ISSN 1393 – 6670

NATIONAL PARKS AND WILDLIFE SERVICE

WHITE-CLAWED CRAYFISH *AUSTROPOTAMOBIUS PALLIPES* SURVEY IN DESIGNATED SACS IN 2017

Martin Gammell, Adon McFarlane, Daniel Brady, Joanne O'Brien, Luca Mirimin, Conor Graham, Heather Lally, Cóilín Minto & Ian O'Connor

An Roinn Tithíochta, Rialtais Áitiúil agus Oidhreachta
Department of Housing, Local Government and Heritage

IRISH WILDLIFE MANUALS 131

National Parks and Wildlife Service (NPWS) commissions a range of reports from external contractors to provide scientific evidence and advice to assist it in its duties. The Irish Wildlife Manuals series serves as a record of work carried out or commissioned by NPWS, and is one means by which it disseminates scientific information. Others include scientific publications in peer reviewed journals. The views and recommendations presented in this report are not necessarily those of NPWS and should, therefore, not be attributed to NPWS.

Front cover, small photographs from top row:

Limestone pavement, Bricklieve Mountains, Co. Sligo, Andy Bleasdale; **Meadow Saffron** *Colchicum autumnale*, Lorcan Scott; **Garden Tiger** *Arctia caja*, Brian Nelson; **Fulmar** *Fulmarus glacialis*, David Tierney; **Common Newt** *Lissotriton vulgaris*, Brian Nelson; **Scots Pine** *Pinus sylvestris*, Jenni Roche; **Raised bog pool**, Derrinea Bog, Co. Roscommon, Fernando Fernandez Valverde; **Coastal heath**, Howth Head, Co. Dublin, Maurice Eakin; **A deep water fly trap anemone** *Phelliactis* sp., Yvonne Leahy; **Violet Crystalwort** *Riccia huebeneriana*, Robert Thompson

Main photograph:

White-clawed Crayfish *Austropotamobius pallipes*, Brian Nelson

White-clawed Crayfish *Austropotamobius pallipes* survey in designated SACs in 2017

Martin Gammell, Adon McFarlane, Daniel Brady, Joanne O'Brien, Luca Mirimin, Conor Graham, Heather Lally, Cóilín Minto & Ian O'Connor

Marine and Freshwater Research Centre, Galway-Mayo Institute of Technology, Dublin Road, Galway

Keywords: White-clawed Crayfish, *Austopotamobius pallipes*, Astacidae, Ireland, Special Areas of Conservation, survey

Site codes: 000297; 000633; 000688; 001656; 001786; 001810; 001919; 001976; 002120; 002121; 002135; 002137; 002162; 002170; 002298

Citation: Gammell, M., McFarlane, A., Brady, D., O'Brien, J., Mirimin, L., Graham, C., Lally, H., Minto, C. & O'Connor, I. (2021) White-clawed Crayfish *Austropotamobius pallipes* survey in designated SACs in 2017. *Irish Wildlife Manuals*, No. 131. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage, Ireland.

The NPWS Project Officer for this report was: Brian Nelson, brian.nelson@housing.gov.ie

This IWM was edited by Brian Nelson

ISSN 1393 – 6670

An Roinn Tithíochta, Rialtais Áitiúil agus Oidhreachta, 90 Sráid an Rí Thuaidh, Baile Átha Cliath 7, D07N7CV
Department of Housing, Local Government and Heritage, 90 North King Street, Dublin 7, D07 N7CV

Contents

Executive Summary

White-clawed Crayfish *Austropotamobius pallipes* surveys were carried out between June and September 2017 in all 15 Special Areas of Conservation (SAC) for which the species is listed as a qualifying interest: Blackwater River (Cork/Waterford) SAC; Bricklieve Mountains and Keishcorran SAC; Glenade Lough SAC; Kilroosky Lough Cluster SAC; Lough Bane and Lough Glass SAC; Lough Corrib SAC; Lough Gill SAC; Lough Hoe Bog SAC; Lough Lene SAC; Lough Nageage SAC; Lough Owel SAC; Lower River Suir SAC; River Barrow and River Nore SAC; River Moy SAC; White Lough, Ben Loughs and Lough Doo SAC.

Crayfish were detected in 13 SACs; they were not detected in the two (Lough Bane and Lough Glass SAC and Lough Lene SAC) from which crayfish populations disappeared in the 1980s following presumed outbreaks of Crayfish Plague *Aphanomyces astaci*. Two SACs (Lower River Suir SAC and River Barrow and River Nore SAC) had confirmed outbreaks of Crayfish Plague in 2017 prior to this survey, but crayfish were detected at unaffected sites in those SACs during this survey. No evidence of Crayfish Plague was found in any other SACs, and no non-indigenous crayfish species were detected.

A total of 123 sites were surveyed (all SACs combined). Crayfish were detected at 65 of those 123 sites (*i.e.* approx. 53% of sites occupied overall). The SACs with the highest crayfish abundances overall were the Bricklieve Mountains and Keishcorran SAC (specifically for Lough Labe within the SAC) and Lough Owel SAC. The SACs with the lowest crayfish abundances overall were Lough Corrib SAC, Lough Gill SAC, Lough Nageage SAC and the River Barrow and River Nore SAC.

For all SACs, the overall proportion of juvenile crayfish was >20%, and for the majority of SACs it was greater than 40%, suggesting that there is a generally healthy level of recruitment in the SACs.

A total of 74 survey sites had previous records of crayfish. Crayfish were detected at 43 of those 74 sites (*i.e.* at approximately 58% of previously occupied sites, which was equivalent to a statistically significant decline in site occupancy of approximately 42%). There appears to have been a significant decline in site occupancy within Lough Corrib SAC, the River Barrow and River Nore SAC and the River Moy SAC, the reasons for which are not clear.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. Most SACs had at least moderate habitat heterogeneity. Two SACs had low habitat heterogeneity: Lough Nageage SAC and White Lough, Ben Loughs and Lough Doo SAC.

Water quality was assessed using Environmental Protection Agency (EPA) water quality status scores. For most SACs, the majority of survey sites, and most lakes and river stretches within each SAC, were of at least Moderate status, the target value for crayfish sites. The SACs that appeared to have some water quality problems were Glenade Lough SAC, Lough Gill SAC, the River Blackwater (Cork/Waterford) SAC, and the River Barrow and River Nore SAC. There was no obvious relationship between the water quality status of a survey site and the probability of detecting crayfish at the survey site, or crayfish abundance at the site.

The main conclusion from the survey was that White-clawed Crayfish populations appear to be in decline in at least some SACs. In particular, there appear to have been losses from Lough Corrib SAC, the River Barrow and River Nore SAC and the River Moy SAC; the reasons for these losses, and the time periods over which they have occurred, are not known. There may be issues affecting crayfish populations in other SACs that were not detected in this survey due to small samples sizes and limited past data on crayfish populations in some SACs.

Future surveys should be designed to ensure an increase in the number of sites within each SAC with data on crayfish presence and abundance, while also ensuring that repeat data is gathered at some sites to facilitate the calculation of robust population trends.

Acknowledgements

We would like to thank all those who helped with surveys, particularly Killian Coakley, Proinsias Hernon and James O'Connor. We are very grateful for the technical assistance provided by Bogna Griffin, Mary Veldon, and our late, sorely missed colleague, Steve Barrett.

1 Introduction

The White-clawed Crayfish, *Austropotamobius pallipes*, is the only indigenous species of freshwater crayfish in Ireland (Holdich, 2002). It is widely distributed throughout the country, primarily in the lime-rich Irish midlands (Demers *et al*., 2005). Although *A. pallipes* is chiefly considered as being associated with good water quality throughout its European range, it can be found in waterbodies of apparently lower quality in Ireland (NPWS, 2013a). It does however require a varied habitat to support all stages of its life cycle, including submerged tree roots, gravel or macrophytes to provide shelter for juveniles, and larger stones or cobbles to act as refuges for adults, or suitable banks in which they can burrow (Demers *et al*., 2003, Gallagher *et al*., 2006, NPWS, 2013a).

Austropotambius pallipes is assessed as Endangered on the IUCN Red List (Füreder *et al*., 2010) and the Irish population is considered to be of substantial conservation importance within Europe (Reynolds, 1998). It is a protected species under Irish and European legislation; it is listed on Annex II and Annex V of the EU Habitats Directive. Ireland is required to designate Special Areas of Conservation (SAC) for the species and to monitor its conservation status (Reynolds *et al*., 2010). The White-clawed Crayfish is listed as a qualifying interest for 15 SACs in Ireland.

Assessment of conservation status is based on the range, population, habitat and future prospects of the species. In the most recent assessment of the conservation status of *A. pallipes* in Ireland (NPWS, 2013a), the range, population and habitat for the species were assessed as Favourable, but the overall assessment was Unfavourable-Inadequate due to an Unfavourable-Inadequate assessment for the future prospects of the species. The Unfavourable-Inadequate assessment for future prospects was based on the recognised risk to the population from the potential introduction of non-indigenous crayfish species (NICS) and Crayfish Plague (*Aphanomyces astaci*) to Ireland; infection by *A. astaci* usually results in 100% mortality in affected populations. As of 2017, there were no known established populations of any NICS in Ireland but there have been recorded incidences of Crayfish Plague. For example, what are presumed to be outbreaks of Crayfish Plague in the 1980s have resulted in the complete disappearance of crayfish populations from two SACs: Lough Bane and Lough Glass SAC, and Lough Lene SAC (NPWS, 2013b, c). More recently (2015, 2017), a number of confirmed Crayfish Plague outbreaks have caused mass mortalities of crayfish in some Irish waterbodies. These include outbreaks in rivers within two SACs: in the River Suir within the Lower River Suir SAC, and in the River Barrow within the River Barrow and River Nore SAC.

The overall aim of this survey was to gather information on the range, population, habitat and future prospects of White-clawed Crayfish in the 15 SACs for which the species is listed as a qualifying interest, and to thereby contribute to the assessment of the conservation status of White-clawed Crayfish within those SACs. This was primarily carried out by (i) collecting data on the presence and abundance of adult and juvenile crayfish at selected monitoring sites within all 15 SACs, as well as data on previous records of crayfish at those sites, (ii) assessing water quality and habitat heterogeneity at those monitoring sites, and within the SAC as a whole, and (iii) reporting on any evidence of NICS or Crayfish Plague in the SACs, and taking tissue samples from some captured crayfish in each SAC, to be stored for future genetic and disease analysis.

2 Methodology

2.1 Survey Sites

Surveys were carried out between June and September 2017 in all 15 SACs with White-clawed Crayfish *Austropotamobius pallipes* listed as a qualifying interest: Blackwater River (Cork/Waterford) (002170); Bricklieve Mountains and Keishcorran (001656); Glenade Lough (001919); Kilroosky Lough Cluster (001786); Lough Bane and Lough Glass (002120); Lough Corrib (000297); Lough Gill (001976); Lough Hoe Bog (000633); Lough Lene (002121); Lough Nageage (002135); Lough Owel (000688); Lower River Suir (002137); River Barrow and River Nore (002162); River Moy (002298); White Lough, Ben Loughs and Lough Doo (001810) (Figure 1).

2.2 Field survey methodology

The field survey methodology used was based on the standard approaches recommended by Reynolds *et al*. (2010) for lakes and Peay (2003) for rivers (See Appendix 1 for more details of the approach taken in the current survey). Characteristics of all SACs were checked on Ordnance Survey maps before each survey, and previous information on the presence and distribution of crayfish in the SACs was consulted when selecting survey sites. Previous information for the SACs was primarily taken from the National Biodiversity Data Centre (NBDC) mapping portal for White-clawed Crayfish (https://maps.biodiversityireland.ie/Species/17487), from the lake survey details in O'Connor *et al.* (2009) and from the most recent Conservation Objectives Reports for the SACs (available from the NPWS website, www.npws.ie). Survey sites in the SACs were selected to ensure that some sites with recent records of crayfish would be included in the survey and to ensure a good geographical coverage of the expected crayfish sites within the SAC.

The survey method chosen for each lake followed the guidelines provided in Reynolds *et al*. (2010). A combination of hand-searching and sweep-netting was used, dependent on habitat type and the characteristics of the lake being surveyed. Although Reynolds *et al.* (2010) recommended hand searching using snorkelling gear as the most successful method for catching crayfish in suitable lake habitats, a major disadvantage of this method is that it is time-consuming. Therefore, for practical purposes, hand-searching without snorkelling gear was used in these surveys. To minimise the potential difficulties that this may have caused (*e.g.* for spotting and catching crayfish), the modified viewing equipment (a small floating wooden drawer with a clear plastic base, attached to the surveyor by a string, Figure 2) proposed by Peay (2003) was used to improve the probability of spotting crayfish while keeping hands relatively free for catching crayfish. Habitat characteristics of lake survey sites were recorded on field recording sheets (habitat cards) adapted from Reynolds *et al*. (2010) and Peay (2003). The crayfish habitat card for lake sites is provided in Appendix 2; more detailed explanations about the categories on the habitat card can be found in Peay (2003).

The survey method chosen for each stretch of river followed guidelines provided in Peay (2003) for monitoring SAC rivers. Hand-searching of potential refuges within suitable habitat patches (again using the modified hand-held viewer) was the primary method used, with sweep-netting and (rarely) trapping used in situations where hand-searching was not practical, *e.g.* due to deep water. Habitat characteristics of river survey sites were recorded on field recording sheets (habitat cards) primarily adapted from Peay (2003). The crayfish habitat card for river sites is provided in Appendix 2; more detailed explanations about the categories on the habitat card can be found in Peay (2003).

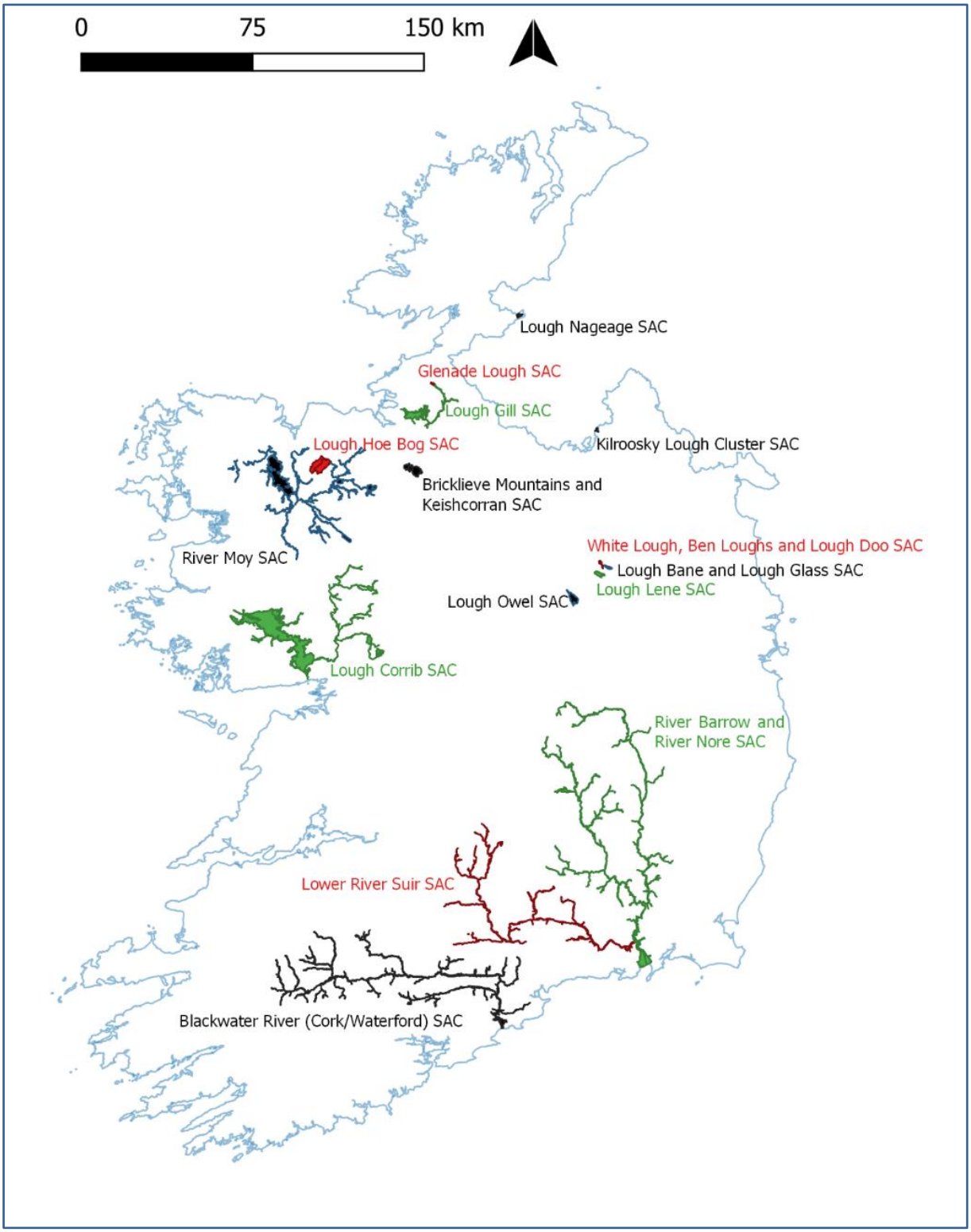

Figure 1 The 15 Special Areas of Conservation in Ireland which were surveyed in 2017 that have White-clawed Crayfish *Austropotamobius pallipes* listed as a qualifying interest.

All captured crayfish were held in containers with water from the survey site prior to processing. Measurements were taken from all crayfish as appropriate, including carapace length, sex of adults, evidence of breeding status, evidence of recent moulting, signs of damage and signs of disease. Any females carrying young were returned without taking detailed measurements, as were some of the smaller individuals that were captured, if it was thought that handling the animals could have caused injury. Crayfish measurements were recorded on field recording sheets (record cards) adapted from Reynolds *et al.* (2010) and Peay (2003). The crayfish record card is provided in Appendix 2; more detailed explanations about the categories on this record card can be found in Peay (2003).

