*) and the oak eggar (*Lasiocampa quercus*). Note that we do not list all moths and butterflies recorded in Jersey as these number in excess of 1100 moths and around 60 butterflies.

Other terrestrial invertebrates that may be encountered during refugia checks include beetles, cockroaches, spiders and ants. The most distinctive beetles are the glow worm (*Lampyris*

noctiluca) and the lesser stag (*Dorcus parallelipipedus*). The former of these is somewhat of a survey priority. Jersey's native cockroach species are the tawny cockroach (*Ectobius pallidus*) and the lesser cockroach (*Ectobius panzeri*). These can occur in large numbers under artificial refugia (R. Ward pers. obs.). Over 200 species of spider and 12 species of harvestman (Opiliones) are recorded in Jersey (Source: Jersey Biodiversity Centre). There are also 18 recorded ant species (Table 4). Though spider and ant species may be abundant under artificial refugia, they can be difficult to identify in the field without specialist knowledge and equipment. Therefore, they are unlikely to be suitable candidates for volunteer monitoring.

Macroinvertebrates are sampled as part of water quality monitoring undertaken by Water Resource Management and Regulation. However, this approach is extremely intensive and not transferable to widespread volunteer monitoring approaches due to the expertise and time commitment required. Among these macroinvertebrates are the larvae (nymphs) of dragonflies and damselflies (Odonates), of which there are 27 species in Jersey (Table 5). Dragonfly and damselfly larvae can be recorded by netting, and adults are often observed in and around freshwater habitats. Though it may be challenging to ask surveyors to identify them to species level, there are several stages of identification by which they may be able to identify which group certain species fall in to (i.e. dragonflies or damselflies, what sort of dragonfly). An improved dataset on the distribution of dragonflies and damselflies can be combined with the data collected by the more intensive efforts of Water Resource Management and Regulation.

Table 4 Ant species recorded in Jersey. (Source: Jersey Biodiversity Centre).

Common name	Species name
Redbacked slave ant	*Formica cunicularia*
Grey-black slave ant	*Formica fusca*
Black backed meadow ant	*Formica pratensis*
Roger's ant	*Hypoponera punctatissima*
Cornfield ant	*Lasius alienus*
	Lasius emarginatus
Yellow meadow ant	*Lasius flavus*
Jet ant	*Lasius fuliginosus*
Black garden ant	*Lasius niger*
	Lasius psammophilus
Pharaoh ant	*Monomorium pharaonis*
	Ponera coarctata
Thief ant	*Solenopsis fugax*
	Stenamma westwoodii
Erratic ant	*Tapinoma erraticum*
Rock ant	*Temnothorax albipennis*
	Temnothorax unifasciatus
Pavement ant	*Tetramorium caespitum*

Table 5 Dragonfly and damselfly species recorded in Jersey. (Source: Jersey Biodiversity Centre).

Common name	Species name
Southern Migrant Hawker	*Aeshna affinis*
Southern Hawker	*Aeshna cyanea*
Brown Hawker	*Aeshna grandis*
Migrant Hawker	*Aeshna mixta*
Vagrant Emperor	*Anax ephippiger*
Emperor Dragonfly	*Anax imperator*
Banded Demoiselle	*Calopteryx splendens*
Beautiful Demoiselle	*Calopteryx virgo*
Willow Emerald Damselfly	*Chalcolestes viridis*
Azure Damselfly	*Coenagrion puella*
Variable Damselfly	*Coenagrion pulchellum*
Dainty Damselfly	*Coenagrion scitulum*
Golden-ringed Dragonfly	*Cordulegaster boltonii*
Scarlet Darter	*Crocothemis erythraea*
Common Blue Damselfly	*Enallagma cyathigerum*
Small Red-eyed Damselfly	*Erythromma viridulum*
Blue-tailed Damselfly	*Ischnura elegans*
Scarce Blue-tailed Damselfly	*Ischnura pumilio*
Southern Emerald Damselfly	*Lestes barbarus*
Broad-bodied Chaser	*Libellula depressa*
Scarce Chaser	*Libellula fulva*
Four-spotted Chaser	*Libellula quadrimaculata*
Black-tailed Skimmer	*Orthetrum cancellatum*
Large Red Damselfly	*Pyrrhosoma nymphula*
Red-veined Darter	*Sympetrum fonscolombii*
Ruddy Darter	*Sympetrum sanguineum*
Common Darter	*Sympetrum striolatum*

5.1.4. Plants

Over 1200 flowering plant species recorded in Jersey (Source: Jersey Biodiversity Centre). The distribution of those receiving protection and with BAPs is monitored by the Société Jersiaise and Natural Environment team. Invasive plants (e.g. Japanese knotweed *Fallopia japonica*) are also monitored by government departments. Several of these are listed in the draft Wildlife (Jersey) Law 201- as shown in Table 6. Further monitoring of invasive non-native aquatic plants could be easily incorporated in to pond surveys provided surveyors are given basic training.

Table 6 Wild animals, birds or plants of invasive non-native (INN) species listed on schedule 11, Article 5 of the draft Wildlife (Jersey) Law 201- listed by Jersey or the EU.

Common name	Species name	Listed by
Mammals		
Ferret (feral)	*Mustela furo*	Jersey
Invertebrates		
Asian hornet	*Vespa velutina*	Jersey
Plants		
Hottentot fig	*Carpobrotus edulis*	Jersey
Pampas grass	*Cortaderia selloana*	Jersey
Japanese knotweed	*Fallopia japonica*	Jersey
New Zealand pigmyweed	*Crassula helmsii*	Jersey
Alligator weed	*Alternanthera philoxeroides*	EU
Eastern baccharis	*Baccharis halimifolia*	EU
Fanwort	*Cabomba caroliniana*	EU
Water hyacinth	*Eichhornia crassipes*	EU
Common milkweed	*Asclepias syriaca*	EU

5.1.5. Fungi

Over 1000 fungi species have been recorded in Jersey (Source: Jersey Biodiversity Centre), with some proposed for protection. Though no structured monitoring exists for fungi currently, local enthusiasts contribute heavily to the datasets available. They are unlikely to be a suitable component of reptile or freshwater monitoring efforts due to the skill and experience required for identifying the many species present.

5.2. Habitats

Jersey contains multiple key habitat types (States of Jersey: Planning and Environment Committee 2002). Those that are terrestrial are mixed woodland, ancient and/or species rich hedgerows, wet meadows, maritime heath, maritime cliff and slope, coastal vegetated shingle structure and coastal sand dune (including fixed dunes with herbaceous vegetation, dune heath, dune scrub and strandline vegetation). Key habitats of local importance include Jersey's wet meadows, woodland, marsh and freshwater and walls and banques. Urban and agricultural areas also hold some value for biodiversity. Ecological monitoring therefore also needs to reflect changes in the status of important habitats.

6. Survey approaches

6.1. Survey methods and design

Here we evaluate the varied survey methods available for sampling Jersey's (i) freshwater biodiversity and (ii) reptile and other terrestrial species. We particularly focus on survey methods and sampling design for amphibians and reptiles, but include information for other taxonomic groups where possible. Information from previous and concurrent studies are used to identify the optimal survey strategy to detect changes in occupancy for each of the species whilst minimising effort.

For species with low abundance and / or low detection, many surveys at many sites may be needed to detect declines (Ficetola et al. 2017; Ward et al. 2017). Deciding between the number of sites to be surveyed and the number of surveys to conduct at each is a trade-off that must be considered. Ficetola et al. (2017) showed that this choice was highly dependent upon the detectability of the study species. In most instances it appears to be preferable to survey more sites less times, unless species detectability is very low.

6.1.1. Freshwater

The methods available for sampling freshwater and terrestrial wildlife are varied. Visual searches are the most accessible approach for many requiring little equipment (perhaps with the exception of binoculars in some instances), and are used in many schemes such as Toadwatch, the Big Butterfly Count (https://www.bigbutterflycount.org/), the Big Garden Birdwatch (https://www.rspb.org.uk/get-involved/activities/birdwatch/) and Dragonfly Spot (https://british-dragonflies.org.uk). Additional methods for surveying freshwater wildlife include

net sampling, night-time torching, bottle trapping, environmental DNA (eDNA) (including metabarcoding) and acoustic monitoring.

Amphibian surveys are best targeted at ponds during the breeding season as species density increases along with detectability. Ponds also provide defined areas to assess, whereas amphibians can be widely dispersed and hidden in the terrestrial landscape. Detectability of amphibians is greatly improved through the application of multiple survey methods. Within NARRS, these methods consist of (i) visual searches (including egg-searches), (ii) netting, (iii) torching (at night) and (iv) bottle-trapping. The latter of these requires specialist training and has greater licensing implications than the other, less-invasive, approaches. We describe the use of these four methods in NARRS below:

Visual searches require surveyors to walk once around the pond edge looking for the species of interest, including eggs. This should be conducted during the day. No specialist equipment is required. This approach is generally more effective for toads and frogs than for newts as toad spawn strings and frog spawn clumps are vastly more visible than newt eggs, which are laid individually and folded in to the leaves of aquatic plants.

Netting is particularly useful where vegetation is present in the pond margins. Effort is standardised by netting vegetation in two-metre segments around the pond perimeter, taking care not to dredge up the pond floor. After each two-metre segment is swept with the net, the contents are inspected for amphibians and then returned to the pond. If more time is needed to inspect the results, the net contents can be transferred to a white plastic sampling tray filled partially with pond water. Where shoreline vegetation is limited or lacking completely, this method may be less productive and yield few or no captures. This should be conducted during the day and requires a proper pond net. Concerns have been raised that netting could damage the gills of larval newt (Sewell et al. 2013).

Torching at night is normally carried out shortly after dusk. Similar to netting, surveyors are instructed to search two-metre sections of the pond from the bank with torchlight, repeating to cover the pond's perimeter. This can be carried out on the same day as other survey methods (assuming earlier netting hasn't affected visibility) or on a different day. Surveyors are recommended to conduct day-time activities before any night-time visit takes place so that the area can be assessed and hazards identified in daylight. This method requires a high-powered torch of 500,000–1,000,000,000 candle power.

Bottle-trapping is primarily designed for newts. As the name suggests, plastic bottles are used to trap newts and therefore has implications on the welfare on the animals being trapped. This includes bycatch of non-target species such as freshwater invertebrates, fish and occasionally small mammals. The method can also be effective at trapping frog tadpoles. Furthermore, trap placement can require surveyors to enter the pond and so brings greater risk to the surveyor. Briefly, bottle-traps consist of two-litre plastic bottles modified by removing and inverting the neck to create a funnel (Griffiths 1985). A cane is run through or attached to the bottle at an angle to provide an anchoring point in the pond sediment. In some instances, string is used to tie the traps to an alternative anchor point or to a float (e.g. a cork) if the pond is steep-sided and the sediment can't be reached, isn't present or the pond could be damaged by the cane (e.g. in the case of a pond-liner). Traps are placed at an angle, allowing an air reservoir in the top of the bottle, at two-metre intervals. Trap placement normally occurs in the evening and they are then checked early the following morning. This is a useful approach when individuals need to be captured, such as when conducting population estimates.

For all methods it may not be possible to access the entirety of the shoreline safely. Therefore, surveyors should record the percentage of shoreline searched.

NARRS amphibian surveyors are also required to record information on habitat suitability, habitat (pond) structure and environmental conditions.

Other methods not currently used in NARRS are pitfall trapping, acoustic surveys, physical searches of terrestrial habitat features (e.g. under logs and other refugia) and eDNA.

Pitfall trapping is particularly resource-intensive and not suitable for the aims of NARRS. Briefly, it requires setting buckets in the ground with a drift fence running the length of the pitfall trap array to guide wildlife in to the buckets. Traps must be checked regularly for the welfare of the captured animals.

Acoustic surveys are applicable to frogs and toads, but not to newts. Surveyors learn the calls of the study species and can then use the calls as a sign of presence of that species. Limitations include difficulties in determining numbers, calls being centred around breeding activity and some species being less audible to humans than others. For instance, agile frogs often call underwater (Sacchi et al. 2015), making them harder to detect in this manner.

