Volume 29 (April 2019), 82-94

Herpetological Journal

FULL PAPER

https://doi.org/10.33256/hj29.2.8294

Published by the British Herpetological Society

Translocation of a large population of great crested newts

John Box[1], Ellen Harpham[2] & Rosie Jackson[2]

[1]17 Jockey Bank, Ironbridge, Telford TF8 7PD, United Kingdom

[2]Atkins, member of SNC-Lavalin Group, 500 Park Avenue, Aztec West, Bristol BS32 4RZ, United Kingdom

The great crested newt, *Triturus cristatus*, is a European Protected Species. Its legal protection requires appropriate mitigation and compensation measures to be developed for populations threatened by built development in order to demonstrate no likely detriment to the maintenance of the favourable conservation status of the species in its natural range. A major regeneration project at a site near Neath Port Talbot in South Wales, United Kingdom, resulted in the destruction of the breeding sites and associated terrestrial habitats of a population of great crested newts. Capture and translocation of 9,500 newts of all life stages was undertaken between 2009 and 2016 to an adjacent receptor site with waterbodies and extensive terrestrial habitats. Eggs and larvae have been observed in waterbodies in the receptor site throughout the monitoring period from 2013 to 2017, and great crested newts are colonising new waterbodies. The translocated population was much larger than the population size predicted from the baseline surveys of waterbodies on the development site. The design, planning and licensing of mitigation and compensation schemes for great crested newts threatened by built development projects need to give full weight to the limitations of survey methods when estimating the size of a population.

Keywords: amphibian, European Protected Species, great crested newt, translocation, *Triturus cristatus*

INTRODUCTION

The great crested newt (*Triturus cristatus*) is one of six species of crested newt in Europe and its global distribution extends as far as central Asia (Jehle et al., 2011). This species, like other amphibians, requires suitable ponds for breeding in proximity to high quality terrestrial habitats for foraging in summer and hibernation in winter (Langton et al., 2001; Jehle et al., 2011). The great crested newt is threatened and declining in the United Kingdom and western Europe (Langton & Burton, 1997; Jehle et al., 2011; Denoel, 2012).

The great crested newt has full legal protection as a European Protected Species through the EC Habitats Directive (Council Directive 92/43/EEC) which is implemented through national legislation by member states of the European Union. The legal protection afforded to the great crested newt has resulted in the capture and translocation of populations that are threatened by built development that has been granted consent, but where there is no alternative to translocation (such as avoiding the loss of aquatic breeding sites or resting places in terrestrial habitats), in order to ensure that the favourable conservation status of the species in its natural range is maintained.

A recent review of great crested newt mitigation measures in England and Wales concluded that there was insufficient evidence to allow general conclusions about the effectiveness of such interventions (Lewis et al., 2017). Reports of translocations of great crested newts (Herpetofauna Consultants International, 2007; Redgrave, 2009; Gustafson et al., 2016) focus on determining the success of the translocation through monitoring of the translocated populations rather than reviewing the translocation process. Edgar et al. (2005), Gustafson et al. (2016) and Lewis et al. (2017) emphasise the crucial role of reporting and evaluating translocations of great crested newts in order to develop appropriate and effective methods for mitigation and compensation for the loss of terrestrial and aquatic habitats from built development projects. More generally, Germano et al. (2015) conclude that there is a failure to document the outcomes of translocations of animals, including amphibians, as part of mitigation for human activities in contrast to translocations undertaken for conservation reasons.

A capture and translocation programme for great crested newts was undertaken between 2009 and 2016 for a major regeneration and redevelopment project at Coed Darcy in South Wales on the site of a decommissioned and demolished oil refinery (Box et al., 2010) (Fig.1). Extensive treatment and remediation of contaminated soils was required involving the destruction of the newt breeding sites and associated terrestrial habitats before redevelopment of the site for residential and commercial uses. It was necessary

Correspondence: John Box (john.box@knowlebox.co.uk)

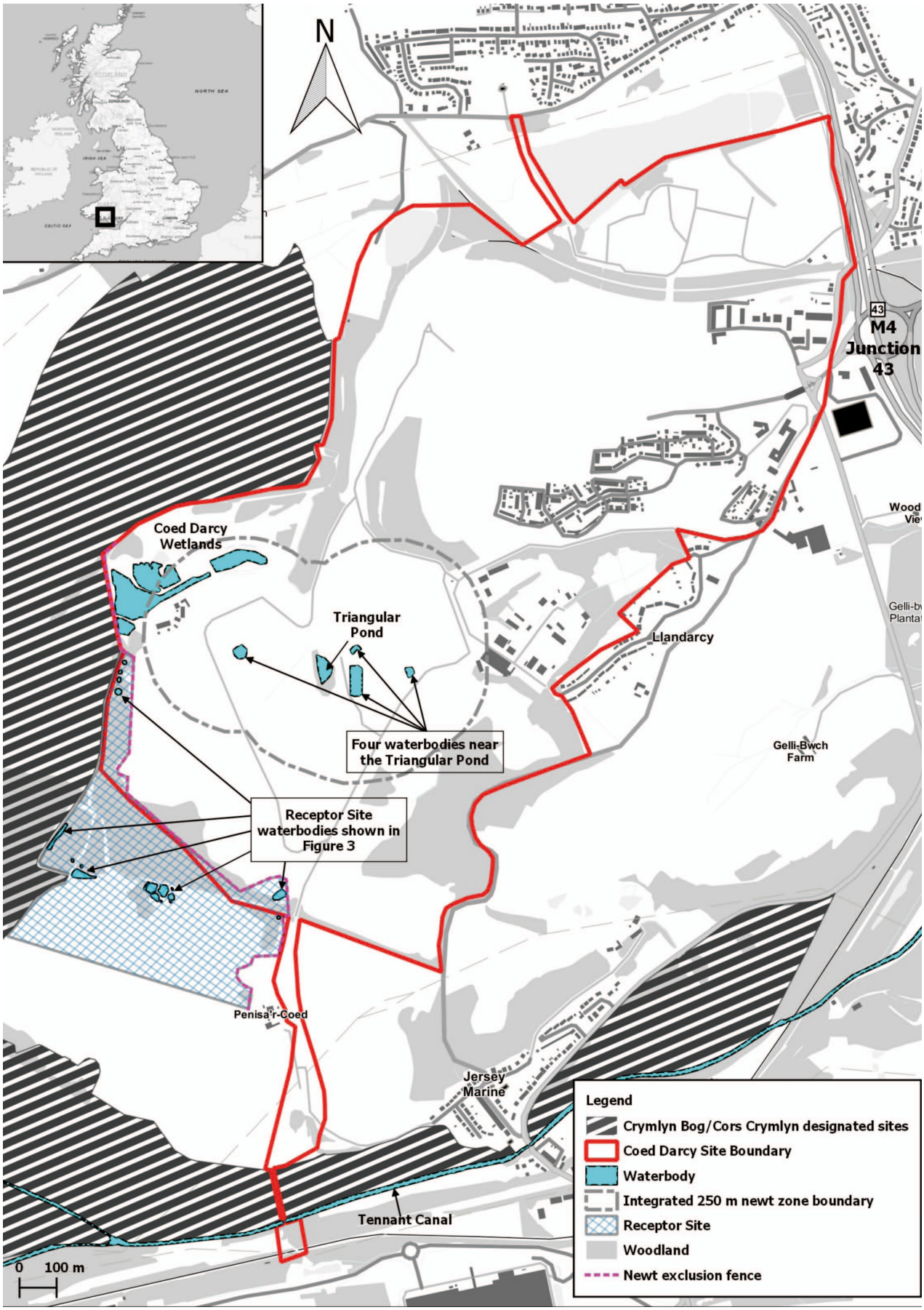

Figure 1. Location of the main Coed Darcy site showing the key waterbodies and the Receptor Site for great crested newts together with the adjacent Cors Crymlyn/Crymlyn Bog

to demonstrate that there was no feasible alternative to the translocation scheme as required by guidance (Joint Nature Conservation Committee, 2003). This paper sets out the lessons learned from one of the largest translocations of great crested newts in Britain with the aim of augmenting the evidence-base for those making decisions about built and infrastructure developments that involve newt habitats and increasing the effectiveness of future mitigation and compensation schemes.