Tissue samples for future genetic and disease analysis were taken from some captured crayfish (up to 30 individuals in each SAC) using non-lethal methods (*i.e.* uropod clippings and abdominal swabs). Mark-recapture studies were also carried out at a small number of sites (one site in Lough Corrib SAC, two sites in Lough Owel SAC and one site in the River Moy SAC - results reported elsewhere: McFarlane *et al.*, 2019). At those sites chosen for mark-recapture studies, crayfish were marked with uropod clips (only adult and sub-adult crayfish, carapace length >20 mm) or a waterproof paint marker (juvenile crayfish, carapace length 10–20 mm) before release back to the site. Following processing, all crayfish were released at the site of capture.

Figure 2 Crayfish surveyors using the modified viewing equipment proposed by Peay (2003).

2.3 Biosecurity

Appropriate decontamination procedures were followed at all survey sites to avoid the potential spread of unwanted organisms or pathogens between sampling localities. Disposable materials such as gloves were used when possible. Before leaving a site, all re-usable equipment that came into contact with water was decontaminated using Virkon S, by submerging in freshly made 1% Virkon and using a brush to scrub areas that may have clogged with mud or sediment, and any debris or vegetation was removed from the equipment. When possible, all equipment was allowed to air dry fully, or was frozen overnight at -20°C, between surveys.

2.4 Abundance estimates and range

Abundance of crayfish at all sites was estimated based on calculated catch per unit effort (CPUE) values. CPUE was calculated as the total number of crayfish detected (including those individuals that evaded capture) at a site divided by the number of patches surveyed. This was usually: 10 patches for lake hand search surveys (1 patch = 10 refuges searched); 5 patches for river hand search surveys (1 patch = 10 refuges searched); 20 patches for sweep net surveys (1 patch = 1 metre sweep over and back); 8 patches for surveys using baited traps (1 patch = 1 trap). An overall CPUE value was also calculated for each SAC by dividing the total number of crayfish detected by the total number of patches surveyed. CPUE values were assigned a population abundance grade based on Peay (2003; Table 1), although it should be noted that these abundance grades were proposed for CPUEs that are calculated following river hand search surveys, and may not be entirely appropriate for CPUEs that are calculated using other survey methods.

Table 1 Catch per unit effort (CPUE) values and proposed population abundance grades (taken from Peay 2003).

CPUE	Population Abundance Grade
> 5	Very high
≥ 3, ≤ 5	High
≥ 1, ≤ 3	Moderate
> 0, < 1	Low
0	Absent or Undetected

Peay (2003) also stated that a healthy crayfish population should consist of approximately 40% juveniles (< 25 mm carapace length) and that if the percentage is less than 20% this could indicate a recruitment problem (or a problem with the survey method used). At all sites where crayfish were detected in this survey, the proportion of juveniles at the site was calculated as the number of identified juveniles divided by the total number of individuals that could be assigned to an age class (for all individuals, *i.e.* those that were captured, but also those that evaded capture if they could be confidently assigned to an age class, either adult or juvenile).

The range of crayfish within the SACs was mapped using QGIS 3.2.0 (https://qgis.org/en/site/). SAC shapefiles were obtained from publicly available datasets provided by the National Parks and Wildlife Service (NPWS), and shapefiles for mapping additional geographical features were obtained from publicly available datasets provided by the Environmental Protection Agency (EPA) and Ordnance Survey Ireland (OSI), all available under a creative commons attribution licence 4.0 (https://creativecommons.org/licenses/by/4.0/legalcode). To estimate whether crayfish were occupying their expected range within a particular SAC, current survey results were compared with information on crayfish range in that SAC from NPWS Conservation Objective Reports (where available), and with previous crayfish records from the NBDC datasets. To estimate the proportion of sites in an SAC occupied by crayfish, while assuming imperfect detection probabilities (*i.e.* assuming that non-detection of crayfish at a site does not necessarily mean that they are not present at the site), simple single season models with constant probability of detection, and with individual survey patches classified as repeat surveys at the selected survey sites (MacKenzie *et al.*, 2002), were fitted to the survey data using the program PRESENCE 12.10 (www.mbr-pwrc.usgs.gov/software/presence.html), for all SACs in which at least eight sites were surveyed. This test was also carried out using data for all survey sites combined (*i.e.* survey sites from all SACs).

2.5 Assessment of Habitat Quality

Water quality was assessed in all SACs based on the most up to date Environmental Protection Agency (EPA) water quality status scores for lakes and rivers (2010–2015) available at https://gis.epa.ie/EPAMaps/. The five possible water quality status scores are: High, Good, Moderate, Poor, Bad. A water quality status score of Moderate is equivalent to a Q-value of 3-4, which is the target value for crayfish sites (Demers & Reynolds, 2002).

Habitat heterogeneity was scored at each site on field recording sheets adapted from Reynolds *et al.*, (2010; Appendix 2) for lakes and Peay (2003; Appendix 2) for rivers. A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the channel in each survey patch (following Peay (2003) and Reynolds *et al.* (2010); also see Appendix 2: Crayfish Habitat Cards: Refuges). The habitat types scored for presence/absence were: Cobble [6.5-15 cm]; Cobble [15-25 cm]; Boulder [26-40 cm]; Boulder [>40 cm]; Rubble; Woody debris; Urban debris; Fine tree roots; Moss (if extensive); Filamentous algae (if extensive); Other submerged vegetation (if dense); Emergents; Charophytes (only for lakes). As an example, a habitat heterogeneity score >0.5 for a survey patch would indicate the presence of at least 50% of those habitat types (potential refuges) in that survey patch. The habitat heterogeneity scores for all patches in a survey site were averaged to give a single habitat heterogeneity score for that site (*i.e.* the average of all patches within the site). Based on the quartiles of the data, a simple classification system for habitat heterogeneity, with four grades, was devised (Table 2).

Table 2 Habitat heterogeneity scores and proposed habitat heterogeneity grades based on the quartiles of the habitat heterogeneity data from the 2017 survey

Habitat Heterogeneity Score	Habitat Heterogeneity Grade
> 0.52	Very high
> 0.43, ≤ 0.52	High
> 0.33, ≤ 0.43	Moderate
> 0, ≤ 0.33	Low

2.6 Assessment of population trends

Trends in crayfish populations within the SACs were assessed by comparing the results of the 2017 survey with the most recent previous crayfish records for those sites surveyed in 2017, according to NBDC data (https://maps.biodiversityireland.ie/Species/17487), and where relevant, by comparing the results of the 2017 survey with the results of lake surveys from 2007 detailed in O'Connor *et al.* (2009). A statistical assessment of population trends over time was carried out for all SACs in which at least eight sites were surveyed in 2017, by conducting a McNemar's test on the 2017 presence/absence data for those survey sites that had previous records of crayfish. This test was also carried out using data for all survey sites combined (*i.e.* survey sites from all SACs). McNemar's test was used to assess whether there had been a statistically significant decrease in the number of occupied sites in 2017. However, in all cases, the results of this test should be interpreted with caution, as due to a lack of detailed past data (*e.g.* on the absence of crayfish from sites), non-random sampling and small sample sizes, as well as differences in survey methods over years, it is difficult to draw definite conclusions or to calculate robust statistical trends.

3 Results

3.1 Survey summary

White-clawed Crayfish *Austropotamobius pallipes* (hereafter often referred to as crayfish) surveys were carried out in all 15 SACs between 23 June 2017 and 21 September 2017 (Table 3). A total of 123 sites were surveyed. Crayfish were detected in 13 SACs; they were not detected in the two SACs (Lough Bane and Lough Glass SAC, Lough Lene SAC) where crayfish populations disappeared in the 1980s following presumed outbreaks of Crayfish Plague. Two SACs (Lower River Suir SAC, River Barrow and River Nore SAC) had confirmed outbreaks of Crayfish Plague in 2017, but crayfish were detected from unaffected sites in those SACs during the current survey. Detailed results for all 15 SACs are provided in the following sections.

Table 3 Summary data for the 15 SACs surveyed for White-clawed Crayfish *Austropotamobius pallipes* in 2017.

SAC	Date ranges of 2017 survey	No. of sites surveyed	Crayfish detected	Crayfish Plague outbreaks
Blackwater River (Cork/Waterford)	22–23 Aug	8	Yes	No
Bricklieve Mountains and Keishcorran	17 Jul	1	Yes	No
Glenade Lough	9 Aug	3	Yes	No
Kilroosky Lough Cluster	21 Jul	3	Yes	No
Lough Bane and Lough Glass	20 Jul	1	No	1980s
Lough Corrib	23 Jun–4 Jul	14	Yes	No
Lough Gill	9–18 Aug	12	Yes	No
Lough Hoe Bog	17 Aug	3	Yes	No
Lough Lene	14 Jul	3	No	1980s
Lough Nageage	16 Aug	4	Yes	No
Lough Owel	11 Jul	2	Yes	No
Lower River Suir	18–21 Sep	22	Yes	2017
River Barrow and River Nore	4–7 Sep	23	Yes	2017
River Moy	26 Jul–2 Aug	21	Yes	No
White Lough, Ben Loughs and Lough Doo	20 Jul	3	Yes	No

The site accounts for each of the SACs follow a standardised format comprising four sections, *Overview*, *Range and abundance*, *Habitat quality* and *Assessment of trends*, and include for each a map showing the SAC boundary, all the sample locations and symbols indicating the sample results. A graph of the frequency distribution of body size of the crayfish is given for those SACs where a sufficiently large sample was available. The full data for each SAC is provided in Tables A3.1 to A3.15 in Appendix 3.

3.2 Blackwater River (Cork/Waterford) SAC

3.2.1 Overview

Surveys were carried out between 22 and 23 August 2017. In total, eight sites were surveyed: seven on the Awbeg River and one on the Finnow Stream. Surveys had been planned for a site on the Blackwater River with previous crayfish records, and for other rivers in the SAC with limestone geology, but those sites were not surveyed due to high flows and access difficulties on the day.

3.2.2 Range and abundance

Crayfish were detected throughout the length of the Awbeg River and in the Finnow Stream just upstream of its confluence with the Blackwater River (the only section of the stream that is within the SAC) (Figure 3). Therefore, crayfish are occupying their expected range within the SAC (see NPWS, 2012).

At most of the sites where crayfish were detected there are apparently healthy populations, with moderate to high abundances (based on the calculated CPUE values and the population abundance grades of Peay (2003)), with a good range of body sizes (Figure 4) and the presence of juvenile crayfish (generally in good proportions, *i.e.* >0.40) at all sites where crayfish were detected (Figure 4; Appendix 3, Table A3.1). The sites with no/low abundances were surveyed using the sweep netting method due to unsuitability for hand searching, which may have contributed to the lower CPUE values (and hence abundance grades) at those sites. However, when considering the SAC as a single monitoring unit, crayfish abundance in their expected range within the SAC is low overall (CPUE = 0.6).

Crayfish were detected at seven of the eight sites that were surveyed (*i.e.* approx. 88% of sites occupied), and a simple single season model with constant probability of detection, and survey patches classified as repeat surveys (MacKenzie *et al*., 2002) gave an estimate of occupancy probability, psi = 0.88 (SE = 0.12, 95% CI = 0.46–0.98).

It should also be noted that although the main Blackwater River is considered chemically unsuitable for crayfish (NPWS, 2012), there are records of crayfish from the Blackwater, most recently from EPA surveys in 2015 (https://maps.biodiversityireland.ie/Species/17487). It was thought that an earlier record downstream of the confluence of the Awbeg and Blackwater may have been the result of an individual moving out of the Awbeg (NPWS, 2012). However, crayfish have now been detected in the Blackwater downstream of the Awbeg on three occasions (by the EPA in 2009, 2012 and 2015). There have also been recent records from two sites on the Blackwater upstream of Mallow (Roskeen Bridge and Longfield's Bridge, 2015). It therefore seems possible that there are established populations of crayfish in the Blackwater River.

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at any of the survey sites.

3.2.3 Habitat quality

Water quality was assessed based on the most up to date EPA water quality status scores for rivers (2010–2015). At five sites surveyed in the SAC, water quality scores were classified as Moderate or higher (Appendix 3, Table A3.1) meaning that they met the target value for crayfish sites. One of the survey sites was classified as Poor (*i.e.* lower than the target value for crayfish sites) and two of the survey sites were classified as Moderate/Poor as they were located at a transition point between a stretch of river classified as Moderate, and a stretch classified as Poor. The Awbeg River as a whole appears to have some water quality issues, with some stretches of the river classified as Poor status, particularly in the Buttevant area. All stretches of the Blackwater River for which there are recent crayfish records are of at least Moderate status.

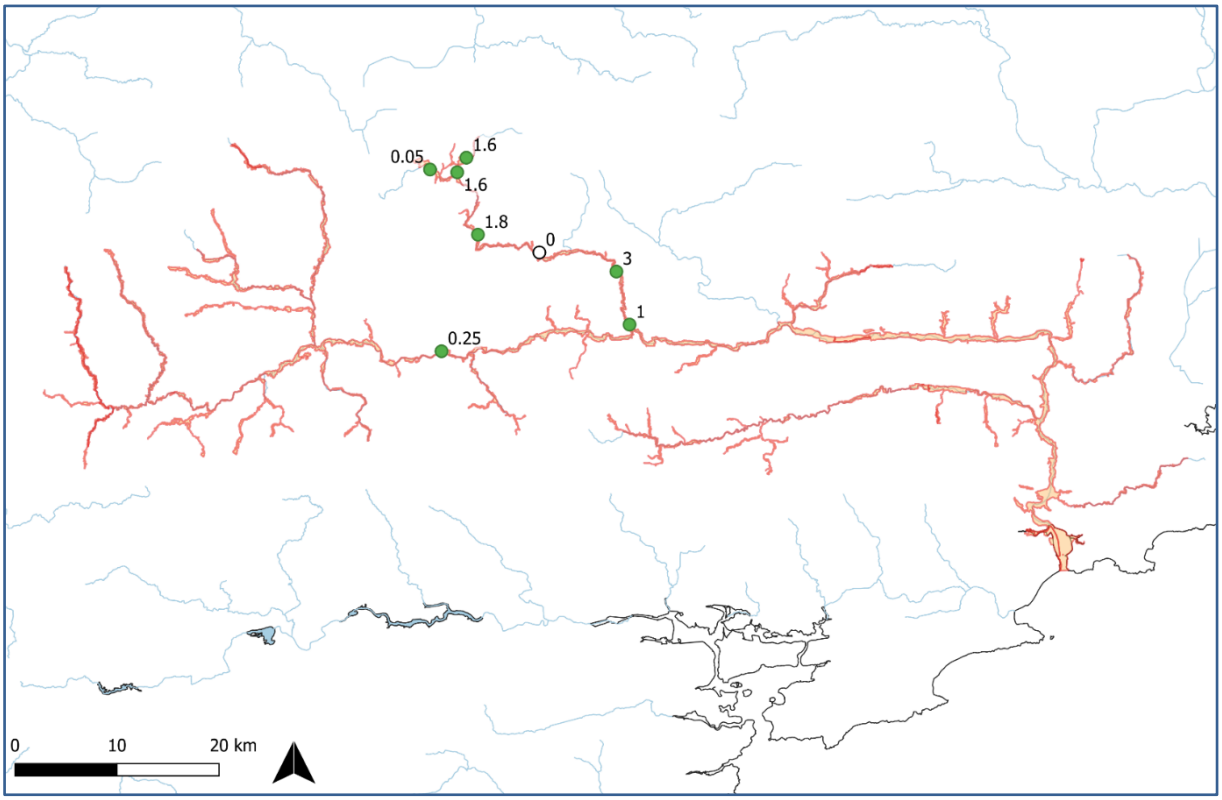

Figure 3 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in the Blackwater River (Cork/Waterford) SAC between 22 August and 23 August 2017. Green dots signify sites where crayfish were detected, and white dots signify sites where crayfish were not detected. CPUE values are included on the map.

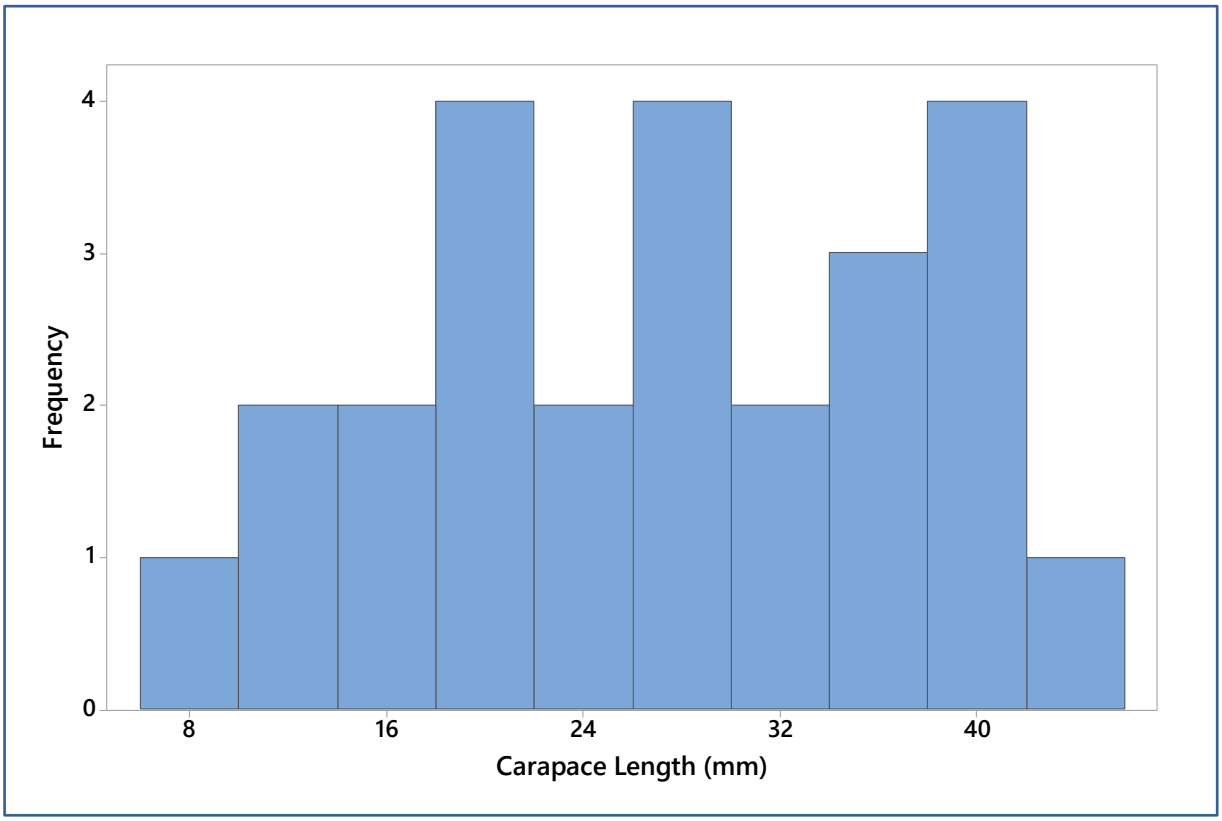

Figure 4 Frequency distribution of body size (measured as carapace length [mm]) of White-clawed Crayfish *Austropotamobius pallipes* from all sites in the Blackwater River (Cork/Waterford) SAC (N = 25).