Searches of natural refugia (e.g. under logs) and other habitat features can be valuable in discovering amphibians in their terrestrial form (Langton et al. 2001).

However, this approach can be unreliable (Sewell et al. 2013), disturbs the habitat and the animals themselves and requires surveyors to have a good understanding of species ecology in order to target appropriate features.

Environmental DNA (eDNA) is an emerging tool that has been widely used for surveying amphibians and other freshwater organisms (Rees et al. 2014). In Britain it is primarily used to detect great crested newts (*Triturus cristatus*) and has been shown to be effective (Biggs et al. 2015). Despite this, it is recommended that it is carried out in conjunction with other methods previously described. Furthermore, there are costs associated with sample analysis which may preclude its use.

Previous work by Sewell et al. (2010) suggested that four surveys utilising bottle trapping, torching, netting and visual searches would allow British amphibian species to be detected or deemed absent from a site with a 95% confidence. This also assumes that surveys are carried out in appropriate conditions and at the right time of year. Sewell et al. (2010) recommended timings of one survey carried out in March and a subsequent three between mid-April and late May. Greater numbers of surveys would be required where abundance or detectability may be lower, such as in sub-optimal habitats and outside of the breeding season. We must be cautious in applying timings of British species and populations to those in Jersey, as Jersey's herpetofaunal assemblage is different and exists in a different environment. Therefore, we review the timings for each of Jersey's species below.

Western toad / Crapaud *(Bufo spinosus)*

Evidence from Toadwatch (Wilkinson and Starnes 2016) suggests that Jersey's toads become active from mid-to-late January at the earliest, with the first spawning occurring in February and in to March. Observations during NARRS were mainly between February and June, with some sightings through to September (Ward and Wilkinson 2019) – however, these timings may be an effect of when surveys were carried out. After breeding, adults may be found in terrestrial habitats through to late autumn, before overwintering until January. Three pond surveys are required to have 95% confidence of absence when appropriate sampling methods are applied (Ward and Wilkinson 2019).

Palmate newt *(Lissotriton helveticus)*

There is comparatively little information on the activity of Jersey's palmate newts. The majority of observations during NARRS surveys were between late February and May (Ward and Wilkinson 2019). However, they may be active from January, and have an extended mating period where eggs may be laid until early summer. When not breeding, they can be found in their terrestrial phase under natural and artificial refugia. Five pond surveys are required to

have 95% confidence of absence when appropriate sampling methods are applied (Ward and Wilkinson 2019).

***Agile frog** (Rana dalmatina)*

Agile frogs were most observed during NARRS surveys carried out between February and March. Spawning tends to begin at low temperatures in mid-February, with peak spawning activity often occurring towards the end of February and beginning of March, associated with temperatures of 6–10℃, and no higher than 15℃ (Ward and Griffiths 2015). The latest spawning is often in late March, but can be extended until the beginning of April. After breeding, adults disperse from their breeding grounds and utilise the surrounding terrestrial habitat. Metamorphosis of tadpoles is usually completed by the end of July or early August, with hibernation expected to occur from October through to January. Three pond surveys are required to have 95% confidence of absence when appropriate sampling methods are applied (Ward and Wilkinson 2019).

Invasive non-native plants

Non-native aquatic plants may be detected throughout the year, however are likely to be most conspicuous between May and the end of September. They can range from single plants to entire mats.

Dragonflies and damselflies

Adult dragonflies and damselflies are best surveyed between May and September on warm sunny days with low wind (Smallshire and Beynon 2010). Surveys for aquatic larvae may be conducted throughout the year, however early summer is likely to result in greater success.

6.1.2. Reptiles and other terrestrial organisms

Reptiles are traditionally monitored through a combination of visual encounter surveys (walking along a transect and looking for the species in question) and refugia surveys (checking artificial refugia for the target species). Additional methods for other terrestrial wildlife include acoustic monitoring, camera trapping, sign surveys (hair, faeces, nests, burrows, tracks), pitfalls and other trapping approaches.

As reptiles do not aggregate in quite the same way as amphibians (but see **emergence surveys** below), the methods available for detection and the numbers recorded in a single observation event are fewer. The use of field craft therefore also plays an important role, and so surveyor experience is an important factor to consider in species detection. NARRS applies

two survey methods in conjunction: (i) visual encounter surveys along transects and (ii) refugia checks.

Visual encounter surveys require surveyors to walk along a survey route, visually searching for the species of interest and recording their observations. This approach is heavily influenced by a surveyor's experience and skill, environmental conditions and habitat structure. It can be constrained by time and the transect length, but can be influenced by external factors such as unexpected weather conditions, seasonal changes in habitat structure (reducing accessibility to sections of the transect) and the presence of others on site who may wish to engage in conversation. Furthermore, timed surveys restrict surveyors from watching any animals they may encounter - which may be perceived negatively.

Refugia checks consist of surveyors checking features that reptiles and other animals may be using to conceal themselves, thermoregulate and for other purposes. These refugia features can be natural (e.g. logs and rocks) or man-made, with man-made items either being laid purposefully (such as the use of roofing felt, corrugated bitumen or corrugated tin sheets) or as the result of discarded refuse (e.g. tyres, metal sheeting, carpet, plastic sheeting, pieces of wood, tiles). Man-made refugia are also often referred to as artificial cover objects (ACOs), and those that are purposefully laid for surveys can be standardised in size and material to make surveys repeatable. The choice of artificial refugia material can influence the species using it, and at what time of day due to their variable thermal properties. Refugia should be positioned so that they are at least partially exposed to the sun during the day (south-facing is preferable) and set in to an area of vegetation that not only helps to conceal them from unwanted attention, but also to provide cover to any wildlife moving to and from it. The suitability of artificial refugia also varies by species. For instance, in the UK they are a fairly poor tool for detecting sand lizards (*Lacerta agilis*). Refugia can be combined with visual encounter surveys by using them as waypoints along the survey route.

Emergence surveys are not used in NARRS, but can be a useful approach to surveying reptile species that communally hibernate. In Britain, this method is applied to the adder (*Vipera berus*) as part of the *Make The Adder Count (MTAC)* scheme (Gardner et al. 2019). Adders typically overwinter in communal hibernacula such as tree roots or banks. In spring, they emerge and spend time near the hibernacula before dispersing. This allows surveyors to count the number of individuals in the vicinity and make an estimate of the local population size. In Jersey this method may not be applicable as communal hibernacula are unknown. Monitoring of grass snake nest

sites could be carried out in a similar fashion due to the potential of communal use (Ward 2017), but low snake density and limited knowledge on the type and location of nest sites precludes this approach.

Sewell et al. (2012) recommended 4–5 survey visits to have reliable detection of most British reptile species, assuming both visual encounter surveys and refugia were used. These values may vary based on a number of factors including the species, surveyor skill and experience, habitat type, weather conditions and season and the number of refugia used.

Slow worm *(Anguis fragilis)*

Slow worms are perhaps the most ubiquitous of Jersey's reptiles. They occur in a variety of habitats, including those modified for human use. Refugia surveys can be particularly important for detecting this species (Sewell et al. 2012), and analysis of Jersey NARRS data suggests this also to be the case in Jersey (Ward and Wilkinson 2019). The species can be active from February through to October, but with higher chance of detection throughout the spring and summer. The young are born late-summer to early-autumn. Four site surveys are required to have 95% confidence of absence when appropriate sampling methods are applied (Ward and Wilkinson 2019).

Green lizard *(Lacerta bilineata)*

Green lizards can be relatively easy to detect using both visual and refugia surveys, in which they may be found on top and beneath refugia as well as out in the open and at the edge of vegetation. They are active between late March and early October, but are most frequently encountered between April and June (Ward and Wilkinson 2019). Mating occurs between April and May, eggs are laid from mid-June to mid-July, and the young hatch from August to September. Three site surveys are required to have 95% confidence of absence when appropriate sampling methods are applied (Ward and Wilkinson 2019).

Wall lizard *(Podarcis muralis)*

The wall lizard is primarily found in rocky habitats or on walls and fortifications. Its arboreal nature and restricted distribution in Jersey makes it an unsuitable subject for the survey methods used in NARRS, as shown by the sporadic timing of encounters and observed occurrence at few sites (Ward and Wilkinson 2019). Visual surveys are likely to be the most suitable survey method, and can be conducted with comparably little effort to other reptile species. One additional method that may have some merit but requires testing is that of arboreal cover boards (Nordberg and Schwarzkopf 2015). Monitoring for this species should therefore be carried out separately to that of widespread species (i.e. green lizards and slow worms). Wall lizards are active in any warm sunny conditions, especially between March and

October, with mating occurring from late March to early May, egg-laying between late May and mid-July, and hatching from August to September. They are expected to enter hibernation around the start of November. We do not provide a specific number of surveys required to have confidence of absence for this species due to limited data and the unsuitability of NARRS data for informing any estimates.

***Grass snake** (Natrix helvetica)*

The grass snake is Jersey's most elusive reptile, and has been encountered infrequently during NARRS efforts in the island (Ward and Wilkinson 2019). Intensive research of the population has shown that, though the species is present across a number of sites in the west of the island, profound effort is required to adequately detect them – making them a challenge for monitoring (Ward et al. 2017). Monitoring for this species should therefore focus on intensively surveying known and suspected sites in order to track local changes in occupancy. Grass snakes emerge in March before mating from April through to May and then egg-laying mid-June to mid-July. The resulting young hatch between August and September. Hibernation occurs from late autumn. Based on the findings of Ward and Wilkinson (2019), 39 site surveys are required to have 95% confidence of absence using existing NARRS sampling methods. However, Ward et al. (2017) found detection to primarily be driven by survey effort (i.e. number of refugia checked) and so this number can be heavily reduced with appropriate effort.

Small mammals

Small mammals can be monitored through several methods. These include intensive approaches such as trapping which can provide local abundance measures, moderately intensive approaches such as the use of refugia, ink pads, hair tubes and camera trapping, or more indirect measures such as identification of food remains, skeletal remains in owl pellets, faeces, nest and burrows. Observations in Jersey suggest they may regularly be recorded under artificial refugia, particularly during nesting. They can be recorded from spring through to autumn, with trapping approaches usually taking place during spring and autumn as two separate sampling periods.

***Cockroaches** (Ectobius spp.)*

Jersey's two cockroach species (*Ectobius* spp.) can be detected on the underside of natural and artificial refugia between May and October.

Beetles

The glow worm (*Lampyris noctiluca*) can be found on the underside of natural and artificial refugia and is most likely to be observed between April and October. The lesser stag beetle

(*Dorcus parallelipipedus*) is active between May and September, and may also be encountered under refugia.

Butterflies and moths

Butterflies and moth species vary in the timings of their different lifestages and activity (https://www.ukbutterflies.co.uk/species_phenologies.php). Broadly speaking, butterflies are best detected in flight between April and September. However, some moth species can be observed using the underside of artificial refugia, particularly as pupa or larva (K. Le Feuvre, pers. comm.). The more commonly observed Lasiocampids (e.g. fox moths) can be seen in pupa form from late spring to early summer, and then as larva from autumn through until late spring of the following year.

6.2. Environmental data

The influences of environmental variability on species occurrence and detectability are an important aspect of biological recording. For example, water temperature has been shown to influence the capture rate of great crested newts (*Triturus cristatus*) and so Sewell et al. (2010) suggested that great crested newt surveys utilising bottle traps should also record water temperature during their surveys. Therefore, any proposed scheme(s) should incorporate appropriate environmental measures.

6.3. Locations

The way in which survey sites are defined and distributed is particularly important from an analytical point of view. Many schemes utilise a simple 1-km square (monad) approach to divide the sampling area and direct a specific sampling approach. In the case of amphibians being monitored during the spring, ponds are the most suitable unit of measure. In comparison, it can be difficult to quantify the terrestrial area being surveyed for reptiles and other species due to heterogeneity in the landscape and a poor understanding of the true area that is being searched. Many schemes surveying species terrestrially utilise transects, including the UK Butterfly Monitoring Scheme, the Dragonfly Monitoring Scheme (Smallshire and Beynon 2010) and NARRS. It could then be said that the area surveyed is that falling within a certain buffer distance of the transect (e.g. 2 metres), but this may still be a poor approximation.