SITE DESCRIPTION AND METHODS

Coed Darcy site

Coed Darcy is an urban development of around 250 ha comprising residential, business and commercial uses, education and other community facilities together with woodlands and landscaped areas being undertaken by St. Modwen Developments Ltd. (St. Modwen) on the site of the former British Petroleum (BP) Llandarcy oil refinery in South Wales (Fig. 1). The site has a complex topography resulting from its industrial past and was dominated by scrub vegetation in association with oak/birch woodland, wet woodland with alder and willow, ephemeral/short perennial vegetation, tall ruderal vegetation, bare ground, spoil and the remnants of oil refinery infrastructure which included large piles of rubble. Coed Darcy is adjacent to the internationally important Crymlyn Bog/Cors Crymlyn Special Area of Conservation, Wetland of International Importance (Ramsar site), National Nature Reserve and Site of Special Scientific Interest.

Great crested newts were recorded at Coed Darcy in only one waterbody (the Triangular Pond) (Fig. 1) as 15 newts in 2001 (torchlight survey on two occasions from April to May) and one newt in 2003 (egg search, torchlight survey and bottle trapping on four occasions from March to June) (Parsons Brinckerhoff, 2005). The 2001 survey was undertaken before publication of the standard survey methodology for great crested newts (English Nature, 2001) and was a much simpler survey. The 2003 survey followed the standard presence/absence methodology in this guidance but was constrained by dense scrub around one waterbody. This population was at the lower end of the 'medium' population size class (defined as 11 to 100 adult newts (English Nature, 2001)) and was considered to be an isolated population that was either a relict or an introduced population (Parsons Brinckerhoff, 2005).

Great crested newts were confirmed in 2008 by Atkins using standard population surveys involving torchlight surveys and bottle trapping on six visits between March and June (English Nature, 2001) in the Triangular Pond as a 'medium' population (the maximum adult count was 15 great crested newts) and as 'small' populations (defined as up to 10 adult newts (English Nature, 2001)) in each of four vegetated waterbodies near the Triangular Pond (Fig. 1). These surveys were constrained because three of the four waterbodies associated with the Triangular Pond were too shallow to use bottle traps and because scrub along the shorelines of some waterbodies was so dense that access to the waterline was not possible (e.g. only 10 % of the shoreline of the Triangular Pond was accessible). The maximum distance between the five waterbodies was 430 m and the great crested newt metapopulation was assessed as being a 'medium' population size class with a cumulative peak count of 15 adult newts summed across the five waterbodies on the same survey date. Great crested newts were not recorded in a comprehensive presence/absence survey in 2008 of the other waterbodies on the Coed Darcy site and all the waterbodies within 500 m of the site boundary.

The Triangular Pond, the main breeding site, was approximately 900 m^2 in area at the water level and 1-1.5 m in depth with abundant broad-leaved pondweed (*Potamogeton natans*) and rigid hornwort (*Ceratophyllum demersum*), frequent white water-lily (*Nymphaea alba*) and occasional common water-starwort (*Callitriche stagnalis*) and bulrush (*Typha latifolia*) (Fig. 2). The Triangular Pond is a distinct feature on two aerial photographs dated 1923 (the oil refinery was opened in 1922) and one dated 1947 (Aerofilms Ltd./Britain from Above). It had an artificial bund on its two eastern sides and was probably constructed to impound surface water runoff as a source of fire-fighting water for the refinery fire station which was based at that time in the southern tank farm that contained the crude oil storage tanks; the Triangular Pond continued in this role in the 1960s during the substantial expansion of the refinery (John Smith, BP & St. Modwen, pers. comm., 6 February 2017).

Figure 2. Marginal aquatic vegetation in the Triangular Pond

There was no alternative to the capture and translocation of the great crested newts (Joint Nature Conservation Committee, 2003) because treatment and remediation of the contaminated soils involved destruction of the Triangular Pond and associated terrestrial habitats. The land around the Triangular Pond had a history of contaminative uses and 'special process areas' were identified for particular attention during remediation in agreement with the regulator Environment Agency Wales, now Cyfoeth Naturiol Cyrmu/Natural Resources Wales (NRW). The Triangular Pond and surrounding areas required excavation to allow for the treatment of hydrocarbon and heavy metal

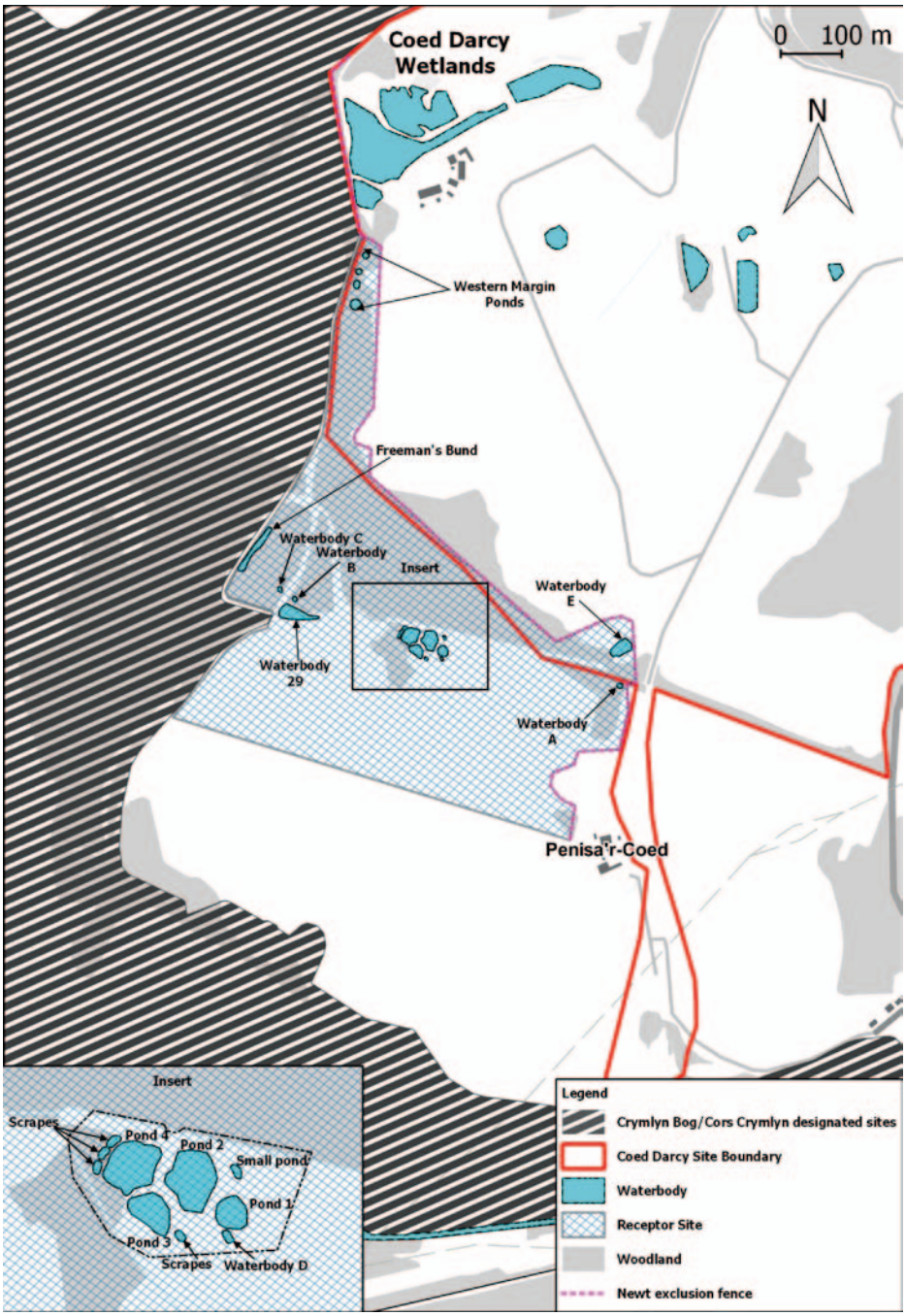

Figure 3. Great crested newt Receptor Site

contamination.