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at each survey site. For the Blackwater River (Cork/Waterford) SAC, habitat heterogeneity ranged from 0.38-0.80 (Appendix 3, Table A3.1). Mean habitat heterogeneity was 0.57 (SD= 0.12, N = 8) suggesting that, overall, there was a very high level of habitat heterogeneity at the sites surveyed in the Blackwater River (Cork/Waterford) SAC.

3.2.4 Assessment of trends

Of the eight sites surveyed in the Blackwater River (Cork/Waterford) SAC, seven had previous records of crayfish (according to NBDC datasets, accessed 17 July 2018). Crayfish were detected at six of those seven sites (*i.e.* 86% of previously occupied sites) during the survey (Appendix 3, Table A3.1). A McNemar's test on the 2017 presence/absence data for the seven sites that had previous records of crayfish indicated no statistically significant decrease in the number of occupied sites in 2017 (Estimated Decrease = 0.143, 95% CI = -0.259–0.545, P = 1.000). However, this result should be interpreted with caution, as due to a lack of detailed past data (*e.g.* on the absence of crayfish from sites), non-random sampling and small sample sizes, along with differences in survey methods over years, it is difficult to draw definite conclusions or to calculate robust statistical trends.

3.3 Bricklieve Mountains and Keishcorran SAC

3.3.1 Overview

The survey was carried out on 17 July 2017 at a single site on Lough Labe, the only waterbody within the SAC known to contain White-clawed Crayfish. Surveys had also been planned for Lough Gowra (south of Lough Labe) and for the stream connecting Lough Gowra and Lough Labe, but those sites could not be accessed on the day.

3.3.2 Range and abundance

Crayfish were detected in Lough Labe (Figure 5; Appendix 3, Table A3.2). This lake appears to hold a healthy population of crayfish; the CPUE at the survey site indicated a very high abundance (based on the population abundance grades of Peay (2003)), with a good range of body sizes (Figure 6) and the presence of a good proportion of juvenile crayfish, *i.e.* 65% of detected crayfish, which is greater than the value of 40% that Peay (2003) suggested was indicative of healthy recruitment in a population (Figure 6; Appendix 3, Table A3.2).

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey site.

3.3.3 Habitat quality

In the most up to date EPA water quality status scores for lakes (2010–2015), Lough Labe was not assigned a water quality status.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges, which were present in the water at the survey site. For the survey site on Lough Labe, habitat heterogeneity was high (0.45).

3.3.4 Assessment of trends

Because there are limited data on crayfish populations at Lough Labe it is not possible to statistically assess trends in this population over time. During hand search surveys of Lough Labe in 2007, 21 and 39 crayfish were caught (O'Connor *et al.*, 2009), suggesting that the population has remained relatively stable between 2007 and 2017.

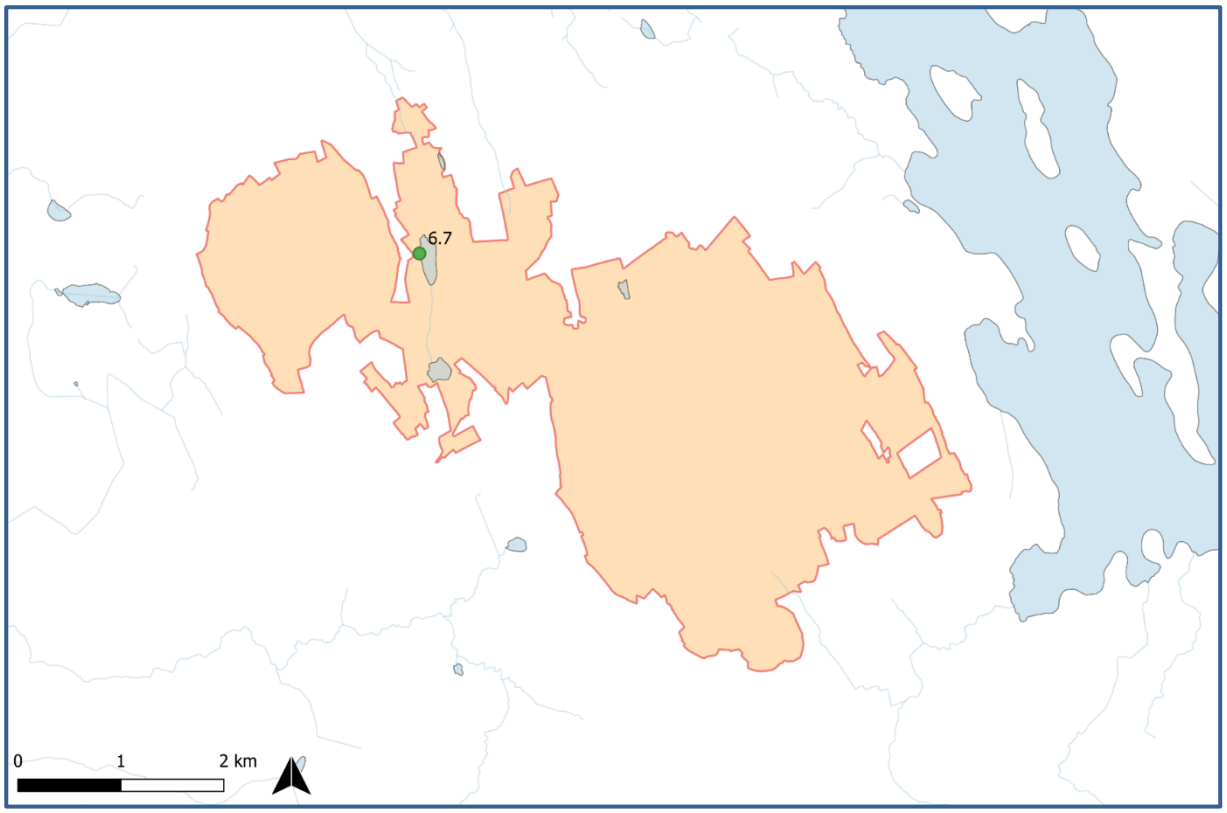

Figure 5 Site surveyed for White-clawed Crayfish *Austropotamobius pallipes* in Lough Labe, within the Bricklieve Mountains and Keishcorran SAC, on 17 July 2017. The green dot signifies where crayfish were detected (at the only survey site). The CPUE value is included on the map.

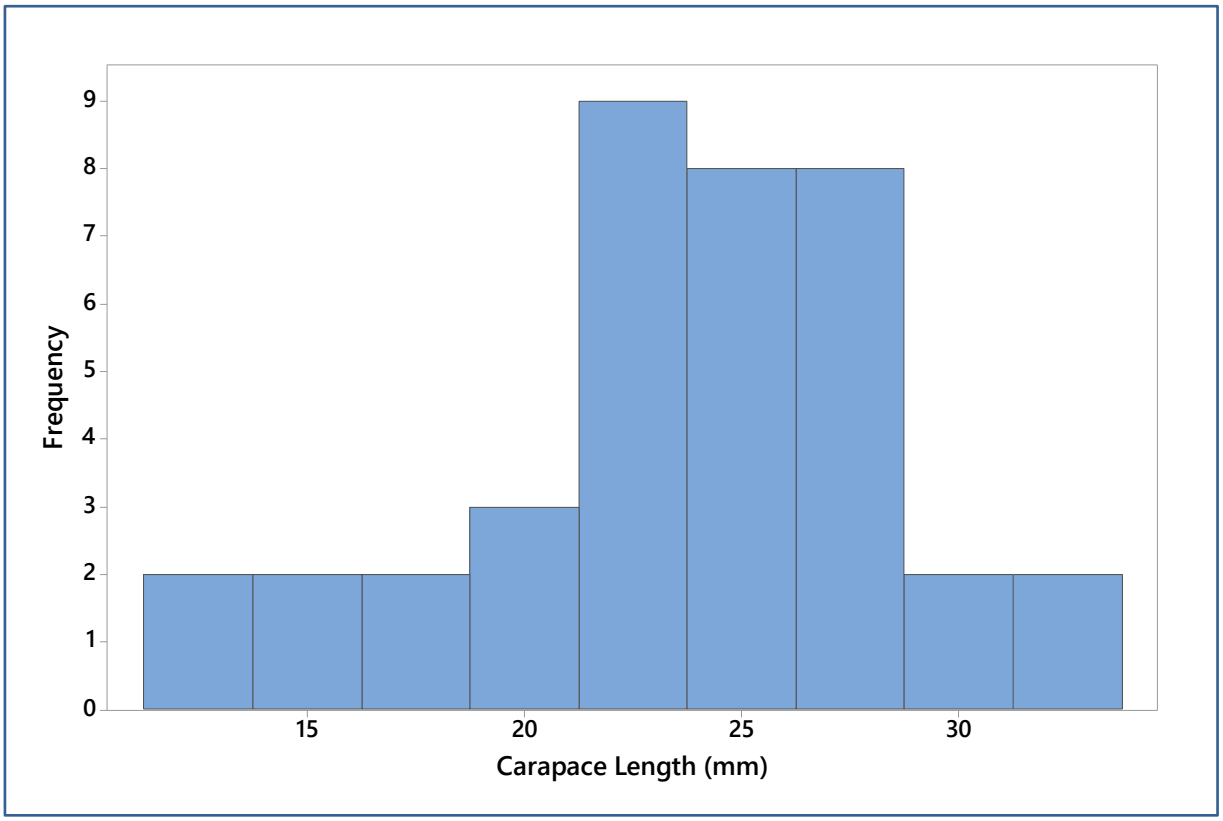

Figure 6 Frequency distribution of body size (measured as carapace length [mm]) of White-clawed Crayfish *Austropotamobius pallipes* from one site on Lough Labe, in the Bricklieve Mountains and Keishcorran SAC (N = 38).

3.4 Glenade Lough SAC

3.4.1 Overview

Surveys were carried out on 9 August 2017, at three sites on the south-east shore of Glenade Lough.

3.4.2 Range and abundance

Crayfish were detected at all three survey sites (Figure 7; Appendix 3, Table A3.3). Glenade Lough appears to hold a good population of crayfish; all three survey sites had moderate to high abundances (based on the population abundance grades of Peay (2003)), and when the results for all three sites are considered together, crayfish abundance is moderate overall (CPUE= 2.27). The captured crayfish had a generally good range of body sizes, although there were fewer small individuals when compared to surveys carried out at other SACs in 2017 (Figure 8). Juvenile crayfish were found at two of the three survey sites, but only in good proportions (>40%) at one site (Appendix 3, Table A3.3). This might suggest a potential issue with recruitment in Glenade Lough (Peay, 2003), although it is difficult to draw strong conclusions about recruitment based on three surveys on a single date in 2017.

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey sites.

3.4.3 Habitat quality

In the most up to date EPA water quality status scores for lakes (2010–2015) Glenade Lough is classified as Poor; it does not meet the target value for crayfish sites.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at each survey site. For Glenade Lough SAC, habitat heterogeneity ranged from 0.32-0.48 (Appendix 3, Table A3.3). Mean habitat heterogeneity was 0.42 (SD = 0.09, N = 3) suggesting that, overall, there was a moderate level of habitat heterogeneity at the sites surveyed in Glenade Lough SAC.

3.4.4 Assessment of trends

Because there are limited data on crayfish populations in Glenade Lough it is not possible to statistically assess trends in this population over time. During surveys of Glenade Lough in 2007, four adult crayfish were caught using hand searching (O'Connor *et al.*, 2009); 34 crayfish were detected in this part of the lake (near the River Bonet outflow) during the current survey.

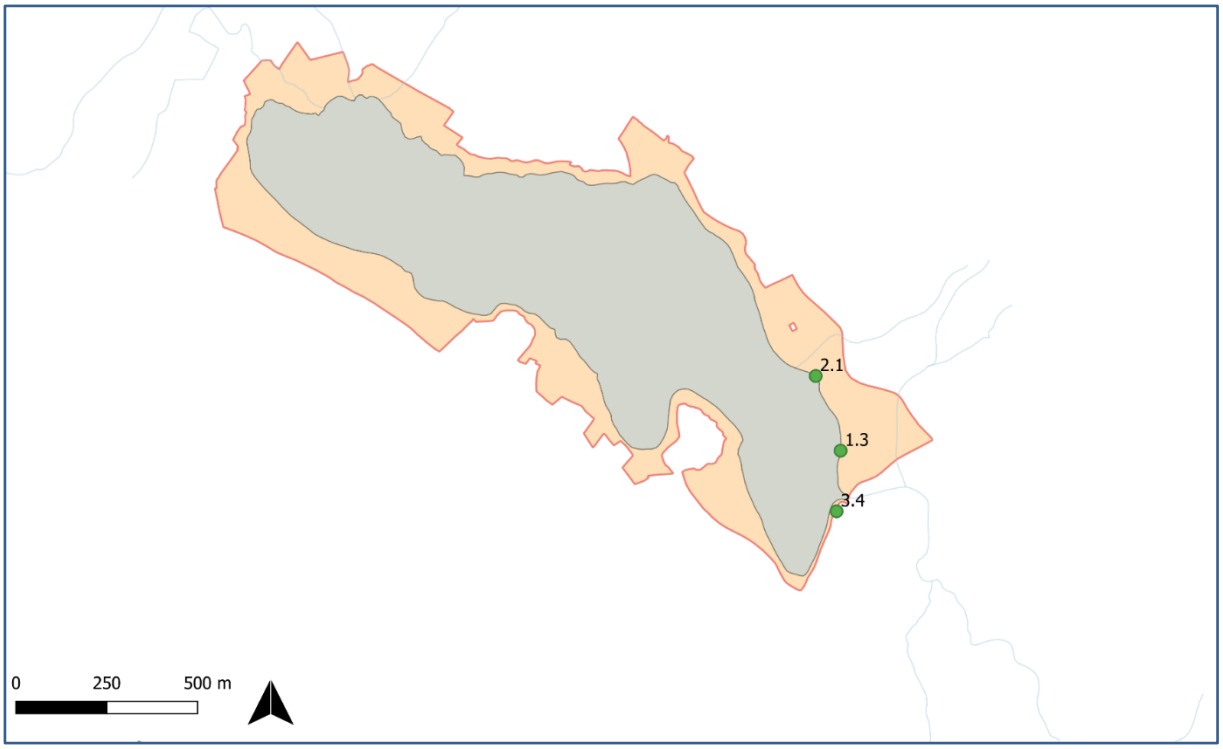

Figure 7 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in Glenade Lough SAC on 9 August 2017. The green dots signify where crayfish were detected. The CPUE values are included on the map.

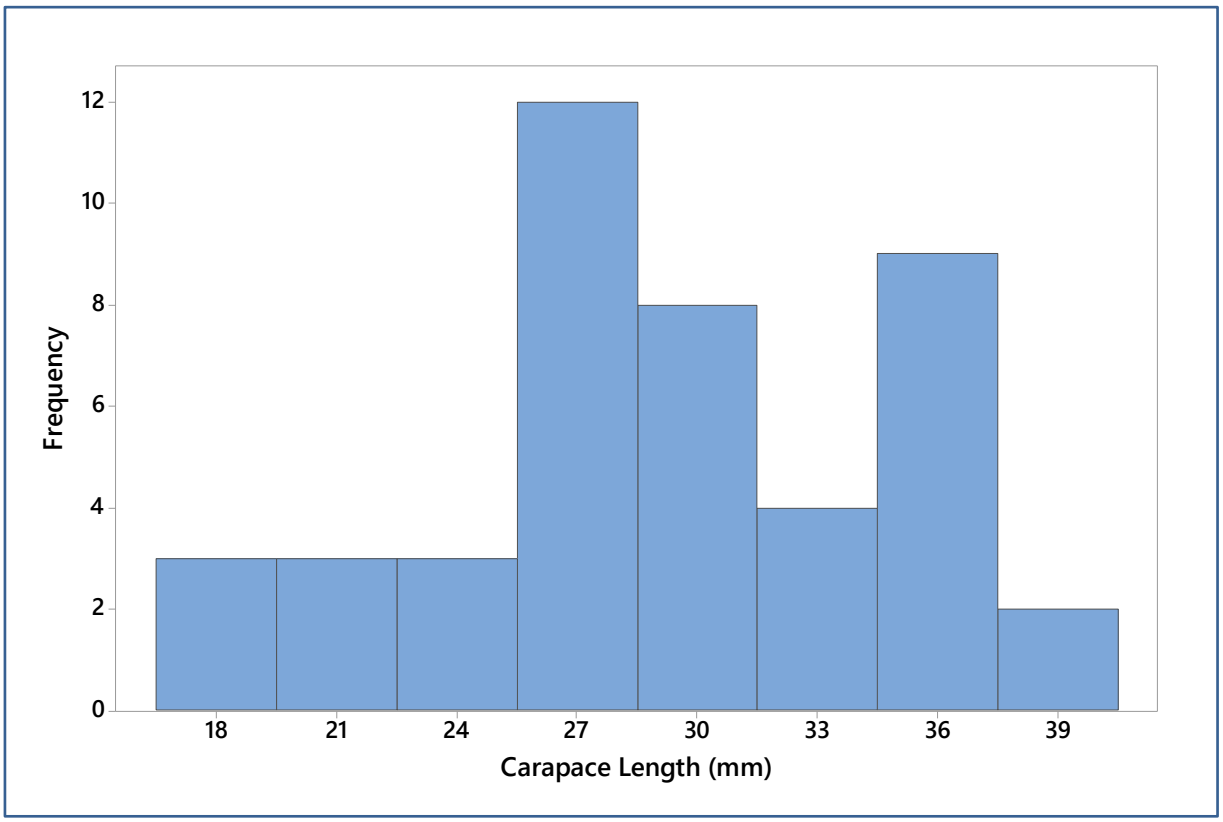

Figure 8 Frequency distribution of body size (measured as carapace length [mm]) of White-clawed Crayfish *Austropotamobius pallipes* from Glenade Lough SAC (N = 44).

