Reptile populations persist following the installation of a hydroelectric scheme at Loch Lomond, Scotland

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ABSTRACT - The land adjacent to Loch Lomond, Scotland, contains areas that have populations of reptiles, including northern vipers *Vipera berus*, slow-worms *Anguis fragilis* and common lizards *Zootoca vivipara*. At one site, where reptile numbers and breeding activity have been monitored, a hydroelectric scheme was implemented that passed through an area of high reptile density. This paper describes the reptile monitoring before, during and after the development; and an environmental management plan put in place to mitigate the effect of the installation on the reptiles. The observation of breeding of all three species adjacent to the area during construction, and of high numbers of reptiles in the vicinity the following year, suggest that the environmental management was successful, at least in the short-term.

INTRODUCTION

The numbers and ranges of some reptile species have shown declines in parts of the UK (Beebee and Griffiths, 2000; Baker et al., 2004; Gleed-Owen & Langham, 2012). This is due in large part to human activities, through the loss of habitat because of changes in land use, construction and developments and, in some cases, persecution, despite all species being protected by law. However, in places where the habitat is protected and animals are undisturbed, high numbers can still be found.

In some areas of Scotland there are healthy populations of northern vipers (i.e. adders) *Vipera berus*, slow-worms *Anguis fragilis* and common lizards *Zootoca vivipara* (Reading et al., 1994; Reading et al., 1996; McInerny & Minting, 2016). One such area is the shore of Loch Lomond, to the north of Glasgow. Here, all three species are present with numbers monitored and their distribution, habitat preferences and breeding activity studied (McInerny, 2014a; McInerny 2014b).

At one site, where northern vipers, slow-worms and common lizards co-exist (McInerny, 2014a), a hydroelectric scheme was proposed in 2013. The development required the construction of a turbine powerhouse, and the laying of underground water pipes and electrical cables that passed through an area with high reptile density. This paper describes the environmental plan put in place to mitigate the effects of the development on the reptiles, and the surveying completed to monitor the process. The present paper may have value for others who are involved with similar developments and wish to avoid impacts on reptiles that are found to be present.

MATERIALS AND METHODS

Study site

The site (here kept anonymous to protect both the habitat and the reptiles) is an area of replanted native forest and forestry plantation on south and west facing hills flanking the east shore of Loch Lomond, with the upper regions leading to heather *Calluna vulgaris* moorland. It contains slopes and boggy areas, patches of exposed rock, and a small stream along the northern edge. The site is fenced, preventing the entry of red deer *Cervus elaphus*, and is rich in native fauna and flora. The forest consists of a mosaic of ash *Fraxinus* spp., birch *Betula* spp., oak *Quercus* spp. and rowan *Sorbus* spp., with an adjacent mature conifer plantation; these are interspersed with open areas containing bracken *Pteridium* spp., gorse *Ulex* spp., bramble *Rubus fruticosus* agg., heather, and other native flora. The lower parts were once a sheep-farm. Many stonewalls have collapsed and have been grown over by vegetation; these piles of covered rocks have created underground hibernation sites (hibernacula), suitable for reptiles.

Survey work

Up to 30 artificial cover objects, made from 50 cm by 50 cm roofing felt, were placed at suitable locations on the site in March 2012. These were inspected about once a week from early February until November, from 2012 to 2015, and were effective in revealing slow-worms. Most adders and common lizards were found not to use the felts, but were instead identified by visual inspection of sunning locations throughout the site. The survey methods used are described in McInerny (2014a), and followed published protocols (Sewell et al., 2013).

The number, age and gender of northern vipers, slow-worms and common lizards were noted on each visit. Individual vipers were recognised by inspection of photographs of head patterns, which are unique to each individual (Sheldon and Bradley, 1989; Benson, 1999); this allowed both counts to be recorded and minimum population numbers estimated. In contrast, population numbers of common lizards and slow-worms were not