Receptor Site

The Receptor Site (Fig. 3) was established in 2010 adjacent to the Coed Darcy site on terrestrial and aquatic habitats including rush pasture, lowland heath and mire, semi-improved acid grassland, scrub and bracken (*Pteridium aquilinum*), wet woodland and open water. Great crested newts were not present in the existing waterbodies in the Receptor Site prior to the newt translocation. New waterbodies were created in autumn 2010: these were Ponds 1-4, Small pond, Waterbody D and the Scrapes shown in Figure 3; one of the new waterbodies is shown in Figure 4. Extensions to the original Receptor Site were required in 2011, 2015 and 2016 to give a final area of 26.3 ha in conjunction with the creation of further ponds and scrapes in response to the greater than expected numbers

Figure 4. Pond 4 in the Receptor Site in September 2012 following creation in autumn 2010

of great crested newts that had been captured. Habitat management works were undertaken to the existing waterbodies involving vegetation clearance in and around the waterbodies and tree felling to reduce shading. Amphibian refuges/hibernation sites were created using sandstone blocks, rocks, logs, tree stumps and soil.

A sturdy plastic panel newt fence was erected along the boundaries of the Receptor Site with the Coed Darcy site, and along its boundary with the route of the proposed Southern Access Road to Coed Darcy, to exclude the translocated newts from the Coed Darcy site and the remediation and construction activities. This sturdy plastic panel newt fence followed standard guidance (English Nature, 2001) and comprised 500 mm high plastic panels with a 50 mm overhang at the top and 300 mm buried underground; the fence was inspected monthly and repaired swiftly to maintain its integrity.

Capture and translocation

Capture and translocation of great crested newts was undertaken from 2009 to 2012 under licence from the Welsh Government; stopped from 2013 to 2015 to agree extensions to the area of the Receptor Site to support the numbers of captured great crested newts which were very much greater than expected from the newt surveys; resumed in 2016 under licence from NRW, the statutory nature conservation agency in Wales; and followed the standard guidance used in Britain (English Nature, 2001).

Capture of great crested newts relies on the movement of adult newts in the spring from terrestrial

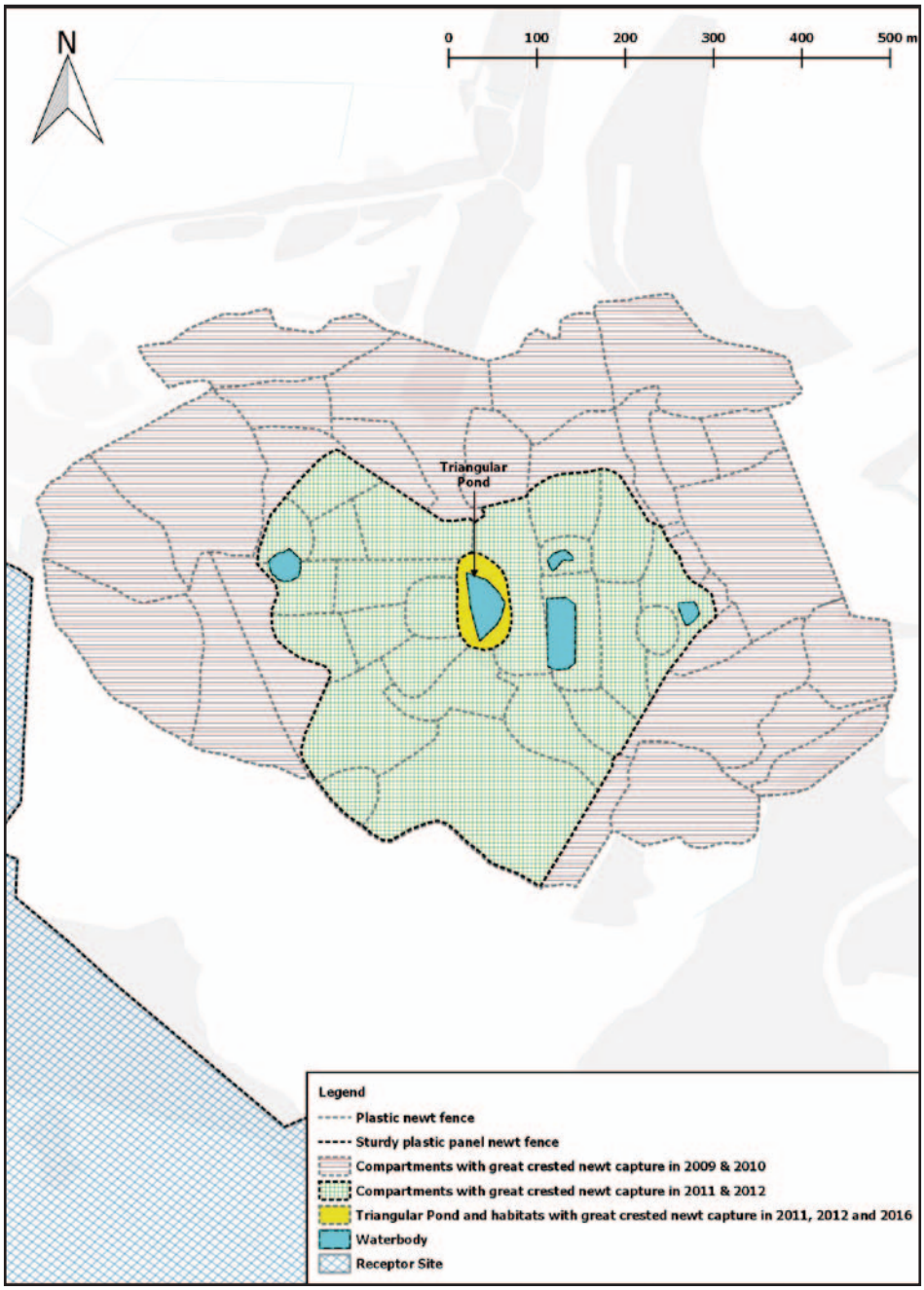

Figure 5. Arrangement of compartments for trapping great crested newts 2009-2016

habitats towards waterbodies to breed. At Coed Darcy, there was agreement with NRW that great crested newts would use suitable habitats within an integrated zone of 250 m around the five waterbodies containing great crested newts (the 'newt zone') (Fig. 1). The movements of the newts were intercepted by plastic newt fences that both completely enclosed the newt zone (47.1 ha) and divided this area into compartments (a total of 11 km of newt fences were installed over the whole of the capture programme) (Fig. 5). These plastic newt fences followed standard guidance (English Nature, 2001) and generally comprised 500 mm high plastic membrane with a 50 mm overhang at the top and with 300 mm plastic buried underground with 200 mm vertical depth and 100 mm horizontal underlap. A sturdy plastic panel newt fence surrounded the 'central compartment' (see below) and comprised 500 mm high plastic panels with a 50 mm overhang at the top and 300 mm buried underground. All the newt fences were inspected daily when the newt captures were taking place and swiftly repaired to maintain their integrity; these inspections took place monthly during the winter months, and during 2013 to 2015 when there was no capture programme.