3.5 Kilroosky Lough Cluster SAC

3.5.1 Overview

Surveys were carried out on 21 July 2017 at three sites, two sites on Kilroosky Lough, and one site on Summerhill Lough (Figure 9). Surveys had also been planned for Burdautien Lough and Dummy's Lough, but suitable survey sites could not be found on the day (due primarily to deep silt along the margins of the lakes, and very steep gradients into deeper water).

3.5.2 Range and abundance

Crayfish were detected at both survey sites on Kilroosky Lough. Crayfish were not detected at the single survey site on Summerhill Lough (Figure 9; Appendix 3, Table A3.4). Kilroosky Lough appears to hold a relatively good population of crayfish; one survey site had low abundance, and one had moderate abundance (based on the population abundance grades of Peay (2003)). When the result of both sites on Kilroosky Lough are considered together, crayfish abundance for Kilroosky Lough is moderate overall (CPUE = 1.03). However, when the results for all three sites (including the site on Summerhill Lough) are considered together, crayfish abundance for the Kilroosky Lough Cluster SAC is low overall (CPUE = 0.68); it should however be noted that sites were surveyed using the sweep netting method due to unsuitability for hand searching, which may have negatively impacted CPUE values (and hence abundance grades). The crayfish that were captured in Kilroosky Lough had a generally good range of body sizes, although a majority of the captured crayfish were juveniles (Figure 10); the high proportion of juvenile crayfish (>75% at both sites on Kilroosky Lough) suggests a healthy level of recruitment in the lake, although it should also be noted that this high proportion may also be a reflection of the survey method used (sweep netting, which is likely to result in the capture of a higher proportion of smaller individuals).

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey sites.

3.5.3 Habitat quality

In the most up to date EPA water quality status scores for lakes (2010–2015) Summerhill Lough, within the Kilroosky Lough Cluster SAC, is classified as Moderate, meeting the target value for crayfish sites. All other lakes within the SAC, including Kilroosky Lough, were not assigned a water quality status.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at each survey site. For the Kilroosky Lough Cluster SAC, habitat heterogeneity ranged from 0.46-0.54 (Appendix 3, Table A3.4). Mean habitat heterogeneity was 0.51 (SD= 0.05, N = 3) suggesting that, overall, there was a high level of habitat heterogeneity at the sites surveyed in the Kilroosky Lough Cluster SAC.

3.5.4 Assessment of trends

Because there are limited data on crayfish populations from the Kilroosky Lough Cluster SAC it is not possible to statistically assess trends in this population over time. Good numbers of crayfish (a total of 85 using a combination of hand searching, sweep netting and trapping) were detected in Kilroosky Lough in 2007 (O'Connor *et al.*, 2009) and good numbers (a total of 41 using sweep netting) were again detected in the 2017 survey. Crayfish were detected in Summerhill Lough in 2006, but were not detected there in the 2017 survey. Crayfish were also detected in Burdautien Lough in 2006, but this lake was not surveyed in 2017.

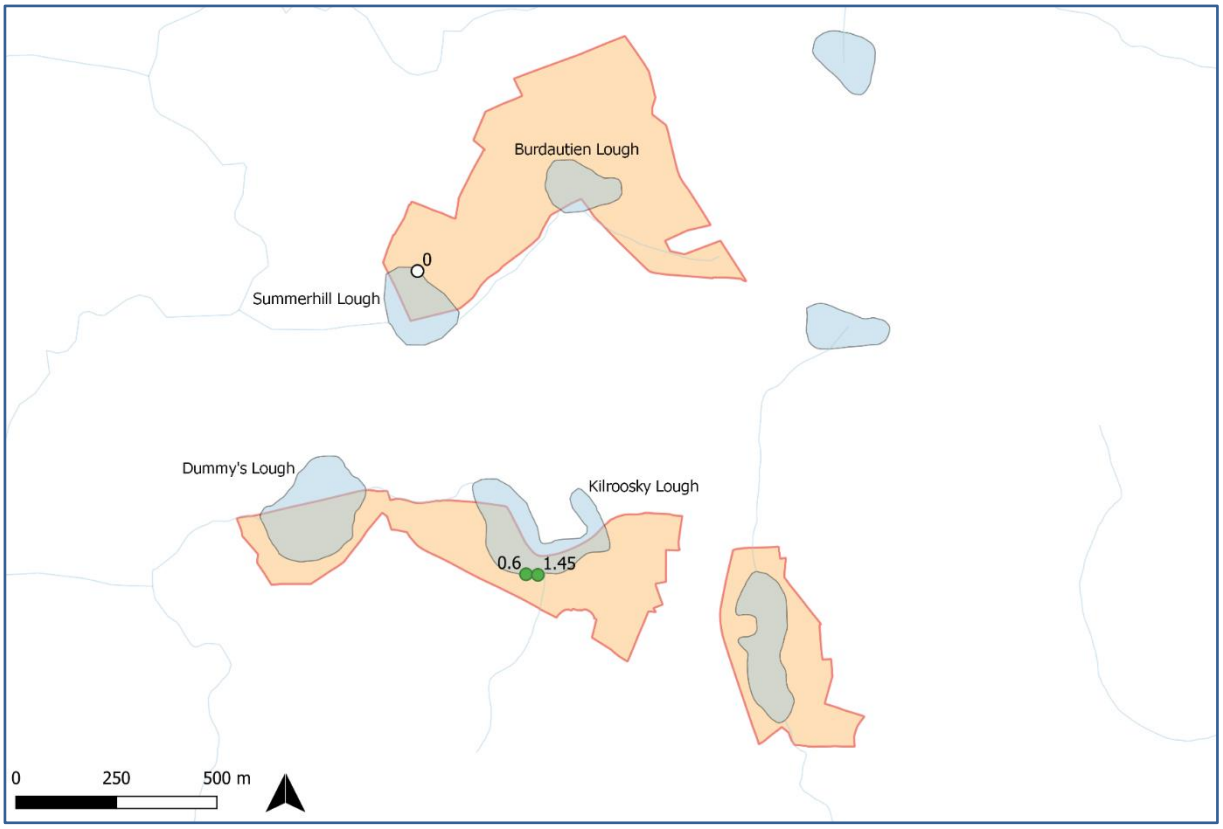

Figure 9 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in the Kilroosky Lough Cluster SAC on 21 July 2017. Green dots signify sites where crayfish were detected, and white dots signify sites where crayfish were not detected. CPUE values are included on the map.

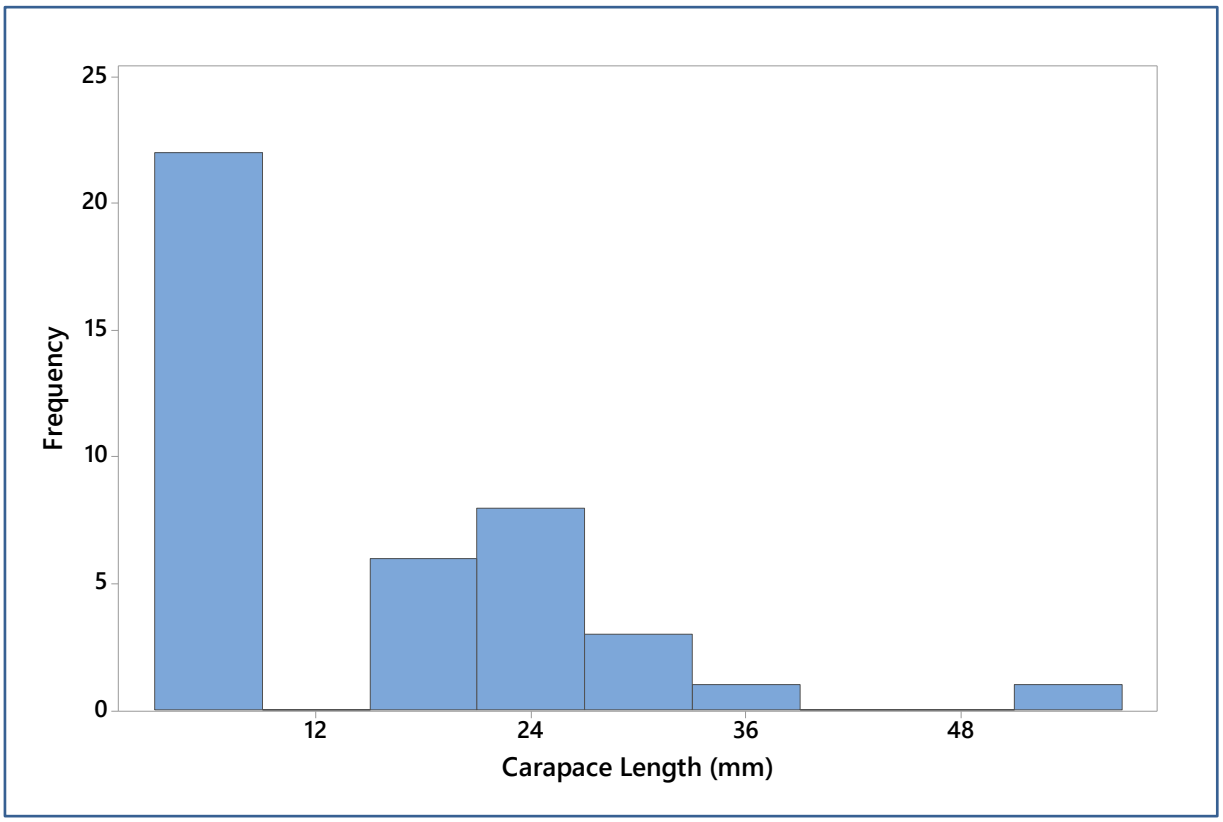

Figure 10 Frequency distribution of body size (measured as carapace length [mm]) of White-clawed Crayfish *Austropotamobius pallipes* from Kilroosky Lough, within the Kilroosky Lough Cluster SAC (N = 41).

3.6 Lough Bane and Lough Glass SAC

3.6.1 Overview

The survey was carried out on 20 July 2017 at a single site on the north shore of Lough Bane. A survey had also been planned for a site on the east shore of Lough Bane, but suitable access to the east shore of the lake could not be found on the day. The crayfish population was lost from this SAC in the 1980s following a presumed outbreak of Crayfish Plague (NPWS, 2013b).

3.6.2 Range and abundance

Crayfish were not detected at the single survey site on Lough Bane (Figure 11; Appendix 3, Table A3.5)

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey site.

3.6.3 Habitat quality

In the most up to date EPA water quality status scores for lakes (2010–2015) Lough Bane is classified as High status, meeting the target value for crayfish sites. Lough Glass and Lough Glass North were not assigned a water quality status.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey site. For the survey site on Lough Bane, habitat heterogeneity was very high (0.57).

3.6.4 Assessment of trends

Lough Bane and Lough Glass SAC previously contained White-clawed Crayfish, but the population disappeared in the 1980s following a presumed outbreak of Crayfish Plague (NPWS, 2013b). No crayfish were detected in Lough Bane in the 2017 survey.

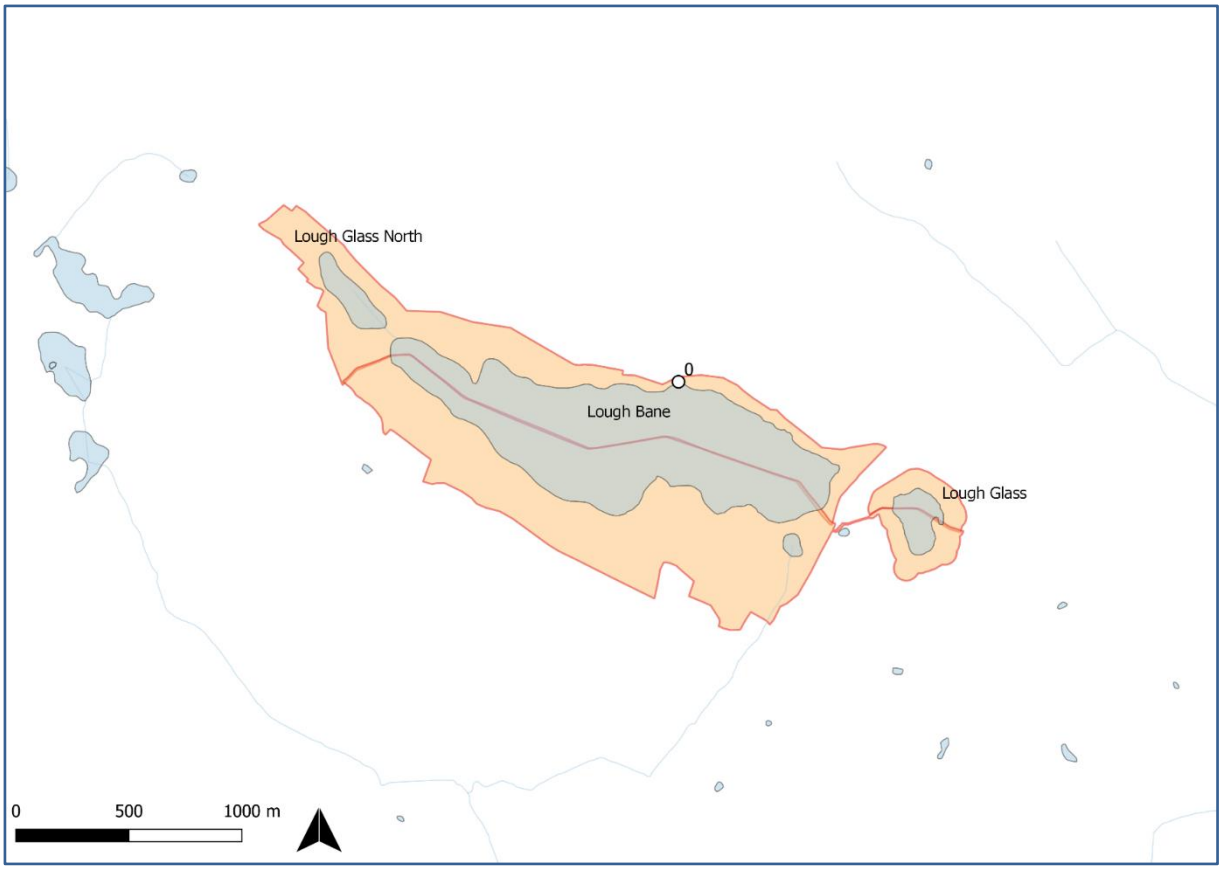

Figure 11 Site surveyed for White-clawed Crayfish *Austropotamobius pallipes* in Lough Bane, within Lough Bane and Lough Glass SAC, on 20 July 2017. The white dot signifies where crayfish were not detected (at the only survey site). The CPUE value is included on the map.

3.7 Lough Corrib SAC

3.7.1 Overview

Surveys were carried out between 23 June and 4 July 2017. In total, 14 sites were surveyed: five in lower Lough Corrib, two on the Abbert River system (one on Mill Stream and one on the Abbert River), three on the Grange River System (all three on the Grange River), two on the Sinking River system (one on the Yellow River and one on the Sinking River) and two on the Dalgan River system (both on the Dalgan River).

3.7.2 Range and abundance

No crayfish were detected in Lough Corrib, or in the Grange River system. Crayfish were detected in the Abbert River and Sinking River systems, but only in the upper reaches. Crayfish were detected in the upper and lower reaches of the Dalgan River system (Figure 12; Appendix 3, Table A3.6). Overall the range of crayfish within the SAC appears to be somewhat restricted, with populations primarily found in the upper reaches of the river systems that were surveyed, and mainly absent/undetected in the lower reaches, and in Lough Corrib. Therefore, crayfish are not fully occupying their expected range within the SAC (see NPWS, 2017a).

At some of the sites where crayfish were detected there are apparently healthy populations, with high to very high abundance (based on the population abundance grades of Peay (2003)), with a good range of body sizes and the presence of high proportions of juvenile crayfish in those populations (Figure 13; Appendix 3, Table A3.6). However, when considering the entire SAC as a single monitoring unit, crayfish abundance in the SAC is low overall (CPUE = 0.77).

Crayfish were detected at only four of the 14 sites that were surveyed (*i.e.* approx. 29% of sites occupied). A simple single season model with constant probability of detection, and survey patches classified as repeat surveys (MacKenzie *et al.*, 2002) gave an estimate of occupancy probability, psi = 0.2859 (SE = 0.1208, 95% CI = 0.1115–0.5607).

No non-indigenous crayfish species were detected during the survey, and there was no evidence of crayfish plague at any of the survey sites.

3.7.3 Habitat quality

Water quality was assessed based on the most up to date EPA water quality status scores for lakes and rivers (2010–2015). At all sites surveyed in the SAC, water quality scores were classified as Moderate or higher, meeting the target value for crayfish sites. Considering the SAC as a whole, all areas that contain potentially suitable crayfish habitat, and which have been assigned a water quality status by the EPA, are of at least Moderate status.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For the Lough Corrib SAC, habitat heterogeneity ranged from 0.25-0.60 (Appendix 3, Table A3.6). Mean habitat heterogeneity was 0.40 (SD = 0.11, N = 14) suggesting that, overall, there was a moderate level of habitat heterogeneity at the sites surveyed in the Lough Corrib SAC.