The size of any sites defined for monitoring purposes needs to consider the methods by which the data will later be analysed. For instance, in the case of occupancy analyses, assumptions may be made that the area surveyed did not change in occupancy during the survey season. A site that is too small therefore has a high likelihood of changing occupancy status over an

extended survey season, and a site that is too large will always appear occupied but provides little information on species distribution and status.

6.4. Habitat surveys

Information about the habitat within which species are present or absent is vital to understanding the factors affecting population trends, thereby influencing further survey effort and habitat management. Recording schemes regularly use nationally or internationally recognised habitat classifications to define habitats. For example, the Butterfly Monitoring Scheme uses categorisations based on the European Nature Information System (EUNIS) classification. Other categorisations include the Phase 1 Habitat Survey and the newly launched UK Habitat Classification scheme (UK Habitat Classification Working Group, 2018). Assessing the quality of these habitats is somewhat more difficult, and can be subjective without clear definitions. The use of a Habitat Suitability Index (HSI) is an effective way of evaluating the quality of certain habitats, but few have been developed.

6.4.1. Pond quality

The quality of a pond can be determined based on its water quality, macroinvertebrate diversity or a Habitat Suitability Index (HSI) approach that seeks to score the habitat by its suitability for one or more species. Many of these incorporate macroinvertebrates in their assessments.

The Predictive System for Multimetrics (PSYM) is designed to allow the quality of a waterbody to be assessed based on a combination of environmental variables (e.g. pH) and the community of organisms present (Biggs et al. 2000). It is designed for use in England, Wales and the Isle of Wight and requires sampling to be carried out between June and August. The Biological Monitoring Working Party (BMWP) index is based on the macroinvertebrates present and can be considered as measure of organic pollution (Armitage et al. 1983). Similarly, a number of pond quality assessment protocols across Europe utilise macroinvertebrates as the basis for assessing water quality (reviewed in Poikane et al. 2016). The National Pond Survey (NPS) (Pond Action 1998) uses an in-depth standardised approach which utilises environmental, chemical and species data (plants and invertebrates) to classify ponds, understand the factors driving species composition and assess the contribution of a pond to wider conservation objectives. Ponds need to be surveyed three times throughout the year (spring, summer and autumn). The Rapid Assessment for Ponds approach was developed by the Freshwater Habitats Trust and has been used in several surveys, including the current Big Pond Dip. The survey method was developed as a simple approach that could

be widely used by the public, and was derived from the National Pond Survey and the PSYM approach.

Habitat Suitability Indices have been developed in the UK for great crested newts (*Triturus cristatus*) (Oldham et al. 2000; ARG UK 2010), reptiles (Brady and Phillips 2012; Brady et al. 2014) and attempts have been made to develop one for Jersey's agile frog (*Rana dalmatina*) population (Radiguet 2012; Masters et al. 2018). These indices utilise multiple metrics that are considered to describe aspects of habitat suitability that combined, give a reliable and repeatable measure for the species in question. However, they can have limitations due to geographical variation and subjectivity.

7. Review of monitoring schemes

We reviewed monitoring schemes occurring within Europe that encompassed freshwater and/or terrestrial species or habitats, with a focus on herpetofauna and freshwater invertebrates. We were particularly interested in barriers to entry such as the expertise required to carry out monitoring, the commitment required (number of visits, survey timing), equipment required, how sites are selected and setup and the survey methods used. Each scheme was assessed against the following questions / statements:

- What is the aim of the scheme?
- What are the target species and habitats?
- What level of skill / experience is required to participate?
- What are the sampling methods used?
- What sampling resources are required? (equipment, transport)
- What is the timing of the sampling?
- What is the sampling effort required? (regularity of sampling, length of sampling)
- What resources are provided to support citizen scientists?

7.1. Freshwater schemes

A large number of freshwater monitoring schemes were evaluated. Within the UK these were primarily those operated by the Freshwater Habitats Trust (FHT) and the British Dragonfly Society (BDS). FHT was found to run 15 schemes, with nine of those falling under the remit of the *PondNet* project. These FHT schemes encompassed amphibians, macroinvertebrates, plants, habitats and water quality assessment. Further water quality monitoring efforts have been carried out on a large scale by Earthwatch. The BDS was found to have 10 schemes of varying involvement, covering dragonflies and damselflies. Monitoring schemes coordinated

by Amphibian and Reptile Conservation (ARC) focused primarily on amphibians. Toad migration patrols were coordinated by Froglife. Elsewhere, a number of schemes were run in the Netherlands by RAVON (Reptile, Amphibian and Fish Research Netherlands) which focused on amphibians and freshwater fish. Amphibian monitoring efforts in France were directed by national action plans, with other efforts coordinated by the Société Herpétologique de France (SHF). In Germany, amphibian monitoring is carried out to monitor toad migrations (Krötenwanderung) and to conduct national species mapping (Landesweite Artenkartierung (LAK)). A number of other regional and national amphibian monitoring programmes were recorded throughout Europe.

7.2. Reptile schemes

Within the UK, national volunteer-based reptile monitoring was only conducted by two organisations; Amphibian and Reptile Conservation (ARC) and Amphibian and Reptile Groups of the UK (ARG UK). ARC listed several schemes, based either on monitoring multiple reptile species (e.g. NARRS), with a single-species focus (e.g. the New Forest Smooth Snake Survey – NFSSS) or as part of multi-taxon efforts (e.g. Gems in the Dunes). Their efforts also included the coordination of a reptile gene bank which utilises sloughs collected in the field. ARG UK's efforts were primarily focused on the adder (*Vipera berus)* through the use of emergence surveys for Make the Adder Count (MTAC). However, local Amphibian and Reptile Groups (ARGs) will sometimes have their own monitoring schemes.

Within Europe, RAVON was found to run a number of schemes in the Netherlands focusing on single and multiple species. As with amphibians, the SHF was found to coordinate reptile monitoring efforts in France, national species mapping was being carried out in Germany, and regional and national efforts were recorded in many countries across Europe.

7.3. Scheme aims

The aims of the schemes that we reviewed could be broken down in to several categories, with some schemes fitting several of these categories. These were detecting species trends, establishing species status, recording species distributions, site-based assessments, recording species phenology, understanding habitat requirements, measuring habitat quality, detecting trends in habitat quality, monitoring disease, reducing mortality, education and community engagement.

7.4. Target species and habitats

The schemes reviewed either focused on single or multiple species, or on particular habitat types. Those that encompassed multiple species were generally focused on single taxonomic

groups, though efforts to monitor multiple taxonomic groups were noted (e.g. Gems in the Dunes). Species monitoring primarily focused on native species, with non-native species recorded as incidental observations in many cases. Efforts were also recorded to monitor disease rather than specific species, though these typically focused on single taxonomic groups (e.g. amphibians).

7.5. Skill and experience

The reviewed schemes ranged in their requirements of participants, from untrained and inexperienced volunteers through to the need for experienced amateur naturalists. Some schemes incorporated multiple levels and survey options, allowing volunteers to choose the most appropriate level of involvement with a survey option of interest. For example, the BDS DragonflyWatch scheme incorporates a recording ladder framework, in which there are three levels; (i) Dragonfly Spot which is aimed at engaging new recorders and eliciting basic records, (ii) Complete Lists which requires volunteers to have some experience identifying species and focuses on a specific set of sites and (iii) Priority Sites which requires experienced volunteers to record detailed information at important dragonfly sites.

7.6. Sampling methods

Amphibian monitoring schemes utilised several methods, including visual surveys, netting, torching, bottle trapping and eDNA. Other freshwater monitoring involved transect-based approaches for dragonflies and damselflies, and the use of water quality testing kits for pollution monitoring. The freshwater schemes varied in their regularity, from single one-off surveys (generally at more basic levels of the survey spectrum) to multiple repeat visits for more structured sampling efforts. Schemes employing macroinvertebrate sampling were among the most intensive. Transect-based approaches were favoured for reptile surveys, often with a fixed number of surveys over a prescribed season. The regularity with which sites were re-visited varied, with some schemes suggesting annual repeats were carried out to detect population changes at the site level, and others allowing for sites to change - particularly when concerned with national trends.

7.7. Resource requirements

The scheme review highlighted an issue with allocated sites occurring within more rural areas, where volunteers were unable or unwilling to travel given the distance. However, this is unlikely to be an issue in Jersey. Basic resources often needed to be provided by the volunteers themselves (e.g. appropriate clothing, torches, nets), however more specialist

equipment was sometimes provided by the coordinating organisation (e.g. eDNA sampling kits).

7.8. Survey timing

The majority of schemes provided guidance on specific timing of the survey season, and in some instances, the timing of each survey within that season. Amphibian surveys were directed towards the spring, whereas habitat, plant and invertebrate surveys were between late spring and autumn. Reptile surveys were typically targeted in the spring and autumn. Recommendations are often also given on how far apart successive surveys should be spaced (e.g. a minimum of five days) and the appropriate survey conditions.

7.9. Sampling effort

The more structured schemes generally required multiple visits, whereas those aimed at beginners only requested a single survey or were casual in nature. For example, a reptile monitoring scheme (meetprogramma reptielen) coordinated by RAVON requires seven surveys, each approximately two hours in duration.

7.10. Resources and support

Volunteer training was offered as workshops in some instances, however funding and resources meant that there was a reliance on local partnerships to assist in training and coordination. Documentation including survey manuals, species identification guides, habitat guides and recording forms were generally available online. Some examples were noted of online training videos, as well as the use of recording apps to facilitate recording in the field. Many schemes had the option to record survey results online.

8. Future monitoring for Jersey's wildlife

In this section we present two new schemes for monitoring biodiversity in Jersey: (i) **Pondwatch JE** and (ii) **Reptilewatch JE**. Pondwatch JE focuses on amphibians and other wildlife occurring in ponds, whereas Reptilewatch JE focuses on reptiles and other terrestrial organisms. These schemes have been developed based on the findings of the concurrent report (Ward and Wilkinson 2019) and the materials reviewed throughout this report.

Both schemes are specifically designed for the island of Jersey, and have been developed in partnership with Natural Environment, Growth, Housing and Environment (Government of Jersey), Jersey Amphibian and Reptile Group and Jersey Biodiversity Centre. Each scheme

provides three levels of involvement, in an aim to maximise accessibility and participation. The primary measure of interest within these new schemes is that of occupancy.

8.1. Pondwatch JE

Pondwatch JE is an island-wide effort to record Jersey's pondlife, with the aim of detecting changes in the conservation status of freshwater species. Additionally, it is expected to provide informative data on the distribution and habitat requirements of the species monitored.

8.1.1. Volunteer involvement

Multiple survey options are offered over three primary levels of participation dependent upon experience and available time:

Level			Methods
1	30 minutes 1 survey	No experience required No training required	Visual
2	30–60 minutes 5 surveys	No experience required Training is required	Visual, net, torch
3	60+ minutes Many surveys	Experience required Training is required	Visual, net, torch

8.1.2. Level 1

Experience

Volunteers participating in Level 1 of Pondwatch JE do not require survey training or experience.

Survey location

They are asked to survey a pond of their choice for which they have permission to survey, with an emphasis on their own (or a friend's) garden pond(s).

Survey timing

At least one survey January–May, though survey data outside of this sampling period will be accepted. The time of day is not constrained.

Survey duration

The survey takes 30 minutes, plus five minutes to fill out the survey form.

Equipment

Participants will require:

- a Pondwatch JE Level 1 survey form (available from https://groups.arguk.org/jarg)
- a pen or pencil
- a mobile phone (for use in the event of an emergency)

Optional (recommended):

- a camera to take pictures which will assist in record validation
- a torch if surveying at night

Survey protocol

Step 1: Visit the chosen pond and record its location, type and pond construction as shown on the survey form.

Step 2: Spend 30 minutes visually searching for pondlife from the bank. When possible, take photos of what is seen but remember not to touch or handle any wildlife. If help is needed identifying the species seen, see the species ID guides on the JARG website.

Step 3: Record the survey date and the number of any plants or animals seen. Amphibian spawn and tadpoles can be difficult to count, so instead a range can be recorded (e.g. 10–20) or the box of the appropriate species can be ticked indicating what was seen.