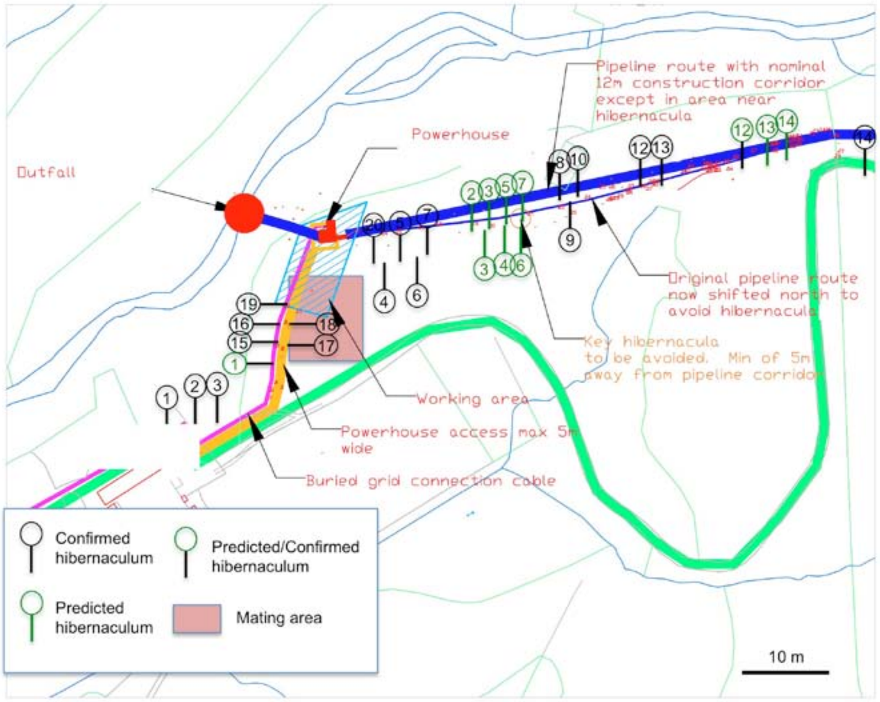

Figure 1. Map of the lower section of a hydroelectric development at Loch Lomond, showing the results of reptile surveys in spring 2013. The layout of the water pipe (blue line), the location of the water outfall (red dot), and the site of the powerhouse (red block) containing the turbines are indicated. The access roads (green and yellow lines) and underground electric cables (pink line) are also shown. The locations of numbered 'confirmed' and 'predicted' reptile hibernacula, where reptiles were seen at the same location on multiple days or 1-2 days, respectively, are plotted. An area where northern vipers mating activity was observed in April 2013 is mapped.

estimated, as individual recognition, though possible (Sewell et al., 2013), was not attempted. Instead, these were recorded as counts.

In total the site was visited 36 times in 2012, 47 times in 2013, 58 times in 2014, and 45 times in 2015. The results from the 2012 survey are published in McInerny (2014a).

Three additional surveys were commissioned in March/April 2013 by Clyde Ecology Ltd (www.clyde-ecology.com) and the developers in preparation for the development, where the author monitored reptile numbers and mapped underground hibernation sites the length of the proposed hydroelectric scheme. The location and numbers of reptile hibernacula were mapped by detecting the repeated sunning locations of reptiles in early spring when they were still near hibernation sites (Sewell et al., 2013). Hibernacula were designated as either 'confirmed' or 'predicted': confirmed was when reptiles were seen at the same location on multiple days, and predicted where reptiles were seen at a location for 1-2 days.

Hydroelectric scheme

The development was instigated in 2014. It involves the diversion of water at three intakes from a stream along an underground pipe, about 2 km long and 300 m down a hillside, to water turbines in a powerhouse, with the return of the water to the stream at an outfall; underground electric cables were required to link the powerhouse to the national grid.

Environmental mitigation plan

Based on the survey work it was discovered that the proposed hydroelectric scheme at the lower parts of the slope, coincided with or was adjacent to areas with highest numbers of the three reptile species (Fig. 1). The developers employed Direct Ecology Ltd (www.directecology.co.uk),

Figure 2. A Loch Lomond hydroelectric development. **A**. Arial view of the lower section of the site, similar to that shown in Fig. 1, August 2014. The fenced area encompassing the construction site, with powerhouse containing the turbines, the cleared areas where the pipes had been laid, and the movable heavy sheet 'gate' placed across the access road, are apparent. **B**. Reptile-proof fencing that surrounded the construction area, February 2014; this was 50 cm high and included 10 cm beneath the ground. **C**. The completed powerhouse, with reptile fencing removed, November 2014.