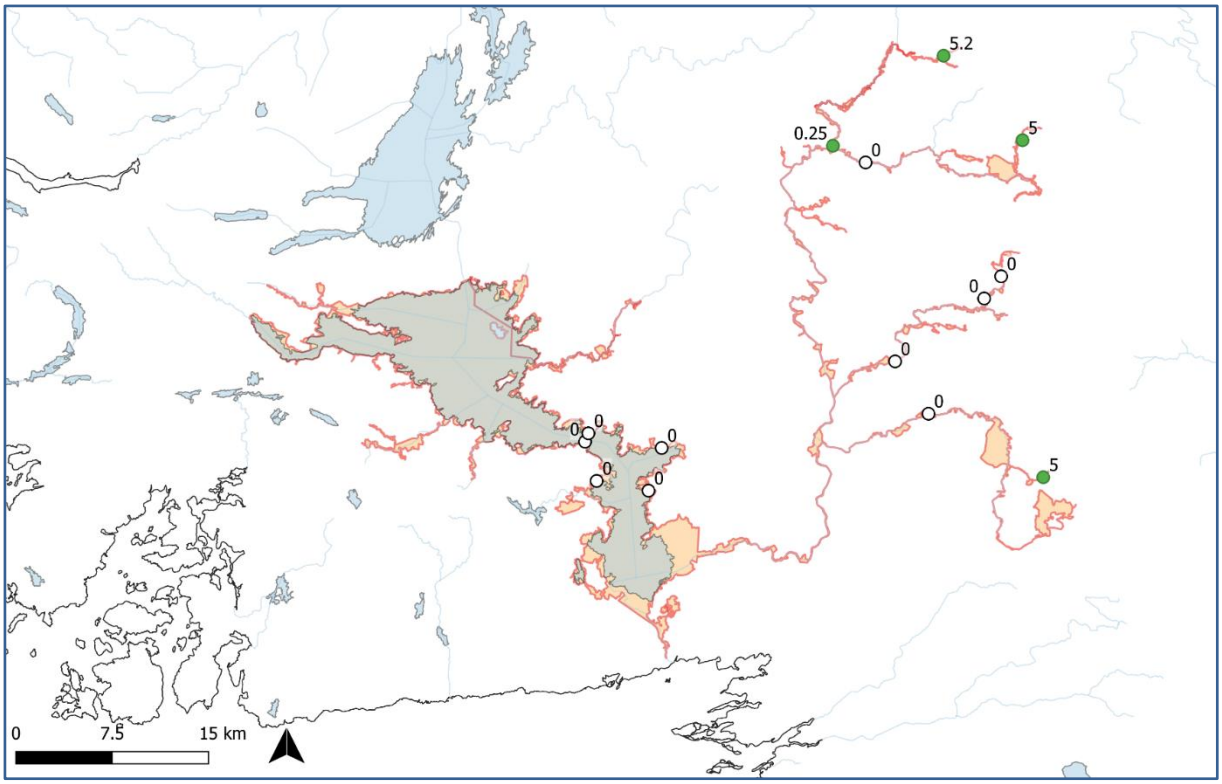

Figure 12 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in Lough Corrib SAC between 23 June and 4 July 2017. Green dots signify sites where crayfish were detected, and white dots signify sites where crayfish were not detected. CPUE values are included on the map.

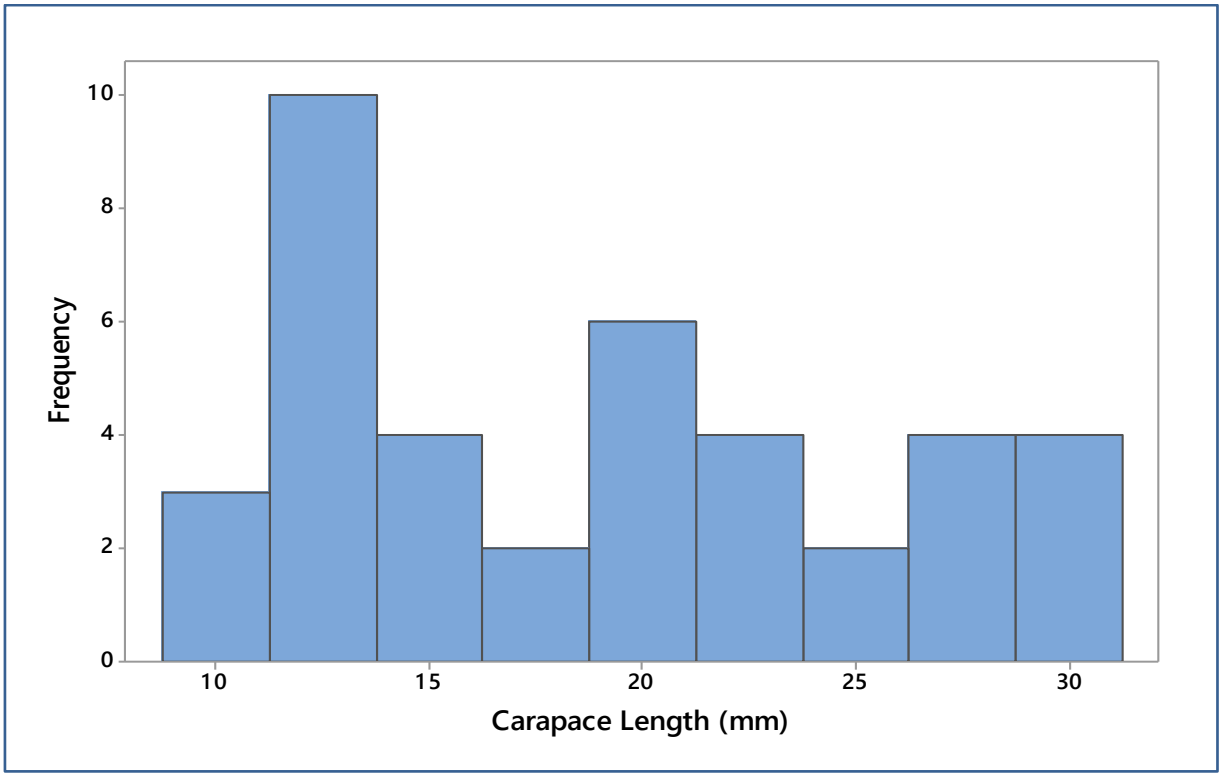

Figure 13 Frequency distribution of body size (measured as carapace length [mm]) of White-clawed Crayfish *Austropotamobius pallipes* from three sites in Lough Corrib SAC with high to very high abundances, *i.e.* the upper reaches of the Abbert, Sinking and Dalgan systems (N = 39).

3.7.4 Assessment of trends

Of the 14 sites surveyed here, eight had previous records of crayfish (according to NBDC datasets, accessed 17 July 2018). Crayfish were detected at only two of those eight sites (*i.e.* 25% of previously occupied sites) during the present survey (Appendix 3, Table A3.6). This does not mean that crayfish were not present at all sites where they were not detected during this survey; it is possible that they were present in low numbers, although it should be noted that Peay (2003) states, in relation to calculations of limits of detection for the standard survey method in rivers: "the true abundance has to be below 0.014 (1 in 71 refuges) before there is less than a 50% chance of finding a crayfish". It therefore seems likely that there has been a loss of crayfish from at least some sites at which they were previously recorded. A McNemar's test on the 2017 presence/absence data for the eight sites that had previous records of crayfish indicated a statistically significant decrease in the number of occupied sites in 2017 (Estimated Decrease = 0.750, 95% CI = 0.325–1.000, P = 0.031). However, this result should be interpreted with caution, as due to a lack of detailed past data (*e.g.* on the absence of crayfish from sites), non-random sampling and small sample sizes, along with differences in survey methods over years, it is difficult to draw definite conclusions or to calculate robust statistical trends.

3.8 Lough Gill SAC

3.8.1 Overview

Surveys were carried out between 9 August and 18 August 2017. In total, 12 sites were surveyed: three lake sites (two on Lough Gill and one on Doon Lough) and nine river sites (one on the Cartron River, four on the Bonet River, one on the Shanvaus River, two on the Owenmore River and one on the Ardakip River).

3.8.2 Range and abundance

No crayfish were detected in Lough Gill, Doon Lough, the Cartron River, the Ardakip River or the Owenmore River. Crayfish were detected in the Bonet River and in the Shanvaus River (Figure 14; Appendix 3, Table A3.7). Overall the range of crayfish within the SAC appears to be somewhat restricted; crayfish were detected along most of the length of the Bonet River and in one of the Bonet's tributaries (the Shanvaus River), but they were not detected at any of the other survey sites.

Only one of the sites where crayfish were detected (*i.e.* the Bonet River just downstream of Glenade Lough) had high abundance (based on the population abundance grades of Peay (2003)); all other sites with positive detections had low abundance, and when considering the entire SAC as a single monitoring unit, crayfish abundance in the SAC is low overall (CPUE = 0.25). The crayfish that were captured during the surveys had a good range of body sizes (Figure 15), and there were high proportions of juvenile crayfish at some sites (Appendix 3, Table A3.7); however, the sites with high proportions of juveniles were those where relatively few crayfish were detected overall, and the site with the highest abundance of crayfish had a low proportion of juveniles, with 7% of detected individuals classified as juveniles (Appendix 3, Table A3.7) which is much lower than the 40% proportion of juveniles that Peay (2003) suggested is indicative of healthy recruitment.

Crayfish were detected at only four of the 12 sites that were surveyed (*i.e.* approx. 33% of sites occupied). A simple single season model with constant probability of detection, and survey patches classified as repeat surveys (MacKenzie *et al.*, 2002) gave an estimate of occupancy probability, psi = 0.3484 (SE = 0.1426, 95% CI = 0.1351–0.6469).

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at any of the survey sites.

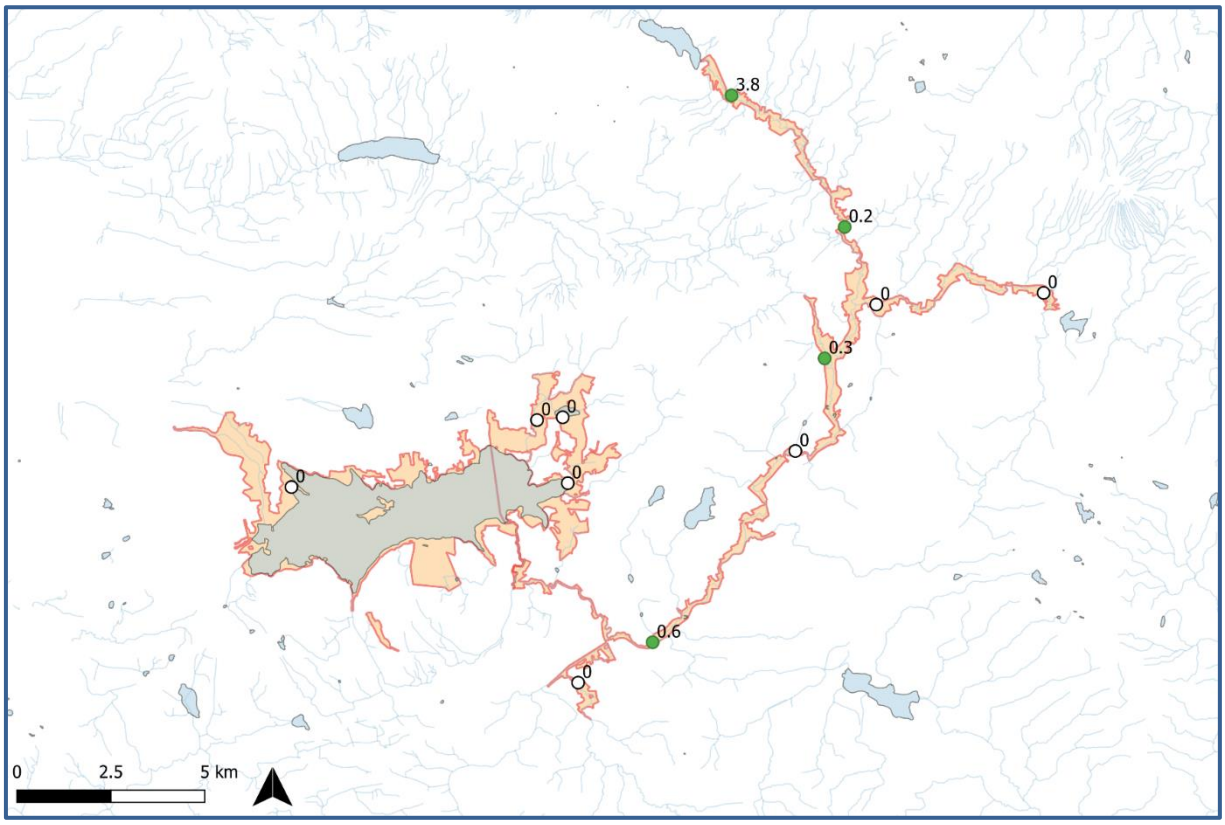

Figure 14 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in Lough Gill SAC between 9 August and 18 August 2017. Green dots signify sites where crayfish were detected, and white dots signify sites where crayfish were not detected. CPUE values are included on the map.

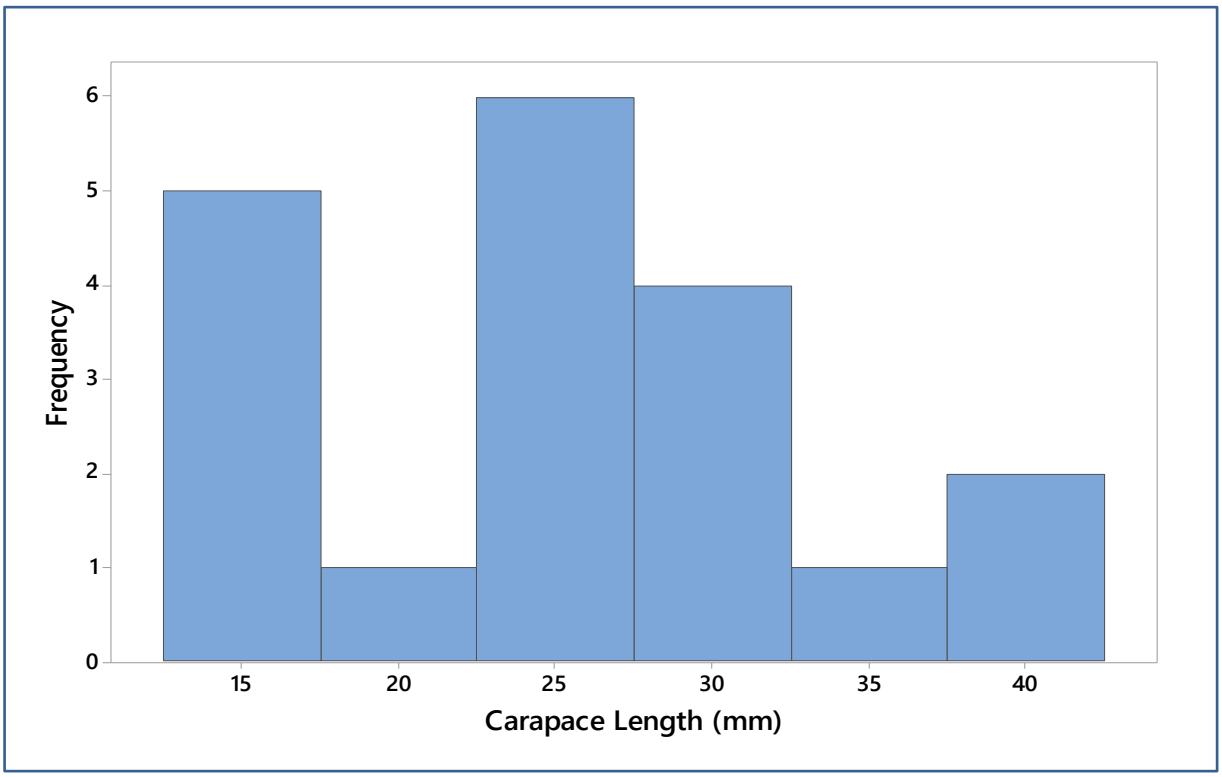

Figure 15 Frequency distribution of body size (measured as carapace length [mm]) of White-clawed Crayfish *Austropotamobius pallipes* from Lough Gill SAC (N = 19).

3.8.3 Habitat quality

Water quality was assessed based on the most up to date EPA water quality status scores for lakes and rivers (2010–2015). At eight of the sites surveyed in the SAC, water quality scores were classified as Moderate or higher, meeting the target value for crayfish sites; Lough Gill (two survey sites) is classified as Poor, as is the Cartron River survey site, while Doon Lough was not assigned a water quality status by the EPA. Considering the SAC as a whole, Lough Gill is a major part of the SAC and does not meet the water quality target value for crayfish sites. On the other hand, most of the rivers within the SAC that contain potentially suitable crayfish habitat, and which have been assigned a water quality status by the EPA, are of at least Moderate status, with the exception of most river stretches close to Lough Gill.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For Lough Gill SAC, habitat heterogeneity ranged from 0.17–0.60 (Appendix 3, Table A3.7). Mean habitat heterogeneity was 0.37 (SD = 0.11, N = 12) suggesting that, overall, there was a moderate level of habitat heterogeneity at the sites surveyed in Lough Gill SAC.

3.8.4 Assessment of trends

Of the 12 sites surveyed in Lough Gill SAC, six had previous records of crayfish (according to NBDC datasets, accessed 8 August 2018). Crayfish were detected at only three of those six sites (*i.e.* 50% of previously occupied sites) during the present survey (Appendix 3, Table A3.7). This does not mean that crayfish were not present at all sites where they were not detected during this survey; it is possible that they were present in low numbers, although it should be noted that Peay (2003) states, in relation to calculations of limits of detection for the standard survey method in rivers: "the true abundance has to below 0.014 (1 in 71 refuges) before there is less than a 50% chance of finding a crayfish". It therefore seems likely that there has been a loss of crayfish from at least some sites at which they were previously recorded. A McNemar's test on the 2017 presence/absence data for the six sites that had previous records of crayfish indicated a non-significant decrease in the number of occupied sites in 2017 (Estimated Decrease = 0.500, 95% CI = -0.067–1.000, P = 0.250). However, this result should be interpreted with caution, as due to a lack of detailed past data (*e.g.* on the absence of crayfish from sites), non-random sampling and small sample sizes, along with differences in survey methods over years, it is difficult to draw definite conclusions or to calculate robust statistical trends.

3.9 Lough Hoe Bog SAC

3.9.1 Overview

Surveys were carried out on 17 August 2017 at three sites on Lough Talt, the only waterbody within the SAC known to contain White-clawed Crayfish. Two of the survey sites were located close to each other on the south-west shore of the lake, and the other site was on the north-east shore of the lake (Figure 16).