Step 4: Record any supplementary information, including the date spawn was first seen in the pond (if applicable), if toads have been run over on nearby roads and if a grass snake has been seen in the pond.

Step 5: O*PTIONAL*: Surveyors can also carry out simple water quality tests at their pond (see 'Measuring water quality') and should indicate whether or not they have done this on the form.

Step 6: Submit the results, **even if nothing was seen**, noting the importance of absence data.

8.1.3. Level 2

Experience

Volunteers participating in Level 2 of Pondwatch JE do not require experience but do need to have undergone survey training.

Survey location

They are asked to survey a pond either (i) allocated by Natural Environment or (ii) a pond of their own choice. Ponds allocated by Natural Environment will have landowner permission pre-arranged, whereas surveyors are required to arrange their permission with the landowner for ponds of their own choosing. Ponds will be assigned to 1-km squares (Figure 4) to help ensure there is a representative distribution of ponds being surveyed across the island, and to allow results to be compared against previous years. Multiple ponds per square can be surveyed, but each pond will require a separate survey form to be filled in. Any survey ponds that are found to no longer be in existence should have as much detail recorded about them and that information passed back to Natural Environment.

Survey timing

Five surveys January–May, though survey data outside of this sampling period will be accepted. The time of day is not constrained though surveyors are required to utilise three survey methods; visual survey, netting, night-time torching. Applying the three methods over different times of the day will assist in maximising species detection.

Survey duration

Each survey takes 30–60 minutes, plus five minutes to fill out the survey form. Additional time is required to carry out habitat assessments, which can be done on a different occasion to the surveys.

Species

Surveyors can record any species in and around the survey pond, however the focus remains on Jersey's three native amphibian species. Non-native amphibians and reptiles should also be recorded if encountered. Surveyors that feel sufficiently competent and have received training can opt-in to record supplementary species from two groups:

1. Invasive Non-Native (INN) aquatic plants

- Water fern (*Azolla filiculoides*)
- New Zealand pigmyweed (*Crassula helmsii*)
- Parrot's feather (*Myriophyllum aquaticum*)
- Canadian pondweed (*Elodea canadensis*)

2. Dragonflies and damselflies (adults and nymphs)

Equipment

Participants will require:

- a Pondwatch JE Level 2 survey form (available from https://groups.arguk.org/jarg)
- a pen or pencil
- a mobile phone for use in the event of an emergency
- a thermometer for recording air temperature*
- a small safety torch for getting around during night surveys
- a high powered survey torch (500,000 to 1,000,000 candlepower)*
- a pond net*

Optional (recommended):

- a camera to take pictures which will assist in record validation
- species ID guides
- map of the survey site

*Thermometers and pond nets can be borrowed and signed out from the Natural Environment team (Government of Jersey). For difficult sites, high powered survey torches can also be borrowed but are limited in availability.

Preparation

Once volunteers have chosen or been allocated a survey pond and arranged landowner permission (if required), they will be required to carry out the following steps before surveying:

Step 1: Read and complete the Volunteer Working Agreement Form and return it to Natural Environment.

Step 2: Visit the chosen pond during the day to familiarise themselves with the site and assess any risks, updating the risk assessment as necessary.

Step 3: Record the pond details (name, location, type and construction).

Step 4: Carry out a pond habitat suitability assessment. This assessment is based on the habitat suitability index (HSI) developed for the great crested newt in Britain (Oldham et al. 2000). Though there are no great crested newts in Jersey, it is an effective and repeatable way of describing a pond and its surrounding habitats, and has shown to be a good indicator of palmate newt occupancy in Jersey (Ward and Wilkinson 2019). Pondwatch JE uses nine HSI measures and is described in detail on the survey form. Habitat suitability metrics are described in the habitat assessment section below.

Step 5: Assess the habitat surrounding the pond. To do this, volunteers will need to identify the three most dominant habitat types occurring within a distance of 0–5 m of the pond

perimeter, and 0–100 m of the pond perimeter. Habitat definitions are given on the survey form, and greater detail is available in the habitat assessment section below.

Surveyors should make themselves familiar with the health and safety considerations laid out in the health and safety section below, as well as appropriate biosecurity measures.

Survey protocol

During each of the five surveys carried out by volunteers between January and May, they must complete the following steps:

Step 6: At the start of each survey first record the visit number, date, the start time, air temperature, whether or not there is bright moonlight (night surveys only) and if wind is disturbing the water. They will also need to record the water clarity, rainfall (choosing the most recent applicable option) and which (if any) supplementary species they are recording.

Step 7: Spend 30–60 minutes using any of the following three methods to survey the pond, aiming to use all three methods across the multiple survey visits.

Visual search: This involves walking once around the pond edge, looking for amphibians, their eggs and other pondlife. Toad spawn strings and frog spawn clumps are fairly easy to spot, but newt eggs will be folded in to leaves individually and may be harder to spot so surveyors should look for any folded leaves and inspect them for eggs. The percentage of shoreline surveyed should be recorded on the survey on the form.

Netting: This is particularly useful for ponds with submerged vegetation. Surveyors should work their way around the pond perimeter in two-metre sections; netting two metres of submerged vegetation then moving two metres along the perimeter before netting another two-metre section. They should check the contents of the net after each section, identify any wildlife found, carefully return it to the pond and record what was found. Pictures are useful for validating species identification.

Pond vegetation is often in patches rather than continuous, and netting in open water is less effective than in vegetation. Therefore, surveyors may wish to select vegetated areas of the pond to net. The percentage of shoreline netted should be recorded on the survey form.

Night time torchlight survey: This technique requires visiting the pond after dusk using a high-powered (500,000 to 1,000,000 candlepower) torch. As with netting, the bank should be split in to two-metre sections, surveying as many accessible sections

as possible and recording the percentage of pond perimeter searched on the survey form. At each two-metre section surveyors should move the torch away from the bank and then back towards themselves in order to cover the area of pond within a segment determined by the two-metre stretch of bank.

Torchlight surveys can be undertaken on the same or a different day as other survey methods have been used, but surveyors must make sure that any netting earlier in the day has not resulted in silt being stirred up thereby reducing visibility for the torchlight survey.

Step 8: Any species seen should be recorded, with as much of the following information recorded as possible: the time, species, lifestage, sex, quantity and certainty of the identification (**C**=certain, **U**=uncertain). For spawn, frog egg clumps can be counted but it can be difficult to count toad spawn strings and palmate newt eggs. Similarly, tadpoles can be difficult to count. For these categories surveyors should therefore estimate a range (e.g. 10–20) that they think is suitable.

Note that both types of supplementary species (dragonflies and damselflies (excluding nymphs) and Invasive Non-Native aquatic plants) should only be recorded during the day.

Step 9: At the end of the survey surveyors must record the end time, the percentage of shoreline that was surveyed and indicate which methods they used during the survey. If a net was used, they also need to record the percentage of shoreline netted.

Step 10: Once all five surveys have been completed, surveyors should record any supplementary information, including the date spawn was first seen in the pond (if applicable), if toads have been run over on nearby roads and if a grass snake has been seen in the pond.

Step 11: O*PTIONAL*: Surveyors can also carry out simple water quality tests at their pond (see 'Measuring water quality') and should indicate whether or not they have done this on the form.

Step 12: Submit the results, **even if nothing was seen**, noting the importance of absence data.

8.1.4. Level 3

Volunteers participating in Level 3 of Pondwatch JE require both experience and survey training. They are asked to survey a pond or ponds (depending on their aggregation) allocated by Natural Environment which is of high conservation value, such as those occupied by or

used as translocation receptor sites for the agile frog. These sites will have landowner permission pre-arranged. Surveys should be carried out between January–May, though survey data outside of this sampling period will be accepted. Survey duration will vary depending on the size of the site, but 30–60 minutes per pond should be sufficient, plus 10 minutes to fill out the survey form. Additional time is required to carry out habitat assessments, which can be done on a different occasion to the surveys.

Surveyors can record any species in and around the survey pond, however the focus remains on Jersey's three native amphibian species. Non-native amphibians and reptiles should also be recorded if encountered. Surveyors that feel sufficiently competent and have received training can opt-in to record supplementary species from two groups:

1. Invasive Non-Native (INN) aquatic plants

- Water fern (*Azolla filiculoides*)
- New Zealand pigmyweed (*Crassula helmsii*)
- Parrot's feather (*Myriophyllum aquaticum*)
- Canadian pondweed (*Elodea canadensis*)

2. Dragonflies and damselflies (adults and nymphs)

Furthermore, select surveyors will be trained how to swab amphibians for disease monitoring efforts.

Survey protocols should follow those employed for current agile frog monitoring (see Ward and Griffiths (2015). Surveyors should make themselves familiar with the health and safety considerations laid out for Level 2 and in the health and safety section below, as well as appropriate biosecurity measures. As part of monitoring surveyors will also be required to carry out pond habitat assessments, as laid out for Level 2.

Disease screening

Two fungi have been responsible for the decimation of anuran and caudate populations the world over; *Batrachochytrium dendrobatidis* (*Bd*) and *B. salamandrivorans* (*Bsal*). A previous survey of the UK (Cunningham and Minting 2008) included samples from two breeding ponds in Jersey collected in the spring of 2008. These samples in Jersey targeted the toad at two breeding localities; Grosnez (86 toads swabbed) and Les Landes (11 toads swabbed). Infection was not detected at either site. No disease screening of wild amphibians has since taken place in Jersey. Here we outline a pre-emptive screening protocol to be carried out by Level 3 Pondwatch JE surveyors.

The primary aim of this screening is to determine the presence or absence of the amphibian chytrid fungus *Batrachochytrium dendrobatidis* and the 'salamander-eating' fungus *B. salamandrivorans* on the Channel Island of Jersey. Additional aims are:

1. If present, to determine the distribution of both fungi.
2. If present, to compare infection prevalence across the three native species.

Experienced Level 3 Pondwatch JE surveyors will be trained how to capture, handle, swab and record data on adult lifestages of Jersey's three native amphibian species. The project will target the adult life stages of the three native amphibian species at sites with large (≥ 30 adults) amphibian populations to maximise confidence of disease detection, with an aim to swab 30 adult amphibians per population* in a single visit. These sites will be identified from the National Amphibian and Reptile Recording Scheme dataset, other site monitoring efforts (e.g. agile frog monitoring) and local knowledge. A distribution of sites across the island will be preferred to maximise coverage of amphibian populations and geographically distributed disease sources. Site access is also considered an important factor in site selection.

*For the purposes of disease screening, populations are defined as amphibians occurring within a 500 m radius with no physical barriers, so multiple ponds in close proximity to one another within a continuous patch of terrestrial can be sampled to provide specimens for a single population sample.

Surveyors will be assigned a survey pond which they will visit during the spring breeding season (Jan–May) during appropriate 'amphibian weather', preferentially sampling animals that are in the water but as late in the season as possible due to a higher likelihood of fungus detection. If surveyors are not familiar with the site, then they should make a day visit to familiarise themselves with the site and associated risks appropriate to any night visits. Surveyors should record the date and time that they visit the site, and collect all samples at that site in a single visit. Efforts should then be made to catch 30 adult amphibians (from any species) and put each one in to an individual sandwich bag. It should be recorded whether animals were captured on land or in water, with preference for animals being captured in the water. Upon capture, animals should be temporarily housed in individual sandwich bags to reduce contamination between animals. Amphibians will be swabbed on the ventral and femoral skin surfaces as well as the webbing between the digits of the hind feet and, for newts, the tail - following the protocol of 'The Big Swab' (Smith 2011), using MW100 medical swabs (available from mwe medical wire). One swab should be used per animal, with three swab strokes on each thigh of the hind legs, three on each lower hind leg, three times on the underside of the feet and toes of for each leg, three times on the drink patch and for newts,

three times on the base of the tail. Between each individual specimen, surveyors should either (i) change gloves or (ii) handle animals through the sandwich bag (to create a physical barrier between the amphibian and their gloves) in order to minimise contamination between individuals. Swabs must be labelled clearly and recording forms filled in. Animals should be released after swabbing at their point of capture.