Guided by these fences, the newts were caught in pitfall traps at 10 m intervals along the fences with an artificial refuge (a carpet tile approximately 0.5 m square) placed between each pair of pitfall traps (in locations where pitfall traps could not be used due to waterlogged or unsuitable ground, artificial refuges were placed at 5 m intervals). The pitfall traps were opened during the trapping season which lasted from March to October/ November (depending on the weather). Newts were captured in the five waterbodies containing great crested newts using bottle traps set at 2 m intervals along the shorelines. The pitfall traps, artificial refuges and bottle traps were checked daily and great crested newts were transported to the Receptor Site (Figs. 1 & 3) together with other amphibians and reptiles. All life stages were translocated: larvae, juveniles with no external gills which had not reached sexual maturity (includes individuals after their first hibernation or 'immatures'), and adults.

Great crested newts captured in 2009 and 2010 could not be moved directly to the Receptor Site as the creation of additional ponds in the Receptor Site and their establishment as suitable habitats with vegetation was subject to planning, technical and construction delays. During these two years, a total of 430 great crested newts were captured in the 27 outer compartments of the 'newt zone' (30.4 ha) and were moved to a large 'central compartment' (16.7 ha) surrounded by a sturdy plastic panel newt fence (Fig. 5). This central compartment was subsequently divided into 24 compartments by plastic newt fences in early 2011. Capture of great crested newts in all these 24 compartments and translocation to the Receptor Site was undertaken in 2011 and 2012. Capture and translocation stopped in October 2012 with only one compartment not completely cleared of newts (0.58 ha comprising the Triangular Pond and surrounding terrestrial habitat). The capture programme stopped from 2013 to 2015 to agree extensions to the area of the Receptor Site to support the numbers of captured great crested newts which were very much greater than expected from the newt surveys in 2008. Capture of great crested newts in the terrestrial and aquatic habitats in this final compartment restarted in March 2016 and was completed in November 2016.

Receptor Site monitoring

Annual monitoring (April to June) of the great crested newt population in the waterbodies in the Receptor Site and the condition of these waterbodies started in 2013. Between 2013 and 2015, monitoring was undertaken on the waterbodies that had been created and that were subject to habitat management. Monitoring was extended in 2016 and 2017 to include other waterbodies that were present in the Receptor Site. Monitoring in 2017 included Waterbody E (Fig. 3) that was created in 2015 and included within the newt fence around the Receptor Site in 2016.

Bottle trapping and torch counts were used to determine the population size class of the newts in the majority of the waterbodies following the standard guidance of six separate visits between mid-March and mid-June (English Nature, 2001). On occasion, lack of safe access to parts of the shoreline or shallow water levels precluded these techniques and the waterbody was monitored using netting and/or egg searches. Unsafe access and low water levels at Freeman's Bund and the most northerly of the Western Margin Ponds in 2017 resulted in monitoring using the environmental DNA (eDNA) methodology (Biggs et al., 2014). This involved a single visit on 4 July to collect 20 water samples which were sent for analysis (this date is just outside the recommended range of mid April to June for eDNA surveys).

The overall condition of the waterbodies was assessed using the Habitat Suitability Index (Oldham et al., 2000). The pH of the water bodies was measured in the field with a portable pH meter. The water bodies were inspected for the presence of plants suitable for egg-laying by newts, invasive non-native plants e.g. New Zealand pigmyweed (*Crassula helmsii*), fish and waterfowl. The shading of the waterbodies by adjacent trees and scrub and the condition of the artificial refuges/hibernation sites were assessed visually.

Deposition of data with local record centres

The data on great crested newts obtained from the surveys of waterbodies at Coed Darcy in 2008, the translocation programme, and the monitoring of the Receptor Site from 2013 onwards has been sent to the South East Wales Biodiversity Records Centre (SEWBReC) and will be sent to Cofnod which is the local environmental records centre for North Wales that hosts the data for the online great crested newt monitoring scheme for Wales (https://www.cofnod.org.uk/LinkInfo?ID=7).

Table 1. Great crested newts captured in 2011, 2012 and 2016 for translocation to the Receptor Site

Year	Terrestrial habitats		Waterbodies			Total
	Adults	Juveniles	Adults	Juveniles	Larvae	
2011	587	1,165	1,369	280	121	3,522
2012	517	1,796	n/a	n/a	n/a	2,313
2016	640	1,040	1,027	9	990	3,706
Total	1,744	4,001	2,396	289	1,111	9,541

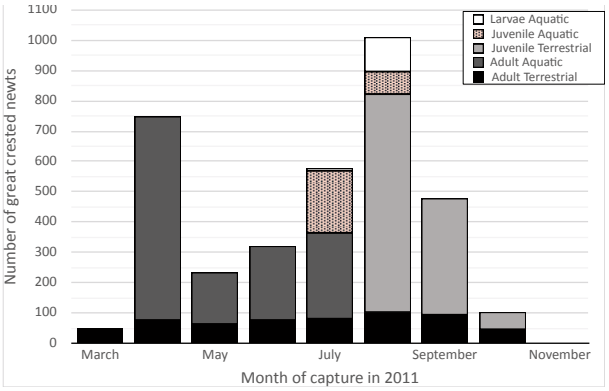

Figure 6. Seasonality of captures of great crested newts in 2011

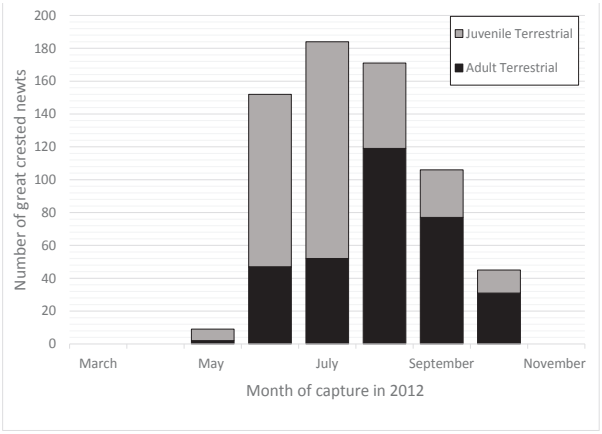

Figure 7. Seasonality of captures of great crested newts in 2012 (no waterbodies were involved)

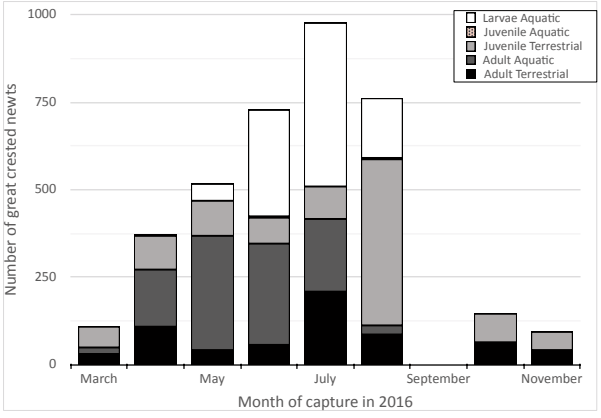

Figure 8. Seasonality of captures of great crested newts in 2016

RESULTS

Capture and translocation

Overall, 9,541 great crested newts were captured and translocated to the Receptor Site (4,140 adults, 4,290 juveniles, 1,111 larvae) (Table 1) as well as 4,094 palmate newts (*Lissotriton helveticus*), 116 smooth newts (*L. vulgaris*), 817 common frogs (*Rana temporaria*), 807 common toads (*Bufo bufo*), 82 common lizards (*Zootoca vivipara*) and 56 grass snakes (*Natrix natrix*).