3.9.2 Range and abundance

Crayfish were detected at all three survey sites (Figure 16; Appendix 3, Table A3.8). Lough Talt appears to hold a good population of crayfish; all three survey sites had moderate to high abundances (based on the population abundance grades of Peay (2003)), and when the results for all three sites are considered together, crayfish abundance is classified as moderate overall (CPUE = 2.93). The captured crayfish had a good range of body sizes (Figure 17). Juvenile crayfish were found in good proportions at all three survey sites, *i.e.* greater than the value of 40% that Peay (2003) suggested was indicative of healthy recruitment in a population (Figure 17; Appendix 3, Table A3.8).

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey sites.

3.9.3 Habitat quality

In the most up to date EPA water quality status scores for lakes (2010–2015) Lough Talt is classified as Good, meeting the target value for crayfish sites.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For Lough Talt, habitat heterogeneity ranged from 0.35–0.46 (Appendix 3, Table A3.8). Mean habitat heterogeneity was 0.39 (SD = 0.06, N = 3) suggesting that, overall, there was a moderate level of habitat heterogeneity at the sites surveyed in Lough Talt.

3.9.4 Assessment of trends

Because there is limited data on the crayfish population in Lough Talt it is not possible to statistically assess trends in this population over time. During surveys of Lough Talt in 2007, 47 crayfish were caught using hand searching (O'Connor *et al.*, 2009); 42 crayfish were detected in the same part of the lake (Latitude: 54.0766379, Longitude: -8.91853643) during the 2017 survey.

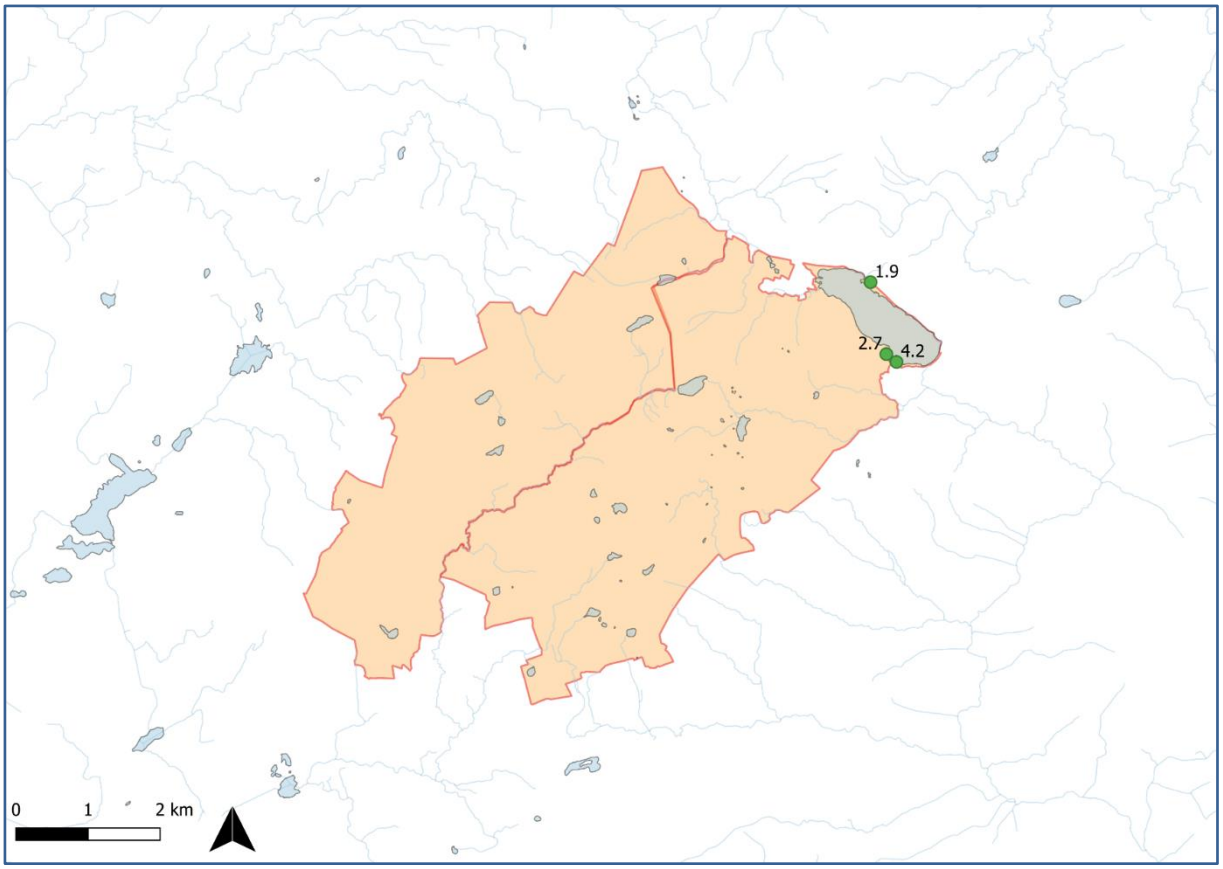

Figure 16 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in Lough Talt, within Lough Hoe Bog SAC, on 17 August 2017. The green dots signify where crayfish were detected. CPUE values are included on the map.

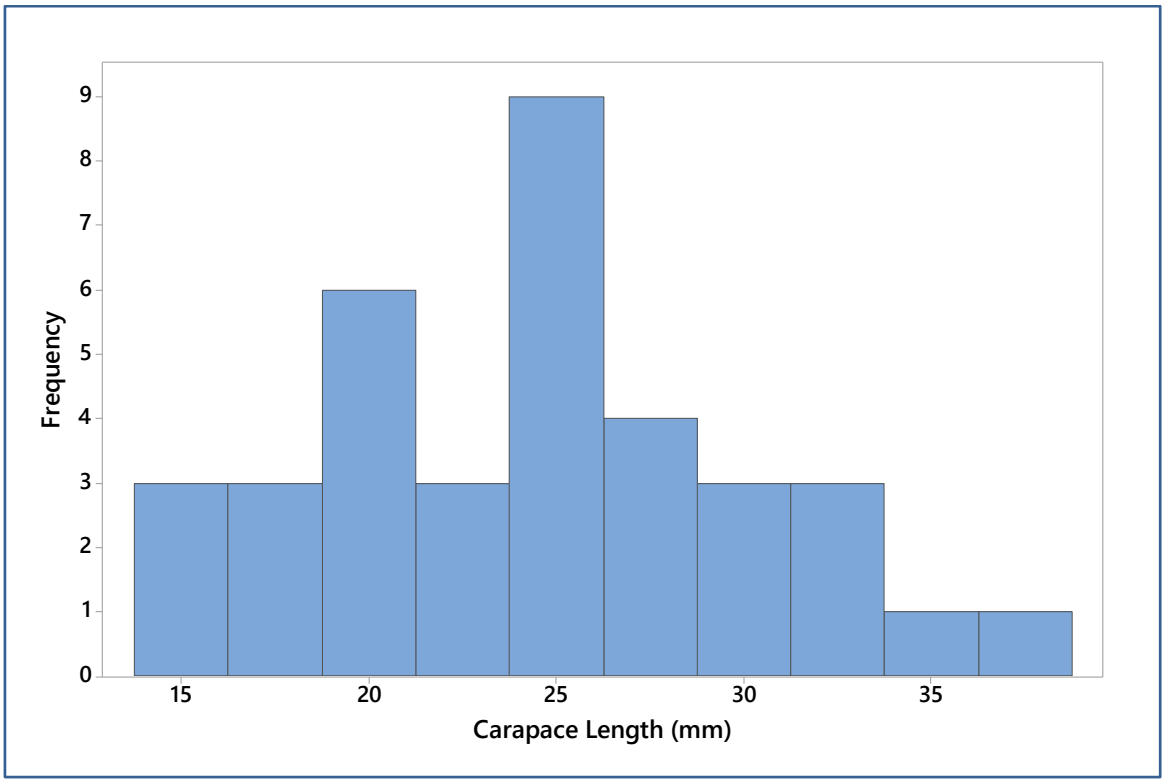

Figure 17 Frequency distribution of body size (measured as carapace length [mm]) of White-clawed Crayfish *Austropotamobius pallipes* from Lough Talt, within Lough Hoe Bog SAC (N = 36).

3.10 Lough Lene SAC

3.10.1 Overview

The survey was carried out on 14 July 2017 at three sites on Lough Lene. The crayfish population was lost from this SAC in the 1980s following a presumed outbreak of Crayfish Plague; a reintroduction was carried out and breeding was recorded in 1995, but the population did not re-establish (NPWS, 2013c).

3.10.2 Range and abundance

Crayfish were not detected at any of the survey sites on Lough Lene (Figure 18; Appendix 3, Table A3.9).

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey sites.

3.10.3 Habitat quality

In the most up to date EPA water quality status scores for lakes (2010–2015) Lough Lene is classified as High status, meeting the target value for crayfish sites.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For Lough Lene SAC, habitat heterogeneity ranged from 0.41–0.53 (Appendix 3, Table A3.9). Mean habitat heterogeneity was 0.48 (SD= 0.06, N = 3) suggesting that, overall, there was a high level of habitat heterogeneity at the sites surveyed in Lough Lene SAC.

3.10.4 Assessment of trends

Lough Lene SAC previously contained White-clawed Crayfish, but the population disappeared in the 1980s following a presumed outbreak of Crayfish Plague. Crayfish were subsequently reintroduced to Lough Lene and breeding was recorded in 1995, but the reintroduction was ultimately unsuccessful (NPWS 2013c). No crayfish were detected in Lough Lene in the 2017 survey.

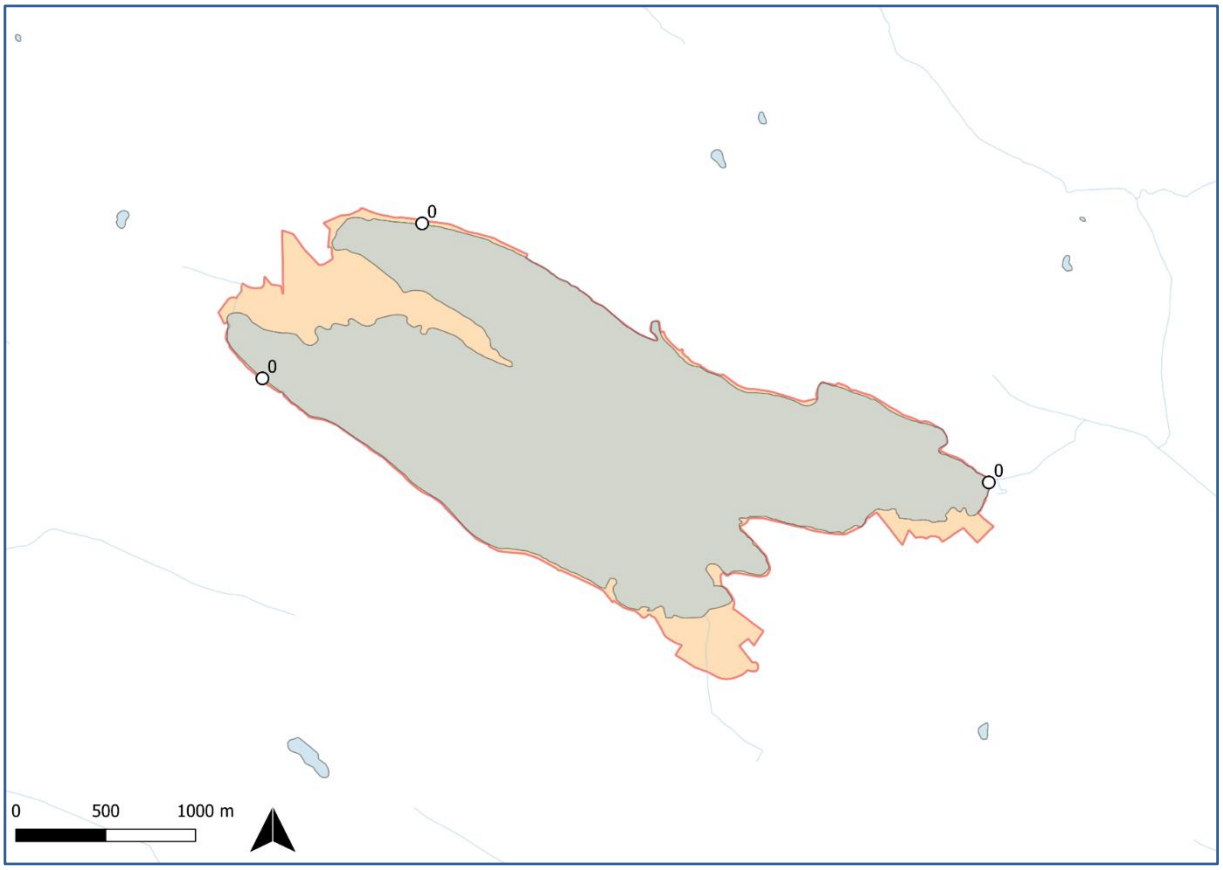

Figure 18 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in Lough Lene SAC on 14 July 2017. The white dots signify where crayfish were not detected. CPUE values are included on the map.

3.11 Lough Nageage SAC

3.11.1 Overview

Surveys were carried out on 16 August 2017 at four sites, two sites on Lough Veenagreane, and two sites on Lough Nageage (Figure 19).

3.11.2 Range and abundance

Crayfish were detected at both survey sites on Lough Veenagreane. Crayfish were not detected at either survey site on Lough Nageage (Figure 19; Appendix 3, Table A3.10). Lough Veenagreane appears to hold a relatively small population of crayfish; both survey sites had low abundance (based on the population abundance grades of Peay (2003)). Crayfish were not detected in Lough Nageage, although crayfish remains were found on a large rock at one of the survey sites in Lough Nageage (Latitude: 54.61327056; Longitude: -7.73905678). When the results for all four sites are considered together, crayfish abundance for Lough Nageage SAC is low overall (CPUE = 0.12). Some juvenile crayfish were detected in Lough Veenagreane (Appendix 3, Table A3.10) so there is currently recruitment in the lake; because so few crayfish were detected (and because some of those that were detected escaped capture) it is not possible to make an assessment on the size range of the population, and whether there is a healthy level of recruitment in the lake.

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey sites.

3.11.3 Habitat quality

In the most up to date EPA water quality status scores for lakes (2010–2015) none of the lakes in the Lough Nageage SAC was assigned a water quality status.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For Lough Nageage SAC, habitat heterogeneity ranged from 0.16–0.42, and was lower overall for the sites surveyed on Lough Nageage than for those surveyed on Lough Veenagreane (Appendix 3, Table A3.10). Mean habitat heterogeneity for Lough Nageage SAC was 0.27 (SD = 0.12, N = 4) suggesting that, overall, there was a low level of habitat heterogeneity at the sites surveyed in Lough Nageage SAC.

3.11.4 Assessment of trends

Because there are limited data on crayfish populations from Lough Nageage SAC it is not currently possible to statistically assess trends in this population over time. Low numbers of crayfish were detected in Lough Veenagreane in 2007 using hand searching during two separate surveys; 11 were detected in one survey and nine in another (O'Conner *et al.*, 2009). Low numbers of crayfish were again detected in the 2017 survey (two and five crayfish detected using hand searching at two separate sites close to the 2007 survey site). Lough Nageage was also surveyed twice in 2007 (O'Connor *et al.*, 2009); no crayfish were detected in one survey (in July), whereas six crayfish were detected in the second survey (in October), five using hand searching and one using trapping (O'Connor *et al.*, 2009). Crayfish were not detected in Lough Nageage in the 2017 survey (in August), although it should be noted that a different survey method (sweep netting) was used compared to the 2007 survey, and crayfish remains were found on a large rock at one of the survey sites in Lough Nageage so it is possible that crayfish are present in low numbers but were not detected in the 2017 survey.

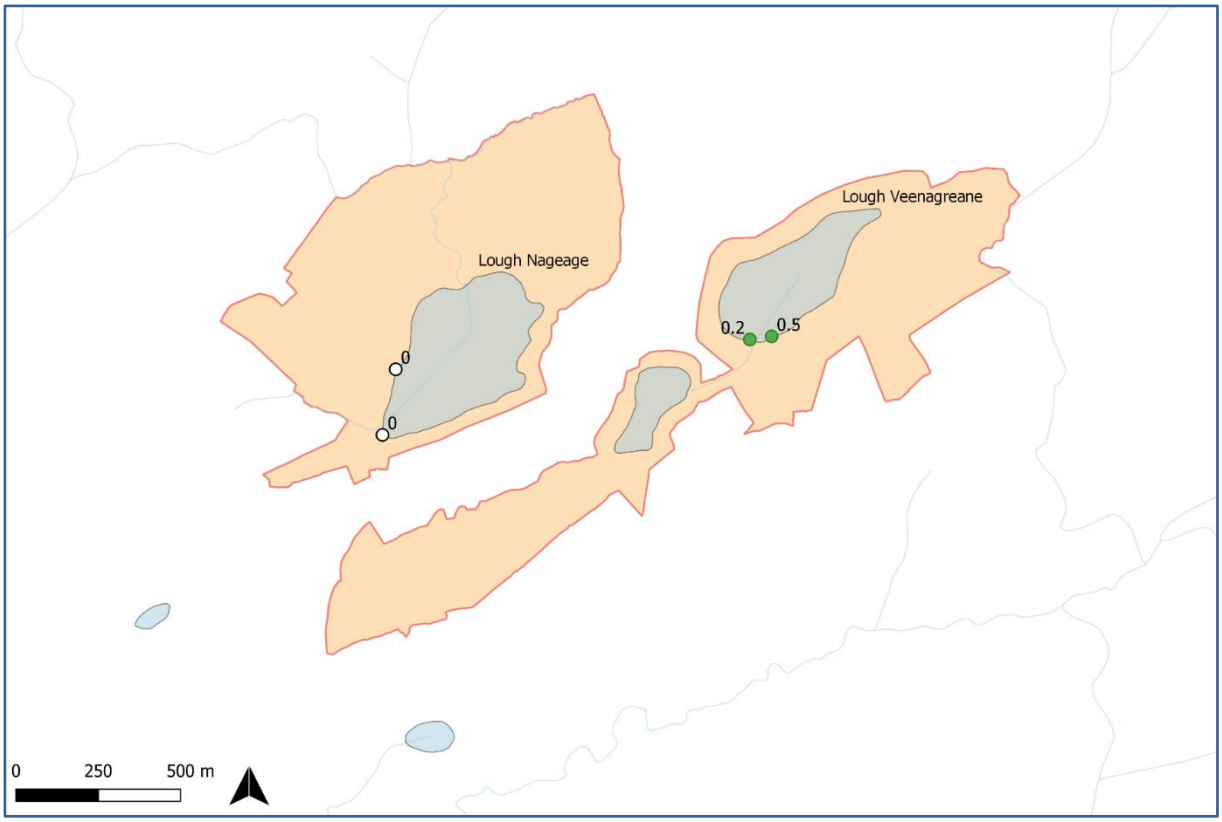

Figure 19 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in Lough Nageage SAC on 16 August 2017. Green dots signify sites where crayfish were detected, and white dots signify sites where crayfish were not detected. CPUE values are included on the map.