Samples should be returned to Natural Environment as soon as possible so that they can be sent to the Institute of Zoology (IoZ). If they cannot be sent immediately then they must be stored in the fridge. Sampling of these same sites should be repeated every three years.

Skin swabs sent to IoZ will be analysed for *Bd* and *Bsal* DNA with qPCR (quantitative Polymerase Chain Reaction). Time and costs can be reduced by pooling pairs of extracted DNA samples from the same site without reducing sensitivity of detection (Hyatt et al. 2007; Cunningham and Minting 2008). The main costs associated with disease screening are the swabs (£67.35 per 100 excluding VAT and carriage) and the qPCR duplex tests (£20 per duplex test excluding VAT, but a reduction in price is expected as part of scientific collaboration with IoZ). Additional consumables are also required.

8.1.5. Pond habitat assessment

This section gives a detailed explanation of how habitat assessments should be carried out, and the habitat classifications and measurements that Pondwatch JE uses. This will help to compare surveys across years, assess changes in the habitat over time and calculate which habitats are best for which species.

Pond type and construction

Surveyors are asked to identify the most appropriate type and construction of pond from a list of multiple choices. These are described in more detail in Table 7 and Table 8.

Habitat suitability

Pondwatch JE uses habitat suitability measurements developed for the great crested newt in Britain (Oldham et al. 2000) that are considered to be a useful assessment of pond quality. Analysis of data from the National Amphibian and Reptile Recording Scheme (NARRS) in Jersey has also shown this index to be correlated with palmate newt occupancy (Ward and Wilkinson 2019).

The habitat classifications

Pondwatch JE uses 18 habitat classes to define terrestrial and freshwater habitats (Table 9), as described in Level 3 of the UK Habitat Classification Scheme (UK Habitat Classification

Working Group, 2018). Further detail on the habitat definitions, their development and relation to other habitat classification schemes are available online at http://ecountability.co.uk/ukhabworkinggroup-ukhab/.

Table 7 Description of pond types.

Pond type	Description
Formal garden pond	Standing or still waters between 1m^2 and 2 ha in area which may be permanent or temporary. Includes both man-made and natural waterbodies occurring within a garden or within the boundary of your curtilage. The pond is heavily manicured.
Wild garden pond	As above but the pond is not heavily manicured.
Fish pond	Any standing or still waters between 1m^2 and 2 ha in area which may be permanent or temporary and are stocked with fish (e.g. goldfish or koi).
Farm pond	Any standing or still waters between 1m^2 and 2 ha in area which may be permanent or temporary occurring on a farm.
School pond	Any standing or still waters between 1m^2 and 2 ha in area which may be permanent or temporary occurring on school grounds.
Golf course pond	Any standing or still waters between 1m^2 and 2 ha in area which may be permanent or temporary occurring on a golf course.
Natural pond	Any standing or still waters between 1m^2 and 2 ha in area which may be permanent or temporary that occurs naturally (i.e. without human interference).
Lake	A body of still water >2 ha in area, includes reservoirs and gravel pits.

Table 8 Description of pond construction types.

Pond construction	Description
Liner	Water is retained by a liner (e.g. butyl).
Preformed plastic	Water is retained by a preformed plastic shell.
Concrete	Water is retained by a layer of concrete.
Clay	The pond has no liner but water is retained by clay.

Assessing the habitats in and around the pond

To assess the habitat in and around the pond, surveyors should follow the approach outlined in the steps below:

Step 1: Visit the survey site during the day, **before** carrying out the first survey and assess the risks associated with surveying it. If they are happy to continue then they can proceed to the next step.

Step 2: Recording habitat suitability (HSI) measurements:

a. Estimate the area of the pond in m^2 by first identifying the outer perimeter of the pond. This is the perimeter when the water is at its highest level (often in early spring), and may be identified by plants such as rushes present at the pond's outer edge. The pond can be measured using an online map or by measuring it in the field. To do this, it is easiest to consider the pond as a series of geometric shapes for which you individually calculate the area and then sum the shapes together. 'Regular' shaped ponds are therefore easier to calculate than irregular ponds. The length of a side can be estimated by pacing (where a single pace is ~0.8–1.0 metre).
b. Working out how often the pond dries is best done by speaking with landowners or those familiar with the pond. Alternatively, surveyors may have to make an informed guess based on the water levels when they carry out the surveys. Seasonality should also be factored in. For instance, a pond that is dry by late spring is likely to dry out most years.
c. Water quality (not to be confused with water clarity) is measured on a subjective index of aquatic invertebrate diversity.
    i. Bad quality is considered as being clearly polluted, containing only pollution-tolerant invertebrates (such as rat-tailed maggots), and with no submerged plants.
    ii. Poor water quality contains low invertebrate diversity (e.g. species such as midge and mosquito larvae) and few submerged plants.
    iii. Moderate water quality is associated to moderate invertebrate diversity.
    iv. Good water quality is that which supports an abundant and diverse invertebrate community. Netting reveals handfuls of diverse invertebrates, including groups such as mayfly larvae and water shrimps.
d. The percentage (%) of perimeter shaded is calculated as the area shaded where shading occurs up to at least 1m from the shore. Shading is usually from trees, but can also include buildings. However, it should not include emergent pond

vegetation. This estimate should be made between May and the end of September.

e. The impact of waterfowl (I.e. ducks, geese and swans) is measured across three categories:
    i. Absent – No evidence of waterfowl impact though moorhens might be present.
    ii. Minor – Waterfowl are present, but there is little indication of an impact on pond vegetation. The pond still supports submerged plants and banks are not denuded of vegetation.
    iii. Major – There is a severe impact of waterfowl. There is also little or no evidence of submerged plants, the water is turbid, pond banks show patches where vegetation has been removed and there is evidence of waterfowl being fed.
f. The presence and abundance of fish is measured across four categories, with information on their presence best gleaned from local knowledge and the surveyor's own observations. Pond owners are often aware of stocking with fish for commercial or aesthetic reasons. However, stickleback (which can be significant predators of newt larvae, when present in large numbers) are unlikely to be deliberately introduced to a pond, but may arrive through other means. Netting is useful in detecting smaller fish, such as sticklebacks, or the fry of larger species.
g. The number of ponds occurring within 1 km of the survey pond is an optional measure. The count should not include the survey pond itself, nor should it count ponds that are completely isolated from the survey pond (e.g. due to barriers such as main roads). If surveyors are unsure, the survey coordinator may be able to calculate the number of ponds using map data held by Natural Environment.
h. The scoring of terrestrial habitat is done over four categories, and requires the surveyor to have a good understanding of newt habitat quality. Though the metric was designed to consider great crested newt terrestrial habitat, we replace that with good terrestrial habitat for palmate newts. Good terrestrial habitat offers cover and foraging opportunities, and includes meadow, rough grassland, hedges, scrub and woodland. Again we do not consider terrestrial areas that are isolated from the survey pond by barriers to dispersal (e.g. by main roads or poor habitat). The four categories are:

i. Good – An extensive area of habitat that offers good opportunities for foraging and shelter completely surrounds the survey pond (e.g. rough grassland, scrub or woodland).
ii. Moderate – The terrestrial habitat offers opportunities for foraging and shelter, but may not be extensive in area and does not completely surround the survey pond.
iii. Poor – The terrestrial habitat has poor structure, offering limited opportunities for foraging and shelter (e.g. amenity grassland).
iv. None – There is clearly no suitable habitat around the survey pond (e.g. it is within a large expanse of bare ground).

i. The final metric requires surveyors to measure the cover of aquatic vegetation on the surface of the pond, including emergent plants, floating plants (excluding duckweed) and submerged plants that reach the surface. This should be estimated between March and May. Figure 1 can be used as a guide for estimating aquatic vegetation cover.

Step 3: Assessing the habitats **around** the pond:

a. Identify the perimeter of the pond (as described in step 2a).
b. Look at the habitat within 0–5 m of the pond perimeter, and tick the three most dominant habitat classifications that apply within this area. The habitat classifications are shown in Table 9 below and on the survey form. An example is shown in Figure 2.
c. Repeat step 3b, this time assessing the habitat within 0–100 m of the pond perimeter.

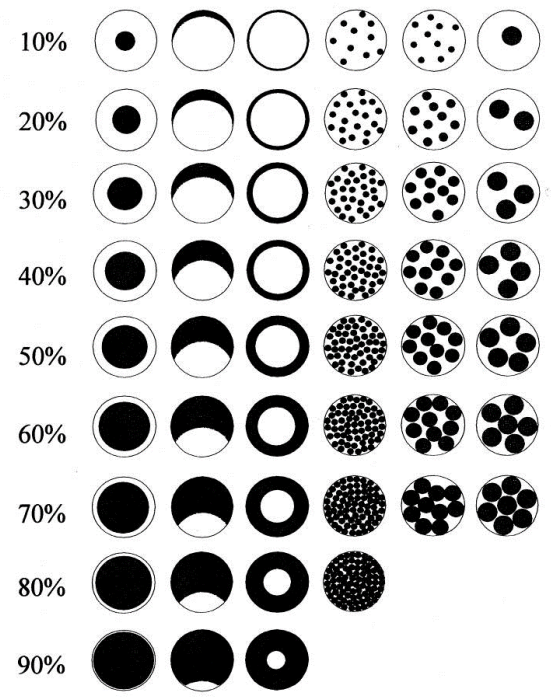

Figure 1 Visual guide for use in assessing the percentage of vegetation cover in a pond (ARG UK, 2010).

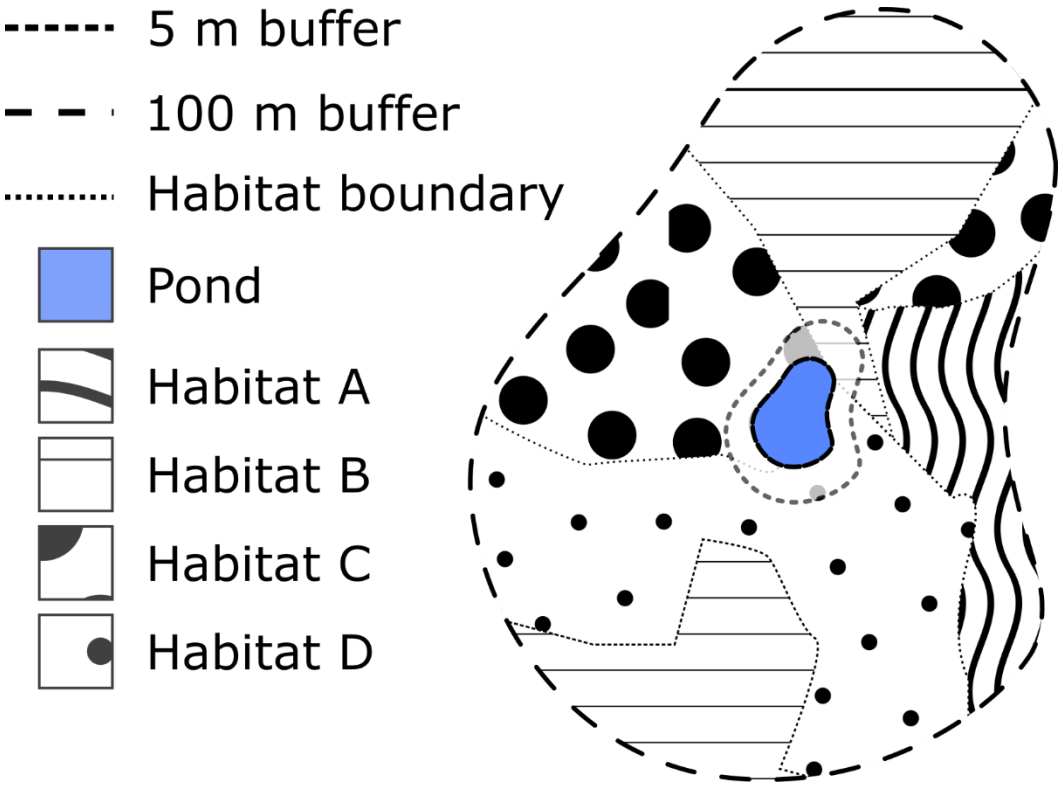

Figure 2 Example of habitats falling with 0–5 and 0–100 m buffer zones from the pond perimeter. In this example, habitats B, C and D are the most dominant in both the 5 metre and 100 metre buffer zones.