Figures 6, 7 and 8 show the seasonality of the different life stages of the great crested newts captured in terrestrial and aquatic habitats in 2011 (24 compartments, five waterbodies including the Triangular Pond, 16.7 ha), in 2012 (26 compartments, no waterbodies, 15.9 ha) and 2016 (one compartment with the Triangular Pond, 0.58 ha).

Between April and July in 2011 and 2016, adult great crested newts were predominantly captured in the waterbodies. Capture of adult newts in waterbodies had almost ceased by August in both 2011 and 2016 as adults left the waterbodies to find suitable terrestrial habitat for foraging and hibernation. In terrestrial habitats, the number of adults captured each month remained relatively constant throughout 2011. There was more variation between monthly captures of terrestrial adults in 2012 and 2016 with peak numbers recorded in August and September in 2012 and in July in 2016.

Juvenile activity in the five waterbodies was recorded in July and August in 2011 (280 juveniles captured) but only nine juveniles were captured in the Triangular Pond in 2016 and these were captured between April and August. Terrestrial juvenile numbers peaked during August in 2011 and 2016, and in June and July in 2012, as individual newts completed metamorphosis and emerged from waterbodies to find suitable terrestrial habitat for foraging and hibernation.

Larvae were captured in July and August in 2011 in the five waterbodies and from May to August in 2016 in the Triangular Pond. Larvae are likely to have completed metamorphosis by late August and no larvae were captured between September and November.

Great crested newts were captured in the pitfall traps and under the carpet tiles placed adjacent to the newt fences and there was no noticeable pattern to the captures. However, there was one particular 20 m section of the newt fence between the Triangular Pond compartment and the adjacent compartment to the east where hundreds of great crested newts (mainly adults with some juveniles) were captured in 2011, 2012 and 2016. Peak numbers were captured along this particular section of newt fence during March to May in the traps in the compartment to the east of the Triangular Pond and during July to September in the traps in the compartment containing the Triangular Pond and associated terrestrial habitat.

Dead great crested newts were found along this one section on both sides of the newt fence. The dead newts had a hole in their abdomen, the abdominal organs were exposed and parts may have been removed; some dead newts were in several separate parts. It was assumed that the injuries were caused by a predator, probably a

bird. This first occurred in March and April 2011 (monthly totals of 102 and 11 newts respectively). Bird scarers (compressed gas air cannon) were used and compact discs (CDs) were hung on branches to discourage the birds and additional artificial refuges (carpet tiles) were placed side by side along both sides of the newt fence to avoid incidental death and injury. Dead great crested newts were recorded in subsequent years along both sides of this section of newt fence: seven in May 2012, 14 in July, 240 in August and five in September; two in March 2013; 62 in March 2014; and none in 2015 or 2016. There was no capture programme for great crested newts in 2013, 2014 and 2015 and the newts were found during the monthly inspections of the newt fences undertaken to maintain their integrity. Two dead palmate newts were found at this location in 2012 with holes in their abdomens.

Receptor Site monitoring

Monitoring was constrained on occasion by a lack of safe access to parts of the shoreline of a waterbody or by shallow water levels precluding the use of bottle traps. The pH of the water in the various waterbodies lies in the range 5.5 to 7.5. The results from the annual monitoring of the Habitat Suitability Index of the waterbodies from 2013 to 2017 are set out in Table 2. The target for this parameter was excellent (>0.8) or good (0.70-0.79). A score below 0.70 in one year is generally followed by a higher score in the next year because of habitat improvement works resulting from the annual monitoring.

The maximum adult count in the various waterbodies and the presence of eggs (indicating a breeding population) from 2013 to 2017 data are set out in Table 3. Peak counts of adult great crested newts can be obtained where there is regular interchange of newts between waterbodies by summing the counts across all the waterbodies on the same visit. The peak counts of 153 in 2013, 95 in 2016 and 64 in 2017 were obtained following the standard methodology of six surveys between mid-March and mid-June (English Nature 2001). The peak counts of 49 in 2014 and 15 in 2015 are lower than the other three years, probably because the surveys in 2014 were restricted to two visits rather than the standard six surveys and the surveys in 2015 started in mid-May rather than mid-March. Eggs and larvae have been recorded in the new ponds and scrapes indicating that these created habitats provide favourable breeding conditions. Adult great crested newts were recorded in 2016 and 2017 in an area that had not been part of the original monitoring surveys (Waterbody B). In 2017, adult newts and eggs were recorded breeding in Waterbody E that was created in 2015 and integrated with the Receptor Site in 2016. Great crested newts were demonstrated to be present in the Western Margin Ponds and Freeman's Bund in 2017 using the eDNA methodology.

DISCUSSION

The original great crested newt population

Great crested newts were recorded at Coed Darcy in 2001 in the Triangular Pond at the lower end of the 'medium' population size class, in 2003 in the Triangular Pond as a 'small' population in 2003, and in 2008 in the Triangular Pond and four associated waterbodies as a metapopulation at the lower end of the 'medium' size class. This species was not recorded in 2008 in the other waterbodies on the Coed Darcy site nor in waterbodies within 500 m of the site boundary.

Great crested newts are usually considered to use terrestrial habitats up to 500 m from a breeding pond and long-distance migrations (> 1 km) are rare (English

Table 2. Habitat Suitability Index (HSI) for the waterbodies in the Receptor Site 2013-2017 (ND- not determined).

Waterbody	Habitat Suitability Index[1]				
	2013	2014	2015	2016	2017
Pond 1	0.77	ND	0.77	0.75	0.76
Pond 2	0.87	ND	0.74	0.89	0.87
Pond 3	0.80	ND	0.74	0.68	0.73
Pond 4	0.87	ND	0.72	0.83	0.78
The Scrapes	ND	ND	ND	0.62	0.76
Waterbody 29	0.84	ND	0.64	0.74	0.83
Freeman's Bund	Not monitored between 2013-2015[2]			0.83	0.75
Waterbody A	Not monitored between 2013-2015[2]			0.41	0.45
Waterbody B	Not monitored between 2013-2015[2]			0.44	0.51
Waterbody C	Not monitored between 2013-2015[2]			0.62	0.57
Western Margin Ponds	0.70	0.70	0.48	0.70	0.85
Waterbody D	Surveyed as part of 'The Scrapes' 2013-2016[3]				0.65
Waterbody E	Created in 2015 and added to the Receptor Site in 2016				0.81
Small Pond	Surveyed as part of 'The Scrapes' 2013-2016[3]				0.66

[1]Habitat Suitability Index (Oldham et al., 2000): Excellent (HSI >0.8), Good (HSI 0.7-0.79), Average (HSI 0.6-0.69), Below Average (0.5-0.59), Poor (HSI <0.5).

[2]Monitoring of these waterbodies was undertaken in 2016 and 2017 to show how great crested newts are utilising the existing waterbodies within the Receptor Site.

[3]Waterbody D and Small Pond were surveyed as part of 'the Scrapes' between 2013-2016. The 2017 results from these ponds have been separated to show how great crested newts are utilising the individual ponds created within the Receptor Site.

Table 3. Great crested newt counts, population size and presence of eggs in the waterbodies in the Receptor Site 2013 – 2017 (NS - not surveyed).