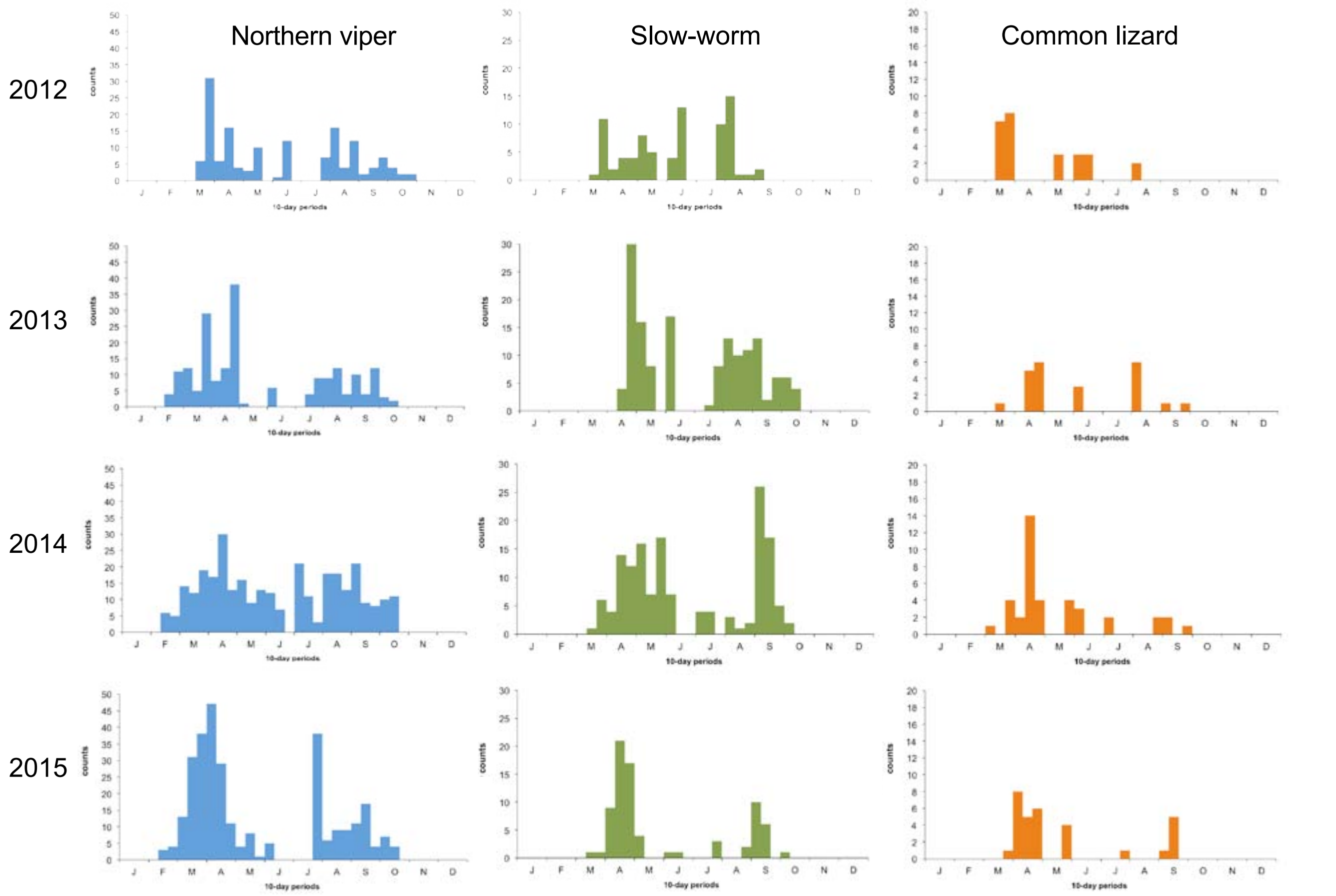

Figure 3. Numbers of northern vipers *V. berus*, slow-worms *A. fragilis* and common lizards *Z. vivipara* before, during and after a hydroelectric development at a Loch Lomond site, from 2012 to 2015. In each case, the reptile counts for 10 day periods are plotted.

who instigated a plan to mitigate effects of construction on the reptiles. First, this involved the revision of the route of the underground water pipe to avoid reptile hibernacula (Fig. 1). Next, a reptile-proof fence was erected around the development at the lower part of the slope, 50 cm high plastic fencing that included ~10 cm below the ground surface (Fig. 2A and 2B). The fencing was laid out to minimise impact on mapped hibernation sites, and installed during January 2014 when reptiles were hibernating. Once it was completed, 50 cm by 50 cm corrugated metal and roofing felt cover objects were placed within the fenced area and these were monitored by Direct Ecology staff for reptiles from March to April, with any found moved outside. One adder could not be caught; here, instead, the fencing was moved so that it was outside. Once the fenced area had been declared clear of reptiles, construction was allowed to proceed; this occurred in May. During construction, the integrity of the fencing was maintained; additionally, a movable heavy sheet ‘gate’ was placed across the access road (Fig. 2A). On completion of the works, in November/December 2014, the plastic fencing was removed (Fig. 2C); this coincided with the time when the reptiles had returned to hibernation.