Table 9 Habitat classifications for Pondwatch JE, adapted from the UK Habitat Classification (UK Habitat Classification Working Group, 2018). For more information on habitat definitions see the UK Habitat Classification Documents at http://ecountability.co.uk/ukhabworkinggroup-ukhab/.

Lev. 1	Level 2	Level 3
Terrestrial	Grassland	**g1**: Acid grassland
		g2: Calcareous grassland
		g3: Neutral grassland
		g4: Modified grassland
	Woodland and forest	**w1**: Broadleaved mixed and yew woodland
		w2: Coniferous woodland
	Heathland and shrub	**h1**: Dwarf shrub heath
		h2: Hedgerows
		h3: Dense scrub
	Wetland	**f1**: Bog
		f2: Fen marsh and swamp
	Cropland	**c1**: Arable and horticulture
	Urban	**u1**: Built-up areas and gardens
	Sparsely vegetated land	**s1**: Inland rock
		s2: Supralittoral Rock
		s3: Supralittoral Sediment
Freshwater	Rivers and lakes	**r1**: Standing open water and canals
		r2: Rivers and streams

8.1.6. Measuring water quality

Note: This information has been sourced from the Freshwater Habitats Trust and Earthwatch FreshWater Watch websites. See https://freshwaterhabitats.org.uk/ and https://freshwaterwatch.thewaterhub.org/content/your-test-kit.

Plants and animals living in freshwater environments can be badly affected by pollution from many sources. Pollutants can introduce excess nutrients in to the environment, which can lead to unnatural increases in algae, plant cover, fungi and bacteria. These increases can make aquatic habitats uninhabitable for many species, for instance due to reduced oxygen in the water. Testing the water quality of a number of ponds allows identification of areas which are still of good quality, and those which are not.

Surveyors will need to request a water quality testing kit from the project coordinator, which will contain:

- nitrate water quality testing tubes
- phosphate water quality testing tubes
- colour charts for use with testing tubes
- plastic or latex gloves
- a sample cup

Surveyors will also need:

- a Pondwatch JE water testing survey form (available from https://groups.arguk.org/jarg)
- a mobile phone in case of emergency
- a pen or pencil to write with
- a stopwatch
- a smartphone with GPS to record the pond coordinates (optional)

Survey protocol

Step 1: Using a survey form, record the location of the pond.

Step 2: Put on some disposable plastic or latex gloves, particularly if you have any cuts the water could get in to.

Step 3: Rinse out the sample cup in the pond water and submerge it to fill it halfway with water (don't just scoop up some surface water).

Step 4: Take the sample cup containing water somewhere safe to can carry out the water tests (e.g. somewhere flat near to the pond).

Step 5: Get out one phosphate and one nitrate tube. The phosphate is marked P on the base of the tube, and the nitrate is marked N.

Step 6: Pull out and discard the yellow pin leaving a small air hole.

Step 7: With the air hole pointing upwards, surveyors should use their finger and thumb to squeeze out the air.

Step 8: Keeping the air squeezed out, turn the tube upside down and insert below the water in the sample cup.

Step 9: Gently release the pressure and suck up enough water to fill the tube just over half way.

Step 10: If they need to, surveyors can turn the tube upright again, squeeze out a bit more air to suck up more water to just over half way.

Step 11: Gently shake the tube to mix the water and powder inside.

Step 12: Start the stopwatch and wait for the colour reaction (**Nitrate: 3 mins, Phosphate: 5 mins**)

Step 13: Compare the tube with the colour chart as soon as the time is up, as the colour will continue to develop.

Step 14: Record the results on the survey form and submit them online or via email.

8.2. Reptilewatch JE

Reptilewatch JE is an island-wide effort to record Jersey's reptiles, with the aim of detecting changes in their conservation status. Additionally, it is expected to provide informative data on the distribution and habitat requirements of the species monitored.

8.2.1. Volunteer involvement

Multiple survey options are offered over three primary levels of participation dependent upon experience and available time:

Level			Methods
1	30 minutes 1 survey	No experience required No training required	Visual
2	1–2 hours 6 surveys	No experience required Training is required	Visual, artificial refugia
3	2+ hours 20 surveys	Experience required Training is required	Visual, artificial refugia

8.2.2. Level 1

Experience

Volunteers participating in Level 1 of Reptile JE do not require survey training or experience.

Survey location

They are asked to survey a location of their choice for which they have permission to survey. These can include 'wild' gardens, sand dunes, heathland, bramble thickets, gorse, tussocky grass, banks, stone walls, forts (wall lizards), forest ride, roadside verges, field margins, log piles, allotments, cemeteries, brownfield sites and piles of vegetation (e.g. compost heaps).

Survey timing

At least one survey March–October, though survey data outside of this sampling period will be accepted. There is a greater chance of seeing reptiles in the spring (April to June) and autumn (mid-August to mid-October). The time of day is not constrained but is dependent upon weather and season, with highest detectability likely to be during the morning and

afternoon on days with sun or partial cloud with temperatures between 10 and 20℃. Surveyors are advised not to survey in strong wind or heavy rain, though sunny periods after rain can be productive. Although long periods of hot dry weather are unfavourable, green lizards and wall lizards may still be found in these conditions.

Survey duration

The survey takes 30 minutes, plus five minutes to fill out the survey form.

Equipment

Participants will require:

- a Reptilewatch JE Level 1 survey form (available from https://groups.arguk.org/jarg)
- a pen or pencil
- a mobile phone for use in the event of an emergency

Optional (recommended):

- a camera to take pictures which will assist in record validation
- a torch if surveying at night

Survey protocol

Step 1: Visit the chosen site and record the survey location, habitat type and type of location as shown on the survey form.

Step 2: Spend 30 minutes visually searching for reptiles. When possible, take photos of what is seen. If help is needed identifying the species seen, species identification guides are available on the JARG website.

Step 3: Record the date the survey was carried out and the number of any reptiles seen.

Step 4: Submit the results, **even if nothing was seen**, noting the importance of absence data.

8.2.3. Level 2 – widespread reptile surveys

Experience

Volunteers participating in Level 2 of Reptilewatch JE do not require experience but do need to have undergone survey training.

Survey location

They are asked to survey a site either (i) allocated by Natural Environment or (ii) of their own choice. Sites allocated by Natural Environment will have landowner permission pre-arranged,

whereas surveyors are required to arrange their permission with the landowner for sites of their own choosing. Sites will be assigned to 500 m squares (Figure 4) to help ensure there is a representative distribution of sites being surveyed across the island, and to allow results to be compared against previous years.

Survey timing

Six surveys March–October with three in spring (April–June) and two in autumn (mid-August–mid-October), though survey data outside of this sampling period will be accepted. The time of day is not constrained though surveyors should be mindful of surveying in appropriate weather conditions to maximise species detection.

Survey duration

Each survey takes 1–2 hours, plus five minutes to fill out the survey form. Additional time is required to carry out habitat assessments, which can be done on a different occasion to the surveys.

Species

Surveyors can record any species; however, the focus remains on Jersey's four native reptile species. Non-native reptiles should also be recorded if encountered. Surveyors that feel sufficiently competent and have received training can opt-in to record supplementary species from four groups:

1. Small mammals
    a. Bank vole (*Myodes glareolus* ssp. *caesarius*)
    b. Wood mouse (*Apodemus sylvaticus*)
    c. Lesser white-toothed shrew (*Crocidura suaveolens*)*
    d. Millet's, Common or French shrew (*Sorex coronatus*)*

2. Cockroaches (Family Ectobiidae)
    a. Tawny cockroach (*Ectobius pallidus*)
    b. Lesser cockroach (*Ectobius panzeri*)

3. Beetles (Order Coleoptera)
    a. Glow worm (*Lampyris noctiluca*)
    b. Lesser stag beetle (*Dorcus parallelipipedus*)

4. Butterflies and moths (Order Lepidoptera)

a. Family Lasiocampidae
    i. Drinker (*Euthrix potatoria*) – larva only
    ii. Fox moth (*Macrothylacia rubi*) – larva and cocoons
    iii. Oak eggar (*Lasiocampa quercus*) – larva and cocoons
b. Subfamily Arctiinae (Tigers and ermines) – larva and cocoons
c. Shoulder stripe (*Earophila badiata*) – adults

* note that the two shrew species can be difficult to distinguish from one another in the field as they rarely stay still when disturbed. Therefore, we recommend they are simply recorded as 'shrew species'.

Species identification guides are provided in the online resources.

Equipment

Participants will require:

- a Reptilewatch JE Level 2 widespread survey form (available from https://groups.arguk.org/jarg)
- a pen or pencil
- a mobile phone for use in the event of an emergency
- 10–20 artificial refugia (available from Natural Environment, Howard Davis Farm, Trinity)

Optional (recommended):

- a camera to take pictures which will assist in record validation
- species ID guides
- Global Positioning System (GPS) / GPS phone app that allows surveyors to record coordinates
- map of the survey site

Preparation

Once volunteers have chosen or been allocated a survey site and arranged landowner permission (if required), they will be required to carry out the following steps before surveying:

Step 1: Read, complete and return the Volunteer Working Agreement Form.

Step 2: Visit their chosen site during the day at least four weeks prior to surveying to familiarise themselves with the site and assess any risks. Update the risk assessment as necessary.

Step 3: Plan a walking survey route that encompasses the most suitable parts of the site and that will take approximately 1–2 hours to survey (small sites may require less time). A map of the site can be useful for doing this.

Step 4: Lay out 10–20 (small sites may require fewer) artificial refugia at least four weeks prior to surveying along the survey route in areas away from public disturbance and livestock, trying to spread them evenly along the route. Press the refugia in to the vegetation and, if possible, leave them for a few weeks to bed in before carrying out the first survey. It can be helpful to plan this route ahead of the visit using online maps, and to discuss it with the landowner or manager in case there are areas they would like avoiding. When laying out the refugia, it is useful to record their location either by marking them on a map or recording their coordinates using the GPS. The refugia can be recorded on the 'refugia list' on the survey form so that surveyors can keep track of which ones they have checked on each survey. Recording their location will help surveyors find them in future, especially if they become obscured by vegetation, and it will also mean that other surveyors and landowners can locate them if needed. Surveyors should inform the landowner or land managers of where they have placed the refugia in case any areas are scheduled for management such as mowing or grazing, which may result in damage to the refugia and to equipment, or the harm of livestock.

Step 5: Fill in the surveyor contact details and record the site details (name, location).

Step 6: Assess the connectivity and patch size of reptile habitat at the survey site.

Step 7: Carry out a habitat assessment along the survey route and divide it in to sections based on the habitat type (Figure 3), recording the length of each survey route section. The habitat classifications can be found in the habitat assessment section below. If possible, surveyors should record the coordinates where the route sections start and end. When they fill in the forms online they will need to draw the survey route on the map. It is also useful to note which route section each of the refugia are within. If surveyors need assistance with this, they can contact the scheme coordinator or an experienced surveyor.