3.12 Lough Owel SAC

3.12.1 Overview

Surveys were carried out on 11 July 2017, at two sites on Lough Owel, one on the south shore and one on the west shore (Figure 20). A survey had also been planned for the north shore of the lake, at a site with a previous crayfish record, but permission to access the lake at the intended survey site could not be gained on the day.

3.12.2 Range and abundance

Crayfish were detected at both survey sites (Figure 20; Appendix 3, Table A3.11). Lough Owel appears to hold a very good population of crayfish; both survey sites had very high abundances (based on the population abundance grades of Peay (2003)), and when the results for both sites are considered together, crayfish abundance is very high overall (CPUE = 9.1). The captured crayfish had a good range of body sizes (Figure 21). Juvenile crayfish were found in good proportions at both survey sites, *i.e.* greater than the value of 40% that Peay (2003) suggested was indicative of healthy recruitment in a population (Figure 21; Appendix 3, Table A3.11).

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey sites.

3.12.3 Habitat quality

In the most up to date Environmental Protection Agency (EPA) water quality status scores for lakes (2010–2015) Lough Owel is classified as good quality, meeting the target value for crayfish sites. On the day of the survey, water levels in the lake were very low; this may suggest a possible issue with abstraction affecting water levels in the lake, as has been noted elsewhere (NPWS, 2018).

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For Lough Owel SAC, habitat heterogeneity ranged from 0.40–0.49 (Appendix 3, Table A3.11). Mean habitat heterogeneity was 0.45 (SD = 0.06, N = 2) suggesting that, overall, there was a high level of habitat heterogeneity at the sites surveyed in Lough Owel SAC.

3.12.4 Assessment of trends

Because there is limited data on crayfish populations at Lough Owel it is not possible to statistically assess trends in this population over time. High abundances of crayfish were detected at both survey sites on Lough Owel in the 2017 survey (Appendix 3, Table A3.11). O'Connor *et al.* (2009) reported high abundances of crayfish (50 crayfish captured using hand searching) from a site on the south shore of Lough Owel in 2007, although the grid reference given (N 3762144429) was for a site on Lough Ennell (south of Lough Owel); this incorrect grid reference is presumably an error.

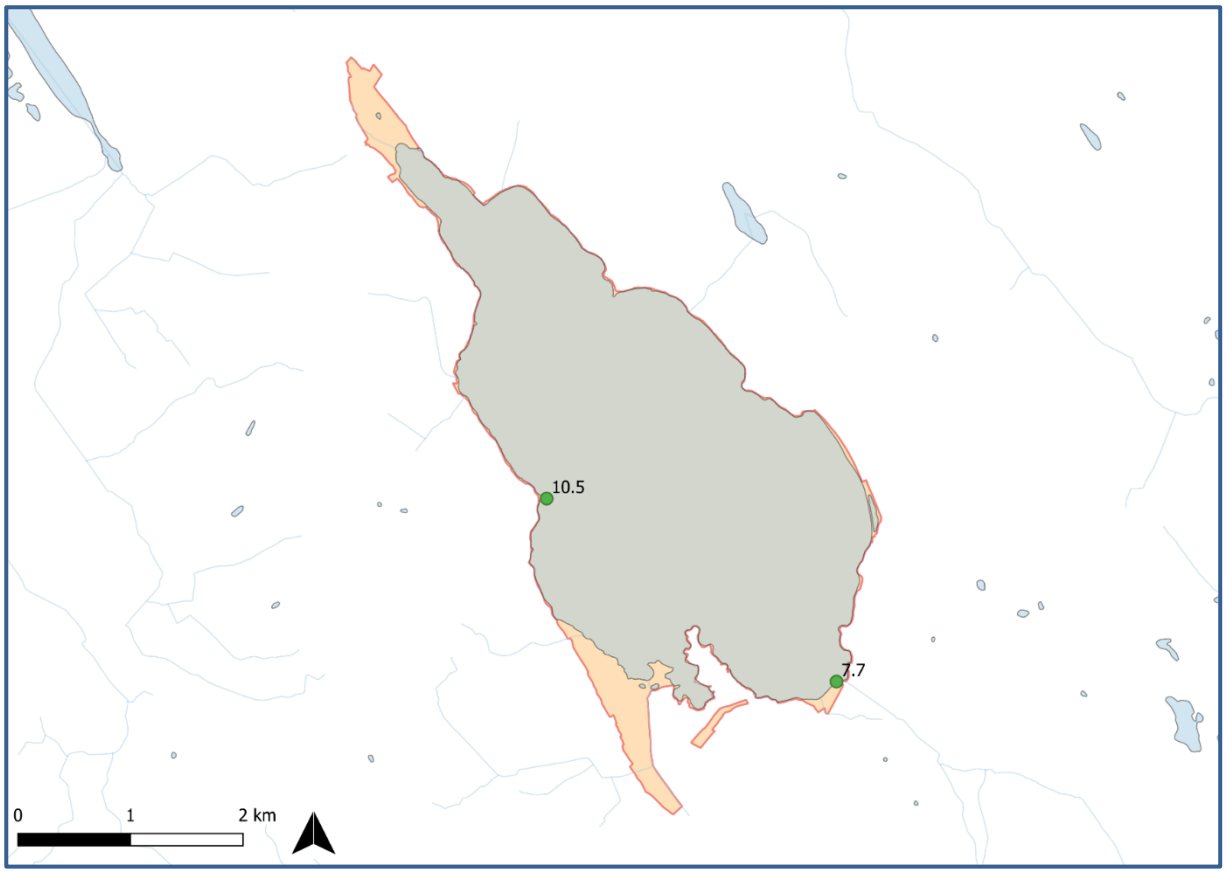

Figure 20 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in Lough Owel SAC on 11 July 2017. The green dots signify sites where crayfish were detected. The CPUE values are included on the map.

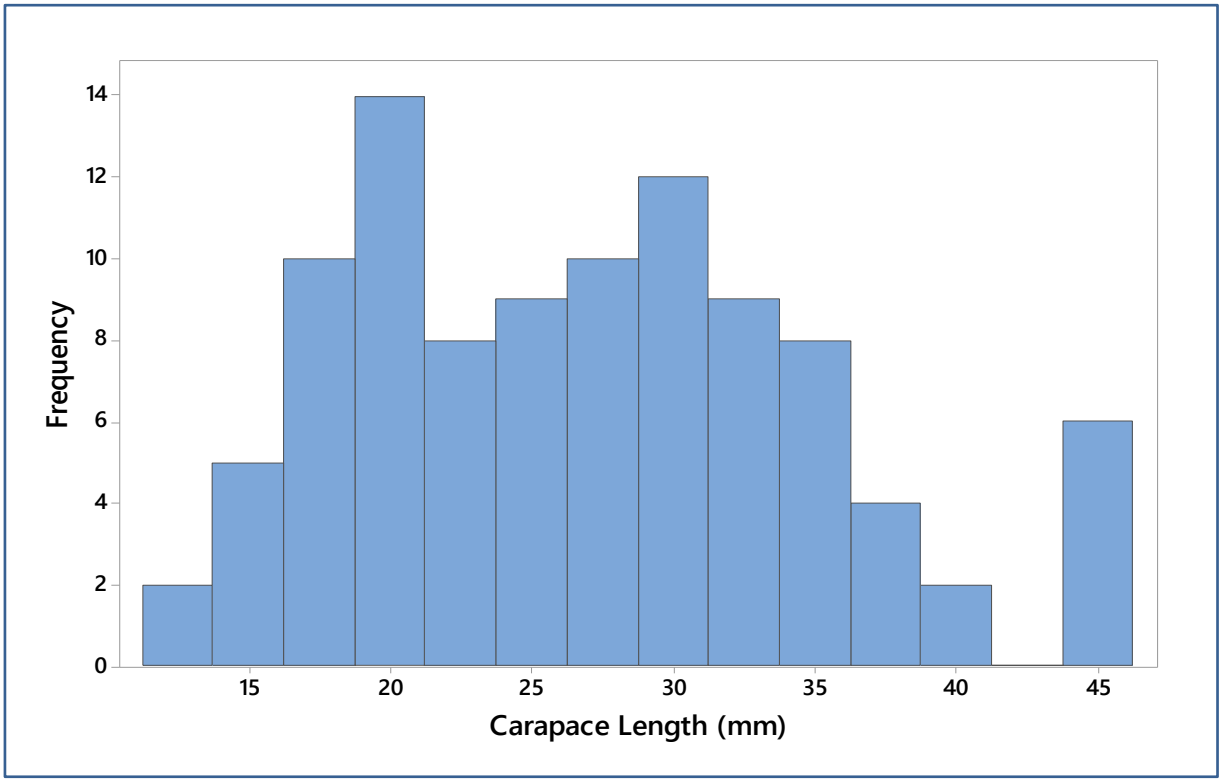

Figure 21 Frequency distribution of body size (measured as carapace length [mm]) of crayfish from Lough Owel SAC (N = 99).

3.13 Lower River Suir SAC

3.13.1 Overview

Surveys were carried out between 18 September 2017 and 21 September 2017. In total, 22 sites were surveyed: five on the River Suir, three on the Multeen, two each on the Clodiagh River, the River Aherlow and the River Tar, and one each on the Owenbeg, River Duag, River Nier, Glenary River, Clashawley River, Anner River, Lingaun River and the Clodiagh Lower River (Figure 22; Appendix 3, Table A3.12).

3.13.2 Range and abundance

Crayfish were detected at all sites surveyed on the River Suir upstream of Clonmel; they were not detected at the River Suir survey site located downstream of Clonmel (*i.e.* in the area where an outbreak of Crayfish Plague caused mass mortalities of crayfish in the River Suir in 2017, prior to this survey). Crayfish were detected at most of the survey sites on tributaries of the River Suir in the upper reaches of the Suir system, but they were not detected at some survey sites, particularly in the lower reaches/more southern sections of the SAC (Figure 22; Appendix 3, Table A3.12). Crayfish appear to be occupying their expected range within the upper reaches of the River Suir system, but are not occupying their expected range within the lower reaches of the system (cf. NPWS, 2017b). Crayfish populations from the lower reaches of the River Suir have been impacted by the outbreak of Crayfish Plague in 2017, but they were also not found in some tributaries from the lower reaches of the system from which there were previous records, *e.g.* the River Nier and the Clodiagh Lower River.

At many of the sites where crayfish were detected there are apparently healthy populations, with some sites having moderate to very high abundances (based on the population abundance grades of Peay (2003)). However, some sites also had low abundances or no detections. Some of the sites in the upper reaches of the system with no/low abundances were surveyed using the sweep netting method due to unsuitability for hand searching on the day, which may have negatively impacted detections and CPUE values (and hence abundance grades) at those sites. However, all the sites on the tributaries of the River Suir in the lower reaches of the system were surveyed using hand searching, so the absence of detections there is more likely to indicate an absence of crayfish at those sites; Peay (2003) states, in relation to calculations of limits of detection for the standard survey method in rivers: "the true abundance has to be below 0.014 (1 in 71 refuges) before there is less than a 50% chance of finding a crayfish". When considering the SAC as a single monitoring unit, crayfish abundance within the SAC is low overall (CPUE = 0.53). For those sites where crayfish were captured, there was a good range of body sizes overall (Figure 23) and juvenile crayfish (generally in good proportions, *i.e.* >0.40) were present at all sites where crayfish were detected, except for one site where only one adult crayfish was detected (Figure 23; Appendix 3, Table A3.12). However, it should be noted that some sites with high proportions of juveniles were those where relatively few crayfish were detected overall, and the site with the highest abundance of crayfish had a low proportion of juveniles, with 18% of detected individuals classified as juveniles (Appendix 3, Table A3.12) which is lower than the 40% proportion of juveniles that Peay (2003) suggested is indicative of healthy recruitment.

Crayfish were detected at 13 of the 22 sites that were surveyed (*i.e.* approx. 59% of sites occupied). A simple single season model with constant probability of detection, and survey patches classified as repeat surveys (MacKenzie *et al.*, 2002) gave an estimate of occupancy probability, psi = 0.6169 (SE = 0.1097, 95% CI = 0.3933–0.8000).

No non-indigenous crayfish species were detected during the survey. There was no evidence of Crayfish Plague at any of the survey sites on the River Suir upstream of Clonmel, or on any of the tributaries. Crayfish Plague had been confirmed from the River Suir downstream of Clonmel in 2017, prior to this survey.

3.13.3 Habitat quality

Water quality was assessed based on the most up to date EPA water quality status scores for rivers (2010–2015). At all sites surveyed in the SAC for which the EPA have assigned water quality status, water quality was classified as Moderate or higher (most were classified as Good), meeting the target value for crayfish sites. Considering the Lower River Suir SAC as a whole, all stretches of the River Suir and of the major River Suir tributaries for which the EPA have assigned water quality status scores were classified as Moderate or higher, and most stretches were classified as Good.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For the Lower River Suir SAC, habitat heterogeneity ranged from 0.08–0.67 (Appendix 3, Table A3.12). Mean habitat heterogeneity was 0.45 (SD = 0.13, N = 21) suggesting that, overall, there was a high level of habitat heterogeneity at the sites surveyed in the Lower River Suir SAC.

3.13.4 Assessment of trends

Of the 22 sites surveyed in the Lower River Suir SAC, 15 had previous records of crayfish (according to NBDC datasets, accessed 9 August 2018). Crayfish were detected at 12 of those 15 sites (*i.e.* 80% of previously occupied sites) during the present survey (Appendix 3, Table A3.12). A McNemar's test on the 2017 presence/absence data for the 15 sites that had previous records of crayfish indicated no statistically significant decrease in the number of occupied sites in 2017 (Estimated Decrease = 0.200, 95% CI = –0.069–0.469, P = 0.250). However, this result should be interpreted with caution, as due to a lack of detailed past data (*e.g.* on the absence of crayfish from sites), non-random sampling and small sample sizes, along with differences in survey methods over years, it is difficult to draw definite conclusions or to calculate robust statistical trends.

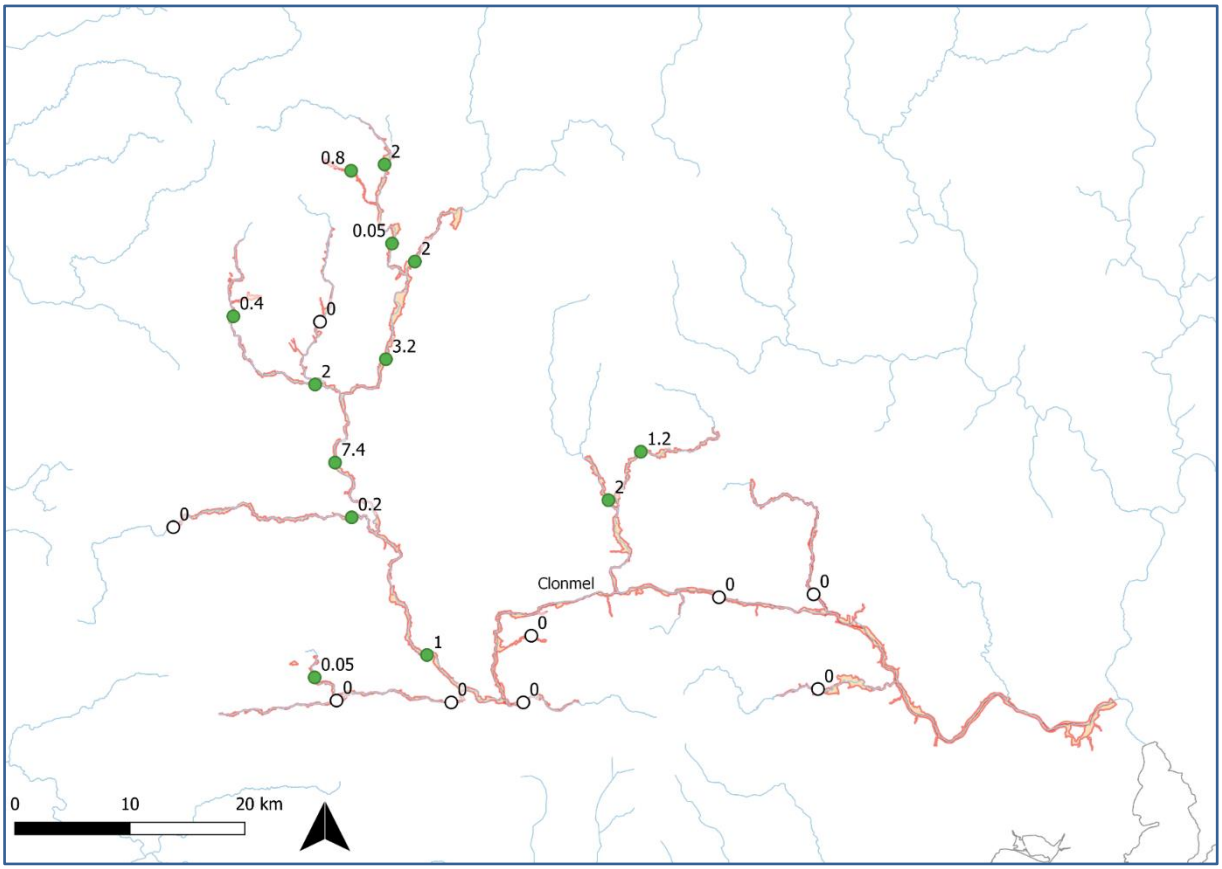

Figure 22 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in the Lower River Suir SAC between 18 September and 21 September 2017. Green dots signify sites where crayfish were detected, and white dots signify sites where crayfish were not detected. CPUE values are included on the map.