RESULTS

Reptile numbers before the hydroelectric development, 2012-2013

High numbers of all three species were detected at the site during 2012 and 2013, with reptiles observed from mid-February to late October (McInerny, 2014a; Fig. 3).

In 2012, 40 individual northern vipers were observed, with 15 males, 24 females and one juvenile. In 2013, 79 individual northern vipers were counted, with 37 males, 39 females and three juveniles. Total counts were 149 in 2012, and 196 in 2013. For slow-worms and common lizards, where individuals were not distinguished, total counts revealed 81 slow-worms in 2012 and 149 in 2013. About 25 common lizard counts were recorded in both years.

For adders, mating activity and multiple gravid females were noted; many gravid slow-worms were also seen. Juveniles of three species were observed with, in 2012, total counts of two for adder, 15 for slow-worm and none for common lizard; and in 2013, six for adder, 35 for slow-worm and four for common lizard.

Reptile numbers during and after the hydroelectric development, 2014-2015

All three species were detected at the site, outside the construction area, during 2014 and 2015, with reptiles observed from mid-February to late October (Fig. 3).

In 2014, 151 individual northern vipers were observed, with 61 males, 78 females and 12 juveniles. In 2015, 148 individual adders were counted, with 78 males, 62 females and eight juveniles. Total counts were 316 in 2014 and 299 in 2015. This included a maximum day count of 26 snakes. In total over 200 different individual adders were recognised by their head patterns at the site, from 2012 to 2015. A number of individuals were present throughout the four years of the survey period, and in few cases these re-used the same hibernation sites each winter, some of which were close to the development. Slow-worms and common lizards were also observed with, in 2014, 148 and 39 total counts, and in 2015, 77 and 30, respectively.

Mating activity and gravid female northern vipers and slow-worms were observed in both years. Indeed, in 2014 during installation of the hydroelectric scheme, the wrestling of rival male adders, males courting and mating with females, and up to 12 sunning gravid females were noted within just a few metres of the construction area. Juveniles of three species were observed with, in 2014, total counts of 23 for northern vipers, 71 for slow-worm and one for common lizard; and in 2015, nine for northern vipers, 54 for slow-worm and one for common lizard.

When examining reptile numbers before (2012-13), during and after (2014-15) the development (Fig. 3), it appears that numbers of all three species have persisted. Though the numbers between years are not directly comparable, as there were differences in observer effort, with more visits in later years, similar numbers of animals were observed, suggesting that the populations have not decreased but have remained stable over the period.

DISCUSSION

This paper describes the monitoring of a population of three species of reptiles during the construction of a hydroelectric scheme, and the mitigation plan instigated to reduce its impact on their numbers, distribution and life cycles. The mitigation measures might well have played a role in the persistence of the populations in the short-term as reptile numbers did not decrease. Furthermore, there was no evidence that disturbance at the site resulted in animals leaving the area, nor that disturbance interrupted breeding. Indeed, it was apparent that the three species of reptiles were all tolerant of the noise and movements associated with the building work.

This preliminary study suggests that, with the support of the landowners and developers, and the instigation of an appropriate mitigation plan following a thorough survey of reptile numbers and their distribution, construction projects can occur at sites with high densities of reptiles without affecting their populations in the short-term. There will be continued monitoring at the site to investigate any possible longer terms effects, and to observe whether the reptiles recolonise the construction area itself.

ACKNOWLEDGEMENTS

I thank the landowners for their support in allowing me to monitor reptiles at the site. I also acknowledge their decision to consider the importance of the reptiles when planning the hydroelectric scheme, and the care that the developers and Direct Ecology Ltd took in implementing the mitigation plan. I thank Roger Downie (University of Glasgow), Pete Minting (Amphibian and Reptile Conservation - Trust), Beccy Osborn (Direct Ecology), and anonymous reviewers for comments on the manuscript. The survey work in 2014-2015 was supported by travel grants awarded by Clyde Ecology and the Glasgow Natural History Society from the Professor Blodwen Lloyd Binns bequest.

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Accepted: 15 December 2015