Waterbody	2013		2014		2015		2016		2017	
	Max. adult count[1]	Eggs	Max. adult count	Eggs	Max. adult count	Eggs	Max. adult count	Eggs	Max. adult count	Eggs
Pond 1	25	✔	3	✔	2	✔	11	✔	10	✔
Pond 2	55	✔	6	✗	3	✔	25	✔	27	✔
Pond 3	39	✔	3	✔	2	✔	10	✔	8	✔
Pond 4	41	✔	35	✔	3	✔	55	✔	27	✔
The Scrapes	1	✗	0[2]	✗	0[2]	✗	6	✔	7	✗
Waterbody 29	0	✗	3	✗	0	✗	0	✗	NS[7]	✗
Freeman's Bund	Not monitored between 2013-2015[5]						0	✗	0[8]	✗
Waterbody A	Not monitored between 2013-2015[5]						0	✗	NS	NS
Waterbody B	Not monitored between 2013-2015[5]						1	✗	3	✗
Waterbody C	Not monitored between 2013-2015[5]						0	✗	NS	NS
Western Margin Ponds	1	✗	0	✗	0	✗	0	✗	0[8]	✗
Waterbody D	Surveyed as part of 'The Scrapes' 2013-2016[6]								1	✗
Waterbody E	Created in 2015 and added to the Receptor Site in 2016								4	✔
Small Pond	Surveyed as part of 'The Scrapes' 2013-2016[6]								6	✗
Receptor Site Peak Adult Count[3] and Population Size Class[4]	153 Large population		49 Medium population		15 Medium population		95 Medium population		64 Medium population	

[1] The maximum adult count for a waterbody taken on any survey date between mid-March and mid-June.
[2] No adult newts but larvae present.
[3] The peak adult count for the Receptor Site involving all the waterbodies on the same survey date between mid-March and mid-June (English Nature, 2001, section 5.8.3).
[4] Small < 11, medium 11-100, large >100 (English Nature, 2001, section 5.8.3).
[5] Monitoring of these waterbodies was undertaken in 2016 and 2017 to ascertain whether great crested newts were utilising the existing waterbodies within the Receptor Site.
[6] Waterbody D and Small Pond were surveyed as part of 'The Scrapes' between 2013-2016. The 2017 results from these waterbodies have been separated to ascertain how great crested newts were utilising the waterbodies created within the Receptor Site.
[7] No population monitoring surveys were undertaken. An eDNA survey was planned, but an adult great crested newt was observed in July 2017 and therefore the planned eDNA survey was not undertaken.
[8] eDNA survey confirmed great crested newt presence.

Nature, 2001; Jehle et al., 2011) and the maximum distance recorded is 1.6 km (Haubrock & Altrichter, 2016). The South East Wales Biodiversity Records Centre has two records from 2013 from Swansea, one approximately 4.5 km to the south-west and the other 5 km to the north-west of the Coed Darcy site, and a record from 2016 from Neath approximately 6.7 km to the north-east. Natural colonisation of the Triangular Pond by terrestrial migration can be discounted unless loss of intermediate ponds with breeding newts is postulated. The risk of extinction of such an isolated population of great crested newts is relatively high as demonstrated through population modelling by Griffiths & Williams (2001). The persistence of this population at Coed Darcy is notable.

The translocated population of great crested newts

This translocated population of great crested newts at Coed Darcy (9,541 newts of all life stages) is one of the largest translocations and one of the largest recorded populations in Britain. Around 24,000 adult and 5,000 juvenile great crested newts were translocated at Orton brickpits near Peterborough in Cambridgeshire to the Hampton reserve (Herpetofauna Consultants International, 2007); now part of the Orton Pit Special Area of Conservation (SAC), this is the largest known population in the UK (Jehle et al., 2011; Joint Nature Conservation Committee undated). Around 6,000 great crested newts were translocated in three separate operations at Standard claypit, Brookhill claypit and Lane End claypit (now part of Deeside and Buckley Newt Sites SAC) (Natural Resources Wales, 2008; Liz Howe, NRW, pers. comm., 13 March 2017).

The pattern of captures of the three life stages in terrestrial and aquatic habitats between March and November (Figs. 6, 7 & 8) accords with the seasonality of this species (English Nature, 2001; Langton et al., 2001; Jehle et al., 2011). The capture of large numbers of juveniles and larvae (56.6 % of the translocated population) contributed to a final translocated population that was at least an order of magnitude larger than the population estimated in 2008 from the survey data. Capture and translocation schemes should complete the capture of newts by the end of June to minimise the numbers of juveniles and larvae whose numbers cannot be predicted but which count to the limits specified in the licences required for such schemes.

Adult great crested newts with some juveniles were captured in large numbers in all three trapping years (2011, 2012, 2016) along a short section of the newt fence between the compartment with the Triangular Pond and the adjacent compartment to the east. The

data suggest that the newts were moving towards the Triangular Pond from the adjacent compartment to the east during the breeding season (March to May); after the breeding season, newts were captured between July and September moving from the Triangular Pond towards suitable terrestrial habitat in the adjacent compartment. The habitat on both sides of the newt fence at this particular short section comprised woodland, dense bramble (*Rubus fruticosus* agg.) scrub, and piles of dead wood; there was more scrub and woodland in the compartment on the eastern side of the fence than in the compartment with the Triangular Pond. The habitats in the adjacent compartments to the north, south and west of the compartment with the Triangular Pond comprised rough grassland, ruderal vegetation and bramble scrub. Woodland is a preferred migratory habitat (Malmgren, 2002; Jehle et al., 2011, pages 53-54) and research has shown that juveniles (metamorphs) can detect cues, probably olfactory, left by both adults and juveniles and may be able to use these for orientation in relation to finding suitable terrestrial habitat (Hayward et al., 2000). Predicting such migration routes, augmenting the numbers of pitfall traps and artificial refuges, and confirming such predicted routes during a capture and translocation scheme may increase the effectiveness of such a scheme, help to reduce the time required for capturing the newts, and avoid predators killing newts in localised concentrations.

The daily trapping data indicated that the final compartment comprising the Triangular Pond and the surrounding terrestrial habitats had almost been cleared of great crested newts when the capture exercise was terminated in October 2012 because the Receptor Site had to be further extended to accommodate the numbers of captured newts which were substantially greater than expected from the 2008 survey data. The translocation was restarted in 2016 after additional terrestrial habitats were included in the Receptor Site together with the creation of a new waterbody. It is inferred that the newts captured in the compartment with the Triangular Pond during 2016 had developed from a very small residual population over the intervening three years. The density of 3,400 adult newts/ha using the terrestrial habitats (0.49 ha) around the Triangular Pond calculated from the trapping results for this compartment in 2016 (1,667 adults) is more than twice the highest densities previously reported of 1,250 to 1,500 great crested newts/ha in deciduous woodland (Oldham, 1994; Latham et al., 1996). However, this density was derived from the residual population of great crested newts that was isolated for three years in a fenced compartment with good quality terrestrial and aquatic habitats but with no opportunities for dispersal to adjacent habitats. Such a very high density of newts was an artefact of the trapping programme. The greater numbers of larvae captured in the Triangular Pond in 2016 (990 larvae) than in 2011 (121 larvae) with comparable terrestrial and aquatic trapping effort in both years is likely to be the result of this artificially large population.

The high mortality rates of juvenile great crested newts (80 %) and larvae (95 %) (Griffiths & Williams, 2001) suggest that the number of adult newts translocated (4,140) may represent a more reliable estimate of the population in the Receptor Site. The population density of 180 adult newts/ha (370 newts of all life stages/ha) in the Receptor Site (26.3 ha) is comparable to those reported for good quality terrestrial habitats (Oldham, 1994; Latham et al., 1996; Langton et al., 2001, p.29; Box, 2017) and the general occupancy estimates of 250-350 newts/ha used for the translocation of a very large population of great crested newts at Hampton Reserve/ Orton Pit (Herpetofauna Consultants International, 2007).