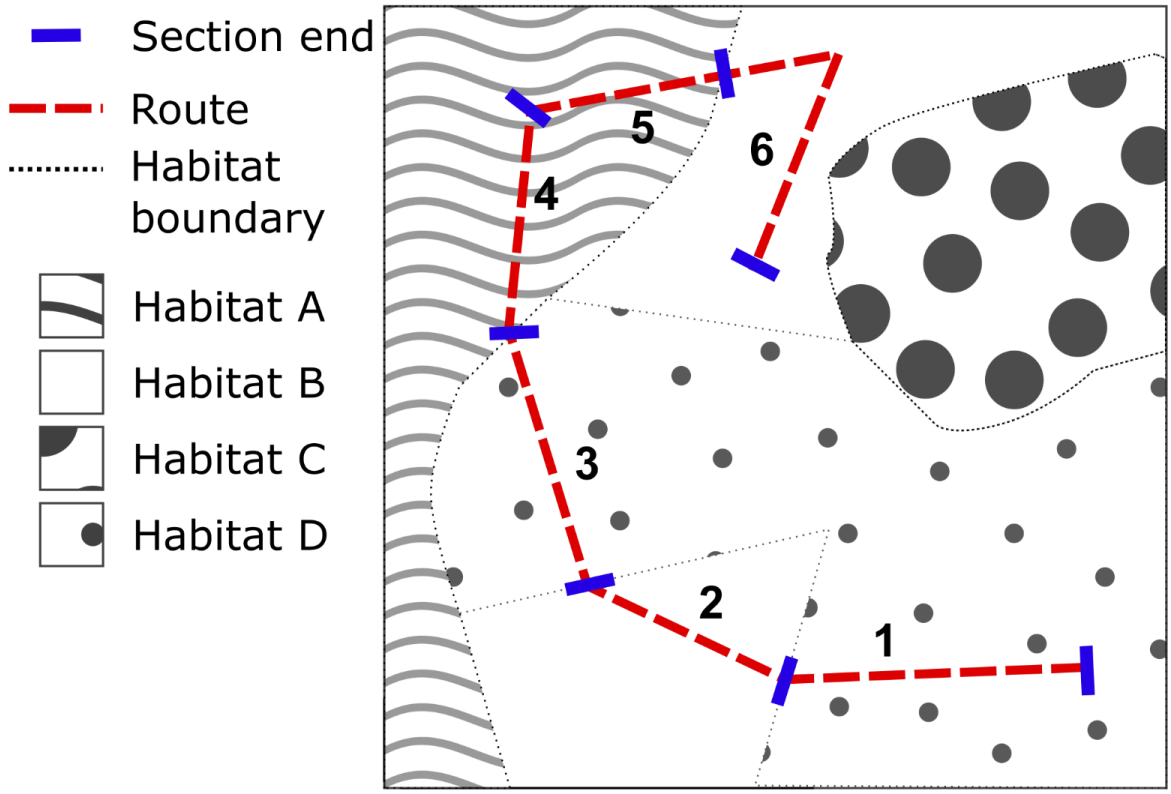

Figure 3 Example map showing a reptile survey route split in to sections based on habitat type.

Survey protocol

During each of the six surveys carried out by volunteers between March and October, they must complete the following steps:

Step 8: At the start of each survey first record the date, the visit number, start time and cloud cover. Also record which (if any) supplementary species are being recorded.

Step 9: Spend 1–2 hours visually searching for reptiles along the survey route and check the artificial refugia as they are encountered. If any pre-existing refugia are encountered, then these should be checked also. When possible, surveyors should take photos of what they see, being careful not to disturb the habitat and wildlife. It's therefore best to take photos from a distance or to have the camera ready when lifting an artificial refugium.

Step 10: Throughout the course of the survey, surveyors should keep note of which refugia they have checked by ticking them off of the refugia list on the survey form. When an animal is encountered during a survey, they should record as much of the following information as possible: the time, species, lifestage, sex, quantity, certainty of identification (**C**=certain, **U**=uncertain), whether the animal was in the open (**O**), under

(**U**) or on top (**T**) of a refugium, the route section the animal was found in and where possible, the refugium ID (if on or under a refugium) or location coordinates of where the animal was spotted. If any need help is needed in identifying species, identification guides are available on the JARG website.

Step 11: At the end of the survey surveyors should record the end time, time spent surveying, the average wind speed during the survey using the Beaufort Scale (0–6) (see Table 10) and the rainfall (**0**=none, **1**=yesterday, **2**=earlier today, **3**=during survey) – choosing the most recent applicable option. They should also note the number of both artificial and pre-existing refugia checked.

Step 12: Submit the results, **even if nothing was seen**, noting the importance of absence data.

Table 10 Beaufort scale for assessing average wind speed on a scale of 0–6.

0	0–1	Calm	Smoke rises vertically
1	1–3	Light air	Slight smoke drift
2	4–7	Light breeze	Wind felt on face and leaves rustle
3	8–12	Gentle breeze	Leaves & twigs in constant motion
4	13–18	Moderate breeze	Raises dust and small branches move
5	19–24	Fresh breeze	Small trees in leaf begin to sway
6	25–31	Strong breeze	Large branches move & trees sway

8.2.4. Level 2 – wall lizard surveys

Experience

Volunteers participating in Level 2 of Reptilewatch JE do not require experience but do need to have undergone survey training.

Survey location

They are asked to survey a site either (i) allocated by Natural Environment or (ii) of their own choice. Sites allocated by Natural Environment will have landowner permission pre-arranged, whereas surveyors are required to arrange their permission with the landowner for sites of their own choosing. Sites will be assigned to 500 m squares (Figure 4) to help ensure there is a representative distribution of sites being surveyed across the island, and to allow results to be compared against previous years.

Survey timing

Six surveys March–October with three in spring (April–June) and two in autumn (mid-August–mid-October), though survey data outside of this sampling period will be accepted. The time of day is not constrained though surveyors should be mindful of surveying in appropriate weather conditions to maximise species detection. Wall lizards are thermophilic and are likely to be found in any warm sunny conditions throughout the year.

Survey duration

Each survey takes 30 minutes, plus five minutes to fill out the survey form.

Species

Surveyors can record any species; however, the focus remains on the wall lizard and any incidental observation of other native reptile species.

Equipment

Participants will require:

- a Reptilewatch JE Level 2 wall lizard survey form (available from https://groups.arguk.org/jarg)
- a pen or pencil
- a mobile phone for use in the event of an emergency

Optional (recommended):

- a camera to take pictures which will assist in record validation
- binoculars to visually search habitat features from a distance
- species ID guides
- Global Positioning System (GPS) / GPS phone app that allows surveyors to record coordinates
- map of the survey site

Preparation

Once volunteers have chosen or been allocated a survey site and arranged landowner permission (if required), they will be required to carry out the following steps before surveying:

Step 1: Read, complete and return the Volunteer Working Agreement Form.

Step 2: Visit the chosen site during the day to familiarise themselves with the site and assess any risks. Update the risk assessment as necessary.

Step 3: Identify either:

a. a walking survey route that allows them to visually search most suitable parts of the site and that will take approximately 30 minutes to survey, **or**
b. a fixed point from which they can visually search the habitat (e.g. by using binoculars to search a large wall).

Suitable habitats are often those regularly exposed to the sun and include dry stone walls, fort walls, steps, rocks, cliffs and quarries.

It can be helpful for surveyors to plan the survey route or fixed survey position ahead of their visit using online maps, and to discuss it with the landowner or manager in case there are areas they would like the surveyor to avoid or that are high risk. If the surveyor is going to survey from a fixed position it is useful to record the location either by marking it on a map or recording the coordinates using a GPS. This will help them and other surveyors to survey from the same location in future.

Step 4: Fill in the contact details and record the site details (name, location).

Step 5: Assess the connectivity and patch size of wall lizard habitat at the survey site.

Survey protocol

During each of the six surveys carried out by volunteers between March and October, they must complete the following steps:

Step 6: At the start of each survey first record the date, the visit number, start time and cloud cover. Also record which survey methods they will be using (walking, surveying from a stationary position, using binoculars). Surveyors can use more than one method in a survey.

Step 7: Spend 30 minutes visually searching for wall lizards along the survey route / from the fixed position, making sure they do not survey an area more than once in a visit. When possible, take photos of what is seen but be careful not to disturb the habitat and wildlife. It's therefore best to take photos from a distance. Do not attempt to touch or handle any animals.

Step 8: When surveyors encounter an animal during their survey, they should record as much of the following information as possible: the time, species, lifestage, sex, quantity, certainty of their identification (**C**=certain, **U**=uncertain) and the habitat code for the habitat the animal was seen in. The habitat codes are available on the survey form, and more information is available in the habitat assessment section below. If the surveyor wants to, they can also record the location coordinates of where the animal was spotted or mark it on a map.

At the end of the survey the surveyor should record the end time, time spent surveying, the average wind speed during the survey using the Beaufort Scale (0–6) (see Table 10) and the rainfall (**0**=none, **1**=yesterday, **2**=earlier today, **3**=during survey) – choosing the most recent applicable option.

Step 9: Submit the results, **even if nothing was seen**, noting the importance of absence data.

8.2.5. Level 3

Volunteers participating in Level 3 of Reptilewatch JE require both experience and survey training. They are asked to survey a site allocated by Natural Environment which is of high conservation value, particularly those occupied by grass snakes. These sites will have landowner permission pre-arranged and are allocated to a 1-km grid (Figure 4). Surveys should be carried out between March and October, though survey data outside of this sampling period will be accepted. Survey duration will vary depending on the size of the site, but 2–3 hours should be sufficient, plus 10 minutes to fill out the survey form. Additional time is required to carry out habitat assessments, which can be done on a different occasion to the surveys.

Surveyors can record any species during their survey, however the focus remains on Jersey's four native reptile species. Non-native amphibians and reptiles should also be recorded if encountered. Surveyors that feel sufficiently competent and have received training can opt-in to record supplementary species from the four groups described for Level 2 widespread reptile surveys.

Survey protocols should follow those described for Level 2 widespread reptile surveys, with the following amendments based on the findings of Ward et al. (2017): for surveyors to utilise 40 artificial refugia per site and to try and survey each site 20 times during a survey season (March–October) to try and achieve 95% confidence of absence. This approach is not expected to detect statistically significant occupancy changes, but instead serves to monitor populations at the site level. Furthermore, surveyors should ensure they record the GPS coordinates of all reptile sightings to build site-level datasets to inform site management. As part of monitoring surveyors will also be required to carry out habitat assessments, as laid out for Level 2 widespread reptile surveys.

8.2.6. Reptile habitat assessment

This section gives a detailed explanation of how habitat assessments should be carried out, and the habitat classifications and measurements that Reptilewatch JE uses. This will help to

compare surveys across years, assess changes in the habitat over time and calculate which habitats are best for which species.

The habitat classifications

Reptilewatch JE uses 18 habitat classes to define terrestrial and freshwater habitats (Table 11), as described in Level 3 of the UK Habitat Classification Scheme (UK Habitat Classification Working Group, 2018). An additional six classes derived from Level 4 of the UK Habitat Classification Scheme are used to describe built-up areas and gardens in greater detail for wall lizard surveys (Table 11). Further detail on the habitat definitions, their development and relation to other habitat classification schemes are available online at http://ecountability.co.uk/ukhabworkinggroup-ukhab/.

Habitat assessments for Level 2 widespread reptile surveys and Level 3 grass snake surveys

Both the Level 2 widespread reptile surveys and Level 3 grass snake surveys use similar survey methods and the same approach for habitat assessment. This approach is outlined in the steps below:

Step 1: Visit the survey site during the day **before** carrying out the first survey and assess the risks associated with surveying it. If laying your artificial refugia on this same visit, then surveyors should aim to do this at least four weeks before the first survey takes place. If the surveyor is happy to continue then they should proceed to the next step.

Step 2: Plan the survey route so that it encompasses as much suitable reptile habitat as possible. Level 2 routes should take approximately 1–2 hours to survey, whereas Level 3 surveys may take longer.

Step 3: Divide the survey route in to sections according to the **Level 3 habitat type** shown in Table 11.

Step 4: Record the details of each survey route section in the **survey route section table** of the survey form.

a. Number each section sequentially
b. Estimate the length in metres using an online mapping tool (e.g. Google Maps). If the surveyor is not sure how, the scheme coordinator or an experienced surveyor can provide assistance.
c. Record the section habitat type based on the level 3 classes listed in Table 11.
d. Record the section habitat type code based on the level 3 classes listed in Table 11.
e. Record the number of artificial refugia in each section.

f. If possible, record the start and end coordinates for each survey route section.
g. Map the survey route and its sections using the online Jersey Biodiversity Centre form.

Habitat assessment for Level 2 wall lizard surveys

For wall lizard surveys, it is necessary to record the habitat type in which any observations are made. The approach is outlined in the steps below:

Step 1: Carry out the survey as described in the protocol.

Step 2: When a wall lizard is observed, note down the details of the sighting (e.g. sex, lifestage) and record the **Level 3 habitat code** as shown in Table 11. If the wall lizard is in a **built-up area or garden**, use the appropriate code from the classifications listed in **Level 4** of the classification scheme.