The great crested newt metapopulation was originally estimated as being between 50 and 750 great crested newts based on a cumulative peak count in 2008 of 15 adult newts summed across all waterbodies surveyed on the same survey date and the assumption that population surveys give estimates of between 2 % and 30 % of the actual population size (English Nature, 2001, section 5.8.3). The translocated population was much larger for reasons that may include:

a)The newt surveys in 2001, 2003 and 2008 were limited by various factors: differences in the numbers of surveys done in the survey year and differences in the survey methods; some waterbodies were too shallow to use bottle traps; and because scrub along the shorelines of some waterbodies was so dense that access to the waterline was not possible (e.g. only 10 % of the shoreline of the Triangular Pond, which was the key breeding site, was accessible in the 2008 surveys);
b) Large piles of rubble colonised by scrub that were adjacent to the Triangular Pond and the waterbodies with breeding great crested newts would have provided ideal foraging habitat and refuges, thus greatly increasing the ability of the habitats to support newts;
c) The waterbodies with great crested newts were in the southern tank farm of the oil refinery that was spread over a large area that would have been generally undisturbed apart from dedicated access routes and footpaths (John Smith, BP & St. Modwen, pers. comm., 7 February 2017).

Redgrave (2009) reported a great crested newt translocation at a site in Hampshire in England where the results of a population class size estimate of the water bodies was 29 adult newts, but the resultant translocation over 5 years involved 1,492 adult newts and 5,289 juvenile newts. The issues resulting from the lack of appropriate surveys prior to a translocation of great crested newts in Sweden are described by Gustafson et al. (2016). Griffiths et al. (2015) provide a cogent overview of the influence of site-specific and survey-specific variables that can affect counts of great crested newts and suggest that population assessments may more reliably reflect species detectability than actual population status.

One key lesson learned from the Coed Darcy scheme is that detailed surveys and population estimates are essential in situations where access to pond margins is restricted (for example, by dense scrub) and where

terrestrial habitat suitability for great crested newts is high. It is necessary to remove dense scrub or cut access paths to the edge of the water in order to survey a waterbody effectively otherwise there will be uncertainty about the size of the newt population because the survey was limited by access to the water. The use of Dewsbury traps (Dewsbury, 2011) in addition to the bottle traps used in the Triangular Pond in the capture programme in 2016 would have given even more certainty that all the newts had been captured before the destructive search of this waterbody.

The future for the great crested newt population

The current conservation status of the species in Wales is considered to be unfavourable declining; the exception is where appropriate long-term management is being implemented (Haysom et al., 2018). The long-term outcome of such compensation schemes is very dependent on the effectiveness of mechanisms to ensure site safeguard and routine habitat management (Edgar et al., 2005; Jehle et al., 2011; Lewis et al., 2017). The great crested newt monitoring and habitat management plan for Coed Darcy aims to maintain the nature conservation value and habitat suitability of the terrestrial habitats and aquatic features within the Receptor Site, and to promote the viability and longevity of the great crested newt population in the long-term. Annual monitoring and management of the great crested newt population and management of the habitats in the Receptor Site will continue up to and beyond 2032 (the period of the current management and monitoring plan) subject to discussions with NRW on the frequency of the population monitoring in the context of the monitoring results and the phased development of Coed Darcy. This monitoring informs the targetted habitat management in the Receptor Site and provides NRW with data for their reporting to the European Union in respect of the licence for the original translocation which permitted a derogation from the EC Habitats Directive (Council Directive 92/43/EEC). The importance of such long-term monitoring of amphibian translocations is emphasised by Germano & Bishop (2009).

Monitoring the population of great crested newts at the Receptor Site at Coed Darcy was constrained on occasion by a lack of safe access to parts of the shoreline of a waterbody or by shallow water levels precluding the use of bottle traps. The monitoring data from 2013 to 2017 (Table 3) demonstrate that great crested newts are moving around the Receptor Site colonising the new ponds and scrapes and are being recorded in small waterbodies in the wet woodland that were not part of the original monitoring scheme. Application of the eDNA method (Biggs et al., 2014), in addition to the annual population surveys on the waterbodies monitored since 2013, could enable a wide range of waterbodies in the Receptor Site to be sampled which would not be possible with existing standard population monitoring methodologies. This would facilitate the determination of which waterbodies across the whole of the Receptor Site are being used by great crested newts. Advances in relation to estimating population size from eDNA surveys (Buxton et al., 2017) may provide a much cheaper and more effective technique for estimating the size of the population in the Receptor Site than standard methodologies.

Breeding has been observed within multiple ponds throughout the monitoring period, which suggests that the habitats within the Receptor Site provide appropriate conditions for great crested newts. The Habitat Suitability Index scores for the original and the created waterbodies in the Receptor Site generally meet the target of good or excellent (>0.7) (Table 2). Lower scores trigger habitat management that takes account of the individual factors from the suite used to derive the HSI (Latham, 2006). The challenge is to maintain, and improve as required, the aquatic habitats because the quality of the water bodies that form the breeding sites for great crested newts is a major factor in the size of a great crested newt population (Oldham et al., 2000).

Once the land on the Coed Darcy site that is within 250 m of all the waterbodies within the Receptor Site is built and fully developed, the sturdy plastic panel newt fence forming the boundary between the Receptor Site and Coed Darcy will be removed and great crested newts will be able to use the woodlands, the landscaped areas and open spaces, and the residential gardens. The Receptor Site will be linked to the Coed Darcy Wetlands (Figs. 1 & 3) whose function as a key site for great crested newts was originally identified in the planning application and the Environmental Statement submitted to Neath Port Talbot County Borough Council (Parsons Brinckerhoff, 2005, 2006) and is described in the Coed Darcy Masterplan Progress Report (St. Modwen, 2011, sections 6.18 & 6.19). The expectation is that the planned relationship between the Receptor Site, the Coed Darcy Wetlands and the Crymlyn Bog/Cors Crymlyn, an internationally important wetland (Fig. 1), will become a practical demonstration of the vision for nature conservation that requires large-scale habitat restoration and habitat creation as part of coherent and resilient ecological networks (Lawton et al., 2010).

ACKNOWLEDGEMENTS

We are grateful for the long and stimulating relationship with St. Modwen Developments Ltd., and for information about the Triangular Pond and the site of the oil refinery from John Smith (British Petroleum & St. Modwen Developments Ltd.). The South East Wales Biodiversity Records Centre provided data on great crested newts and has granted permission to use this data. We are grateful to Liz Howe (Cyfoeth Naturiol Cyrmu/Natural Resources Wales) for information on great crested newt population sizes at Deeside and Buckley Newt Sites SAC. Sandesh Nanda, Kiran Kumar. K, Gopal BS and Emily Clark (all at Atkins, member of SNC-Lavalin Group) created Figures 1, 3 & 5 and we are very grateful for their expertise. Victoria Sloan (Atkins), Ste Nisbet (Atkins), Matt Ellis (Cyfoeth Naturiol Cyrmu/Natural Resources Wales) and Liz Howe made very helpful comments on drafts of the paper.

REFERENCES

Aerofilms Ltd./Britain from Above. http://www.britainfromabove.org.uk/. Images WAW006996, WPW008607 and WPW008608.

Biggs, J., Ewald, N., Valenti, A., Gaboriaud, C., Griffiths, R.A., Foster,J., Wilkinson, J., Arnett, A., Williams, P. & Dunn, F. (2014). *Analytical and methodological development for improved surveillance of the Great Crested Newt. Appendix 5*. Technical advice note for field and laboratory sampling of great crested newt (*Triturus cristatus*) environmental DNA. Freshwater Habitats Trust, Oxford. https://www.adas.uk/DesktopModules/ADAS_eDNA/Documents/12287_WC1067_Appendix_5_TechnicalAdviceNoteUpdatedSept2014.pdf (accessed 14 June 2018).

Box, J., Nightingale, J., Prosser, S., McLaughlin, D., Perry, K., Tooby, M., Sellars, C., Hills, K., Stanhope, K., Girgis, J., Pech, P. & Williams, N. (2010). Coed Darcy urban village – delivering biodiversity during redevelopment of former oil refinery adjacent to a wetland of international importance. In: *Restoration and Recovery: regenerating land and communities*, 295-301, Fox, H.R. & Moore, H.M. (eds). Dunbeath, Whittles Publishing.

Box, J. (2017) How many great crested newts can terrestrial habitats support? *In Practice – Bulletin of the Chartered Institute of Ecology and Environmental Management* 98, 38-40.

Buxton, A.S., Groombridge, J.J., Zakaria, N.B. & Griffiths, R.A. (2017). Seasonal variation in environmental DNA in relation to population size and environmental factors. *Scientific Reports* 7, 46294. https://www.nature.com/articles/srep46294 (accessed 14 June 2018).

Denoel, M. (2012). Newt decline in western Europe: highlights from relative distribution changes within guilds. *Biodiversity and Conservation* 21, 2887–2898.

Dewsbury, D. (2011). An alternative method for catching and surveying newts. *In Practice - Bulletin of the Chartered Institute of Ecology and Environmental Management* 71, 37-40.

Edgar, P.W., Griffiths, R.A. & Foster, J.P. (2005). Evaluation of translocation as a tool for mitigating development threats to great crested newts (*Triturus cristatus*) in England, 1990-2001. *Biological Conservation* 122, 45-52.

English Nature (2001). *Great Crested Newt Mitigation Guidelines*. Peterborough: English Nature (now Natural England). http://webarchive.nationalarchives.gov.uk/20150701000001/http://publications.naturalengland.org.uk/publication/810429 (accessed 14 June 2018)

Germano, J.M. & Bishop, P.J. (2009). Suitability of amphibians and reptiles for translocation. *Conservation Biology* 23, 7-15.

Germano, J. M., Field, K. J., Griffiths, R. A., Clulow, S., Foster, J., Harding, G., & Swaisgood, R. R. (2015). Mitigation-driven translocations: are we moving in the right direction? *Frontiers in Ecology and the Environment* 13, 100-105.

Griffiths, R.A. & Williams, C. (2001). Population modelling of great crested newts (*Triturus cristatus*). *Rana* 4, 239-247.

Griffiths, R.A., Foster, J., Wilkinson, J.W. & Sewell, D. (2015). Science, statistics and surveys: a herpetological perspective. *Journal of Applied Ecology* 52, 1413-1417.

Gustafson, D.H., Blicharska, M. & Mikusiński, G. (2016). When development and amphibians meet: a case study of a translocation of great crested newts (*Triturus cristatus*) in Sweden. *Herpetological Conservation and Biology* 11, 552-562.

Haubrock, P. J. & Altrichter, J. (2016). Northern crested newt (*Triturus cristatus*) migration in a nature reserve: multiple incidents of breeding season displacements exceeding 1 km. *Herpetological Bulletin* 138, 31-33.

Haysom, K., Driver, D., Cartwright, M., Wilkinson, J. & Foster, J. (2018). *Review of the Current Conservation Status (CCS) of the Great Crested Newt in Wales, with specific references to its long-term prospects and within its stronghold in North-East Wales*. NRW Science Report No. 259. Bangor: Natural Resources Wales.

Hayward, R., Oldham, R.S., Watt, P.J. & Head, S.M. (2000). Dispersion patterns of young great crested newts (*Triturus cristatus*). *Herpetological Journal* 10, 129-136.

Herpetofauna Consultants International (2007). *Hampton Western Periphery Road, Stages 2 &3: a review of the protection of great crested newt Triturus cristatus at Hampton Reserve, with particular reference to land adjoining the identified route for WPR Stage 2 & 3*. Halesworth: Herpetofauna Consultants International Ltd.

http://herpecology.co.uk/wp-content/uploads/2009/04/history-report_part1.pdf (accessed 14 June 2018)

http://herpecology.co.uk/wp-content/uploads/2009/04/history-report_part2.pdf (accessed 14 June 2018)

Jehle, R., Thiesmeier, B., & Foster, J. (2011). *The Crested Newt: A dwindling pond-dweller*. Bielefeld, Germany: Laurenti-Verlag.

Joint Nature Conservation Committee (undated). Special Areas of Conservation/SAC selection/Vertebrate species: amphibians/1166 Great crested newt *Triturus cristatus*. http://jncc.defra.gov.uk/protectedsites/sacselection/species.asp?FeatureIntCode=S1166 (accessed 14 June 2018).

Joint Nature Conservation Committee (2003) *A Policy for Conservation Translocations of Species in Britain*. Peterborough: Joint Nature Conservation Committee.

Langton, T. & Burton, J. A. (1997). *Amphibians and Reptiles: Conservation Management of Species and Habitats (Planning and Management Series)*. Strasbourg, Council of Europe.

Langton, T.E.S., Beckett, C.L. & Foster, J.P. (2001). *Great Crested Newt Conservation Handbook*. Halesworth: Froglife.

Latham, D.M. (2006). Applying a Habitat Suitability Index (HSI) to assist site management objectives for the great crested newt (*Triturus cristatus*). *In Practice – Bulletin of the Chartered Institute of Ecology and Environmental Management* 52, 6-7.

Latham, D.M., Oldham, R.S., Stevenson, M.J., Duff, R., Franklin, P., & Head, S.M. (1996). Woodland management and the conservation of the great crested newt (*Triturus cristatus*). *Aspects of Applied Biology* 44, 451-459.

Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.J., Tew, T.E., Varley, J. & Wynne, G.R. (2010). *Making Space for Nature: a review of England's wildlife sites and ecological network*. A report to Defra. http://webarchive.nationalarchives.gov.uk/20130402151656/http:/archive.defra.gov.uk/environment/biodiversity/documents/201009space-for-nature.pdf (accessed 14 June 2018).

Lewis, B., Griffiths, R. A. & Wilkinson, J. W. (2017). Population status of great crested newts (*Triturus cristatus*) at sites subjected to development mitigation. *Herpetological Journal* 27, 133-142.

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

Natural Resources Wales (2008). *Core Management Plan including Conservation Objectives for Deeside and Buckley Newt Sites Special Area of Conservation (SAC)*. Bangor: Natural Resources Wales. https://www.naturalresources.wales/media/671740/Deeside_and_Buckley_WES32_Plan_English.pdf (accessed 14 June 2018).

Oldham, R.S. (1994). Habitat assessment and population ecology. In: *Conservation and Management of Great Crested Newts: Proceedings of a symposium held at Kew Gardens*. Gent, A. & Bray, R. (eds). English Nature Science 20. Peterborough: English Nature (now Natural England). http://publications.naturalengland.org.uk/file/2291292 (accessed 14 June 2018).

Oldham, R.S., Keeble J., Swan, M.J.S. & Jeffcote, M. (2000). Evaluating the suitability of habitat for the great crested newt (*Triturus cristatus*). *Herpetological Journal* 10, 143-155.

Parsons Brinckerhoff (2005) *Coed Darcy Urban Village Environmental Statement*. Prepared for Coed Darcy Urban Village Client Team and submitted to Neath Port Talbot County Borough Council.

Parsons Brinckerhoff (2006) Coed Darcy Urban Village: additional ecological information required under Regulation 19 – newt mitigation strategy, July 2006. Prepared for Coed Darcy Urban Village Client Team and submitted to Neath Port Talbot County Borough Council.

Redgrave, L. (2009). Marnel Park – accommodating great crested newts within a residential development. *In Practice – Bulletin of the Chartered Institute of Ecology and Environmental Management* 64, 23-26.

St. Modwen (2011). *Coed Darcy Masterplan Progress Report, January 2011*. Submitted to Neath Port Talbot County Borough Council.

Accepted: 16 January 2019