Table 11 Habitat classifications for Reptilewatch JE, adapted from the UK Habitat Classification (UK Habitat Classification Working Group, 2018). Level 3 classifications should be used for Level 2 and 3 reptile surveys. Wall lizards occurring in 'Built-up areas and gardens' should be recorded to their Level 4 habitat.

Lev. 1	Level 2	Level 3	Level 4 (wall lizards only)
Terrestrial	Grassland	**g1**: Acid grassland	
		g2: Calcareous grassland	
		g3: Neutral grassland	
		g4: Modified grassland	
	Woodland and forest	**w1**: Broadleaved mixed and yew woodland	
		w2: Coniferous woodland	
	Heathland and shrub	**h1**: Dwarf shrub heath	
		h2: Hedgerows	
		h3: Dense scrub	
	Wetland	**f1**: Bog	
		f2: Fen marsh and swamp	
	Cropland	**c1**: Arable and horticulture	
	Urban	**u1**: Built-up areas and gardens	**u1a**: Open Mosaic Habitats on Previously Developed Land
			u1b5: Developed land; sealed surface - Buildings
			u1b6: Developed land; sealed surface - Other developed land
			u1c: Artificial unvegetated, unsealed surface
			u1d: Suburban/ mosaic of developed/ natural surface
			u1e: Built linear features
	Sparsely vegetated land	**s1**: Inland rock	
		s2: Supralittoral Rock	
		s3: Supralittoral Sediment	
Freshwater	Rivers and lakes	**r1**: Standing open water and canals	
		r2: Rivers and streams	

8.3. Survey ponds / sites

Both Pondwatch JE and Reptilewatch JE offer sites with pre-arranged landowner access (Levels 2 and 3 only). This helps to reduce the time lag in beginning surveys, and lightens the workload for surveyors. Furthermore, both schemes are designed to run with sites surveyed on a semi-annual basis, whereby a set of fixed sites can be surveyed every year (or less frequently depending on surveyor availability) and additional sites are surveyed as and when resources and landowner permission allow. This approach seeks to (i) aid volunteer motivation, (ii) provide sites on which training events can be held, and (iii) build the set of sites for which permission is granted with a view to providing a randomly distributed set of sample locations.

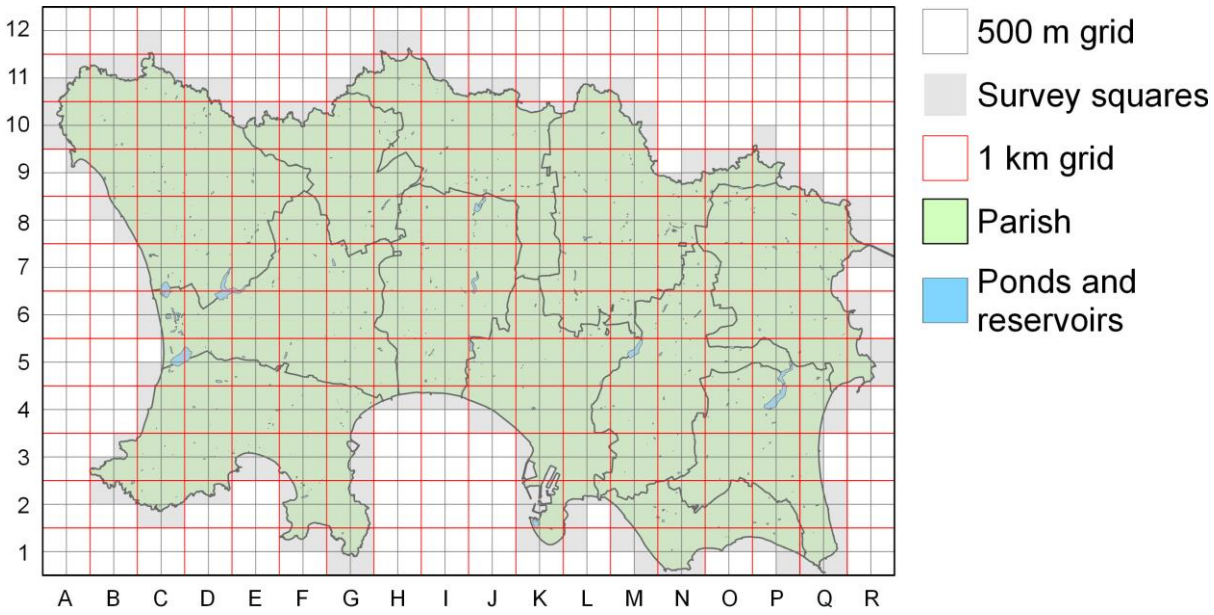

Figure 4 500 m and 1 km survey squares in Jersey. Red grid lines show the 1 km grid and grey grid lines show the new 500 m grid. 500 m grid squares filled in grey are those that intersect with Jersey above the mean high water mark (n=572). Ponds and reservoirs are shown (Source: Jersey Water). 1 km grid references are shown for orientation.

8.4. Arranging landowner permission

If needing to arrange landowner permission, surveyors will be required to complete a Landowner Survey Consent Form. Landowners can often be identified by making local enquiries or by speaking to Natural Environment. A template introductory letter for requesting landowner permission is available from Natural Environment. Speaking with the landowner will also give surveyors an opportunity to identify car parking locations, safety issues, learn

about the site / pond (e.g. if it is stocked with fish, how often it dries out) and to build a relationship with them.

8.5. Health and safety

It is very important that surveyors are safe at all times during any surveys. Working at night can present greater risk for those carrying out night time torching for pondlife. All ponds/sites should first be visited during the day to assess any risks before carrying out surveys. If the surveyor has any concerns, they should not proceed with the survey. A risk assessment template is available to surveyors which can be modified to suit their needs. Surveyors are under no obligation to participate or complete a survey.

Volunteers do not need to enter ponds to conduct surveys, and should only survey from accessible banks. They should avoid surveying areas with steep banks or wet muddy ground. All surveyors should carry a fully charged mobile phone in case of emergency. It is best to do for surveyors to work in pairs, but those working alone need to follow the lone working procedures as described in the Volunteer Working Agreement.

8.6. Biosecurity

Amphibians are globally at risk from amphibian diseases. Furthermore, ponds can contain Invasive Non-Native aquatic plants. Both diseases and invasive plants can easily be transferred on equipment, footwear, clothing or other surfaces. It is therefore important that equipment and other items used during Pondwatch JE surveys are properly cleaned and disinfected between surveys and between ponds. For further advice, see ARG UK Advice Note 4. *Amphibian disease precautions: A guide for UK fieldworkers* and the Check Clean Dry campaign.

8.7. Submitting records

Surveyors should submit their data once they have completed their final survey of the season. The preferred way is using the online forms at http://jerseybiodiversitycentre.org.je. Alternatively, they can email a copy of your form to jbc@societe-jersiaise.org or post it to:

Pondwatch JE **or** Reptilewatch JE

Natural Environment, Growth Housing and Environment

Howard Davis Farm

Trinity

JE3 5JP

If surveyors are carrying out a Level 2 survey or above, they will need to be invited to fill out the appropriate online forms by the scheme coordinator. Survey results should only be submitted using one method, as submitting through multiple avenues can lead to information being duplicated.

8.8. Training materials and further resources

Training materials and resources for both schemes are available on the Jersey Amphibian and Reptile Group website. This includes survey handbooks, survey recording forms, species identification guides, the volunteer working agreement, risk assessment and landowner consent form.

8.9. Detecting change

In order to detect occupancy changes in Jersey's herpetofauna species, we have calculated the number of ponds/sites which must be assessed in a given sampling period (Ward and Wilkinson 2019). These are recreated below in Table 12 for reference. Given a six-year sampling period and, based on NARRS uptake, approximately 50 sites being surveyed in that period, we expect to only detect proportional occupancy changes of 50% or more in the toad and up to 30% in the slow worm when considering mean occupancy estimates. If we consider the best case scenario, this extends to 30% changes for the toad and 50% changes for the green lizard and palmate newt. Estimates for the two most restricted species, the agile frog and grass snake were extremely high due to their low occupancy rates and (for grass snakes) low detectability. The wall lizard estimates are also untrustworthy as they are derived from NARRS surveys which are not appropriate for collecting data on this species. Nonetheless, it is likely that it will not be possible to survey a sufficient number of sites to detect changes in this species. Lastly, the estimates for green lizards are higher than expected due to the settings that were used (dominant habitat type set to arable) in the calculations. Therefore, considering the best occupancy estimate for the species under the specified model settings, it may be possible to detect a 50% change for the green lizard.

Table 12 The number of survey sites required to detect a given proportional change in occupancy at a power of 0.8 and with a significance of 0.1. Changes in detection probability ('det') are given horizontally and changes in occupancy probability ('occ') are given vertically. Calculations are based on low confidence limits ('low CL'), mean values and high confidence limits ('high CL') of occupancy and detection estimates. Values ≤ 50 are shown in bold.

			R = 0.15			***R = 0.30***			***R = 0.50***		
			Det			*Det*			*Det*		
			low CL	mean	high CL	low CL	mean	high CL	low CL	mean	high CL
Bufo spinosus	Occ	low CL	133	133	133	**37**	**37**	**37**	**14**	**14**	**14**
		mean	284	284	284	72	72	72	**25**	**25**	**25**
		high CL	654	654	655	157	157	157	52	52	52
Lissotriton helveticus	Occ	low CL	330	353	416	83	88	102	**28**	**30**	**34**
		mean	632	662	750	152	159	179	**50**	52	59
		high CL	1249	1297	1433	294	305	336	95	99	109
Rana dalmatina	Occ	low CL	-	-	-	-	-	-	-	-	-
		mean	50362	50428	53144	11576	11592	12215	3679	3684	3882
		high CL	-	-	-	-	-	-	-	-	-
Anguis fragilis	Occ	low CL	73	73	74	**23**	**23**	**24**	**9**	**9**	**9**
		mean	143	143	144	**40**	**40**	**40**	**14**	**15**	**15**
		high CL	341	341	343	85	85	85	**29**	**29**	**29**
Podarcis muralis	Occ	low CL	1106	1106	1131	261	261	267	85	85	87
		mean	4611	4611	4691	1066	1066	1084	341	341	346
		high CL	20708	20708	21043	4764	4764	4841	1515	1515	1540
Lacerta bilineata	Occ	low CL	346	346	350	86	86	87	**29**	**29**	**30**
		mean	6895	6897	6932	1591	1591	1599	507	507	510
		high CL	50362	50379	50618	11576	11580	11635	3679	3680	3698
Natrix helvetica	Occ	low CL	428	34030	2089998	105	7825	480141	**35**	2487	152517
		mean	89598	3449851	209046604	20590	792540	48024227	6542	251750	15254756
		high CL	89598	3449851	209046604	20590	792540	48024227	6542	251750	15254756

9. Summary

Within this report we have reviewed the existing monitoring efforts for freshwater and reptilian biodiversity in Jersey, and applied a science-based approach to develop two new monitoring schemes for the island; Pondwatch JE and Reptilewatch JE. These schemes have been designed to be accessible and of interest to volunteers with varying levels of experience, skill and available time. The schemes use robust and repeatable methods to generate data for future analyses of population status and trends, whilst maximising the data collected by volunteers and improving our overall knowledge on many of Jersey's species.

The new schemes provide backwards compatibility with previous survey efforts carried out under the NARRS and Toadwatch schemes, meaning that it may be possible to supplement future analyses with data from these earlier schemes for greater effect.

10. Recommendations

- Scheme performance should be reviewed after a pilot year to trial the methods.
- Level 1 surveys should be advertised widely to the general public, including local community groups and schools.
- A greater sense of community needs to be fostered among volunteers involved in biodiversity monitoring. We suggest this is done through the use of social media and regular updates on scheme findings.
- The water quality testing kits being used measure up to 10 ppm for nitrates. However, the Jersey Water stream nitrate map suggests levels may be much higher in Jersey. Preliminary sampling should therefore determine the appropriate range before ordering additional kits.

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