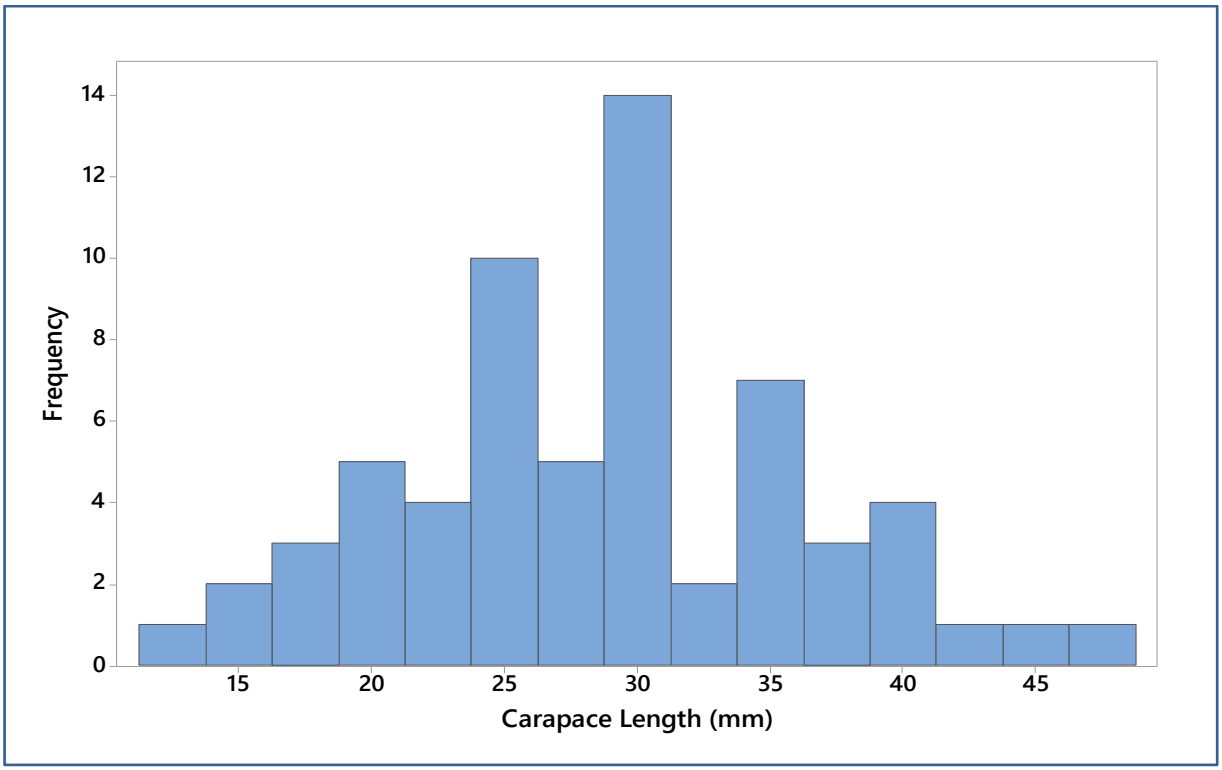

Figure 23 Frequency distribution of body size (measured as carapace length [mm]) of White-clawed Crayfish *Austropotamobius pallipes* from all sites in the Lower River Suir SAC (N = 63).

3.14 River Barrow and River Nore SAC

3.14.1 Overview

Surveys were carried out between 4 September and 7 September 2017. In total, 23 sites were surveyed: 12 on the River Barrow system (four on the River Barrow and one each on the Glenlahan River, Owenass River, Stradbally River, Tully Stream, Lerr River, Fushoge River, Madlin River and Ballyroughan River) and 11 on the River Nore system (two on the Dinin River and one each on the Delour River, Mountrath River, Erkina River, River Goul, Owenbeg River, Pococke River, Munster River, King's River and River Glory) (Figure 24; Appendix 3, Table A3.13). No surveys were carried out on the River Nore; surveys had been planned for the River Nore, but the selected sites were not surveyed due to high flows and access difficulties on the survey days.

3.14.2 Range and abundance

Crayfish were detected at almost all survey sites in the upper reaches of the River Barrow system. Due to an outbreak of Crayfish Plague in the lower reaches of the River Barrow (south of Carlow) in 2017, only a small number of surveys were carried out in this section of the SAC. Crayfish were not detected at two sites on tributaries of the River Barrow in this section. One live crayfish, as well as one recently dead and one decomposed specimen, were found in the River Barrow at Graiguenamanagh. Crayfish were detected at very few sites in the River Nore system (Figure 24; Appendix 3, Table A3.13). Crayfish appear to be occupying their expected range within the upper reaches of the River Barrow system, but are not occupying their expected range within the lower reaches of the River Barrow system or within the River Nore system (see NPWS, 2011). Crayfish populations from the lower reaches of the River Barrow have been negatively impacted by the outbreak of Crayfish Plague in 2017, but their absence from many of the survey sites in the River Nore system for which there were previous records is unexplained; it should also be noted that compared to the River Barrow system, previous crayfish records for the River Nore system are generally not as recent (Appendix 3, Table A3.13), suggesting that crayfish may have been lost from many sites on the River Nore system a number of years ago. Furthermore, although the River Nore was not surveyed during the 2017 survey, the most recent previous crayfish record for any site on the River Nore within the SAC is from 2001, according to NBDC datasets (accessed 20 August 2018), supporting the view that there was a decline in crayfish populations in the River Nore system a number of years ago.

At all the positive sites for crayfish within the SAC, crayfish were only detected in low to moderate abundances (based on the population abundance grades of Peay (2003)). All of the sites in the upper reaches of the River Barrow were surveyed using the sweep netting method due to unsuitability for hand searching on the day, which may have negatively impacted detections and CPUE values (and hence abundance grades) at those sites. However, the majority of sites on the tributaries of the River Barrow and the River Nore were surveyed using hand searching, so low abundances at those sites are more likely to indicate relatively small populations of crayfish, and non-detections are more likely to indicate absence of crayfish; Peay (2003) states, in relation to calculations of limits of detection for the standard survey method in rivers: "the true abundance has to be below 0.014 (1 in 71 refuges) before there is less than a 50% chance of finding a crayfish". When considering the SAC as a single monitoring unit, crayfish abundance within the SAC is low overall (CPUE = 0.30).

For those sites on the upper reaches of the River Barrow system (*i.e.* from the Glenlahan River at the north end of the system, as far south as the Fushoge River site) where crayfish were detected, there was a good range of body sizes overall (Figure 25) and juvenile crayfish (generally in good proportions, *i.e.* >0.40) were present at all sites where crayfish were detected, except for one site where only one adult crayfish was detected (Figure 25; Appendix 3, Table A3.13).

Crayfish were detected at 12 of the 23 sites that were surveyed (*i.e.* approx. 52% of sites occupied). A simple single season model with constant probability of detection, and survey patches classified as

repeat surveys (MacKenzie *et al*., 2002) gave an estimate of occupancy probability, psi = 0.5594 (SE = 0.1132, 95% CI = 0.3404–0.7576).

No non-indigenous crayfish species were detected during the survey. There was no evidence of Crayfish Plague at any of the survey sites on the River Barrow upstream of Carlow, on any of the tributaries of the River Barrow, or at any of the survey sites on the River Nore system. Crayfish plague had been confirmed from the River Barrow downstream of Carlow in 2017, prior to this survey.

3.14.3 Habitat quality

Water quality was assessed based on the most up to date EPA water quality status scores for rivers (2010–2015). At most of the sites surveyed in the SAC for which the EPA have assigned a water quality status, water quality was classified as Moderate or higher, meeting the target value for crayfish sites; some of the survey sites were classified as Poor, failing to meet the target value for crayfish sites (Appendix 3, Table A3.13). Considering the River Barrow and River Nore SAC as a whole, most stretches of the upper River Barrow for which the EPA have assigned a water quality status were classified as Moderate or higher, apart from the River Barrow north of Monasterevin which was classified as Poor. In the lower stretches of the River Barrow, there are substantial sections of the river between Bagenalstown and Graiguenamanagh that are classified as Poor. The major River Barrow tributaries within the SAC for which the EPA have assigned a water quality status were classified as Moderate or higher, apart from a section of the River Lerr at Castledermot, which was classified as Poor. Most stretches of the River Nore for which the EPA have assigned a water quality status were classified as Moderate or higher, apart from the Pococke River, near Kilkenny, which was classified as Poor.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For the River Barrow and River Nore SAC, habitat heterogeneity ranged from 0.08–0.67 (Appendix 3, Table A3.13). Mean habitat heterogeneity was 0.39 (SD= 0.15, N = 22) suggesting that, overall, there was a moderate level of habitat heterogeneity at the sites surveyed in the River Barrow and River Nore SAC.

3.14.4 Assessment of trends

Of the 23 sites surveyed in the River Barrow and River Nore SAC, 16 had previous records of crayfish (according to NBDC datasets, accessed 18 August 2018). Crayfish were detected at eight of those 16 sites (*i.e.* 50% of previously occupied sites) during the present survey (Appendix 3, Table A3.13). A McNemar's test on the 2017 presence/absence data for the 16 sites that had previous records of crayfish indicated a statistically significant decrease in the number of occupied sites in 2017 (Estimated Decrease = 0.500, 95% CI = 0.193–0.807, P = 0.008). However, this result should be interpreted with caution, as due to a lack of detailed past data (*e.g.* on the absence of crayfish from sites), non-random sampling and small sample sizes, along with differences in survey methods over years, it is difficult to draw definite conclusions or to calculate robust statistical trends.

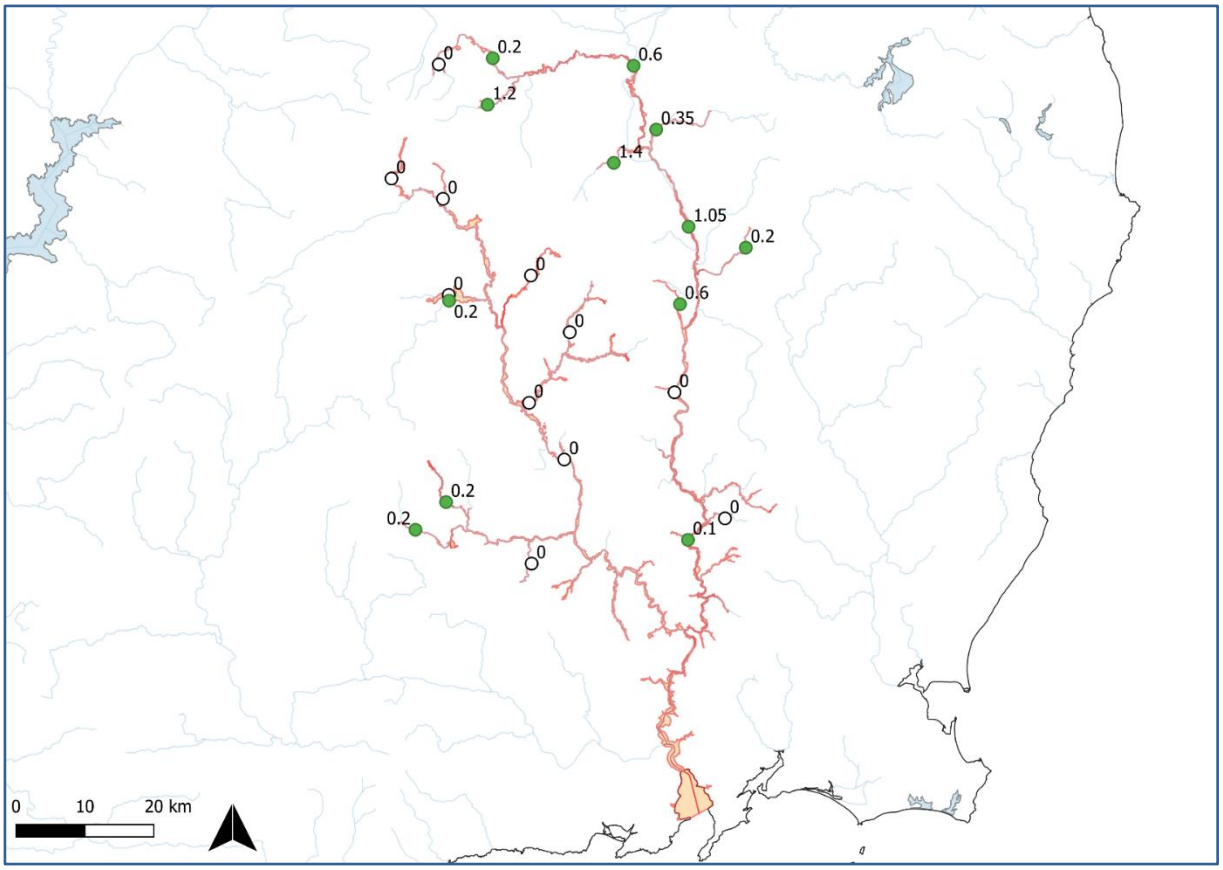

Figure 24 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in the River Barrow and River Nore SAC between 4 September and 7 September 2017. Green dots signify sites where crayfish were detected, and white dots signify sites where crayfish were not detected. CPUE values are included on the map.

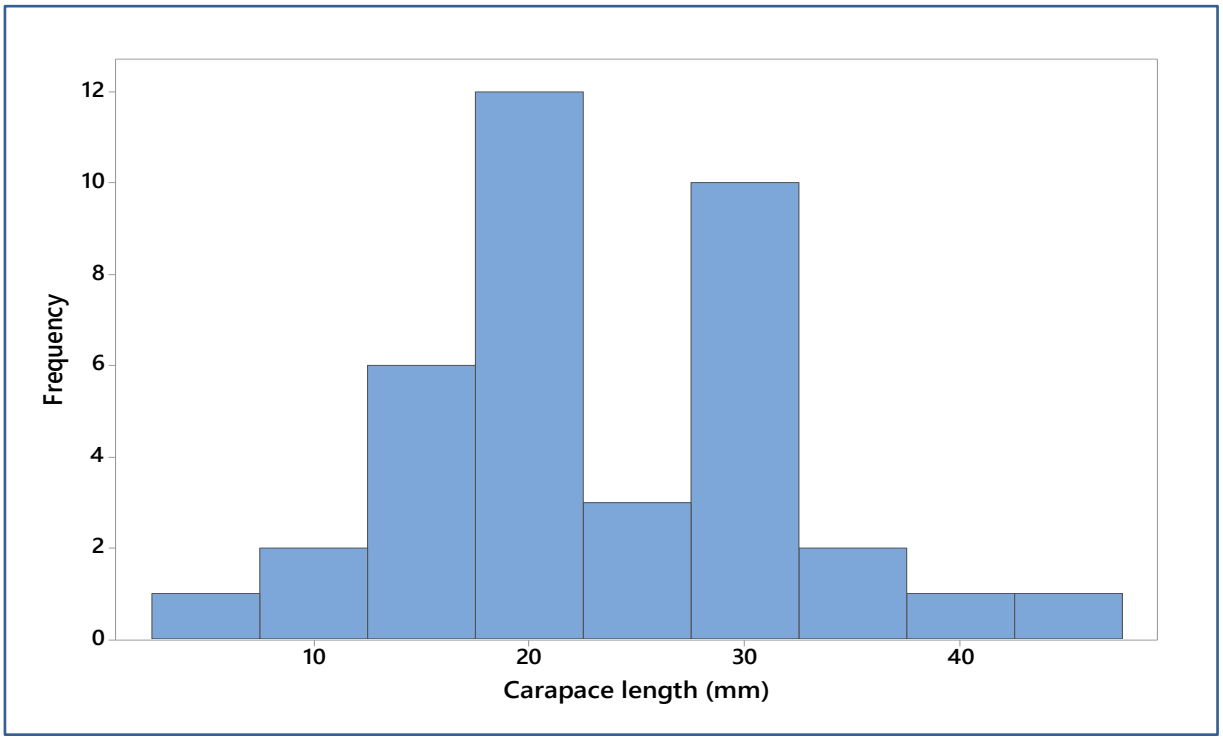

Figure 25 Frequency distribution of body size (measured as carapace length [mm]) of White-clawed Crayfish *Austropotamobius pallipes* from the upper, northern, reaches of the River Barrow system from the Glenlahan River as far south as the Fushoge River (N = 38).

3.15 River Moy SAC

3.15.1 Overview

Surveys were carried out between 26 July and 2 August 2017. In total, 21 sites were surveyed: one survey site each on the Rathnamagh River, Rappa Stream, Deel River, Toreen River, Fiddaunglass, Addergoole River, Tobergal River, Clydagh River, Meander River, Manulla River, Cloonlavis Stream, Geestaun River, Glore River, Trimoge River, Gweestion River, Killeen River. Spaddagh River, Mullaghanoe River, Owenlobnaglaur River, Owenaher River and the River Moy (Figure 26; Appendix 3, Table A3.14).

3.15.2 Range and abundance

Crayfish were detected at most of the survey sites in the rivers feeding Lough Conn in the north-west part of the SAC, and they were detected at some survey sites in rivers feeding Lough Cullin and in tributaries of the River Moy in the southern part of the SAC, but crayfish were not detected in survey sites on rivers in the eastern part of the SAC (Figure 26; Appendix 3, Table A3.14). Crayfish appear to be occupying their expected range in the northern part of the SAC, but do not appear to be fully occupying their expected range in the southern and the eastern part of the SAC (NPWS, 2016). Although only four sites in the eastern part of the SAC were visited during the 2017 survey, no crayfish were detected at any of those sites (Figure 26), and there are very few recent crayfish records for any site in the eastern part of the SAC according to NBDC datasets (accessed 21 August 2018). The most recent previous record for most of the sites in the eastern part of the SAC (out of 14 sites for which there are records in the NBDC datasets) is 1998, with the exception of two sites near the boundary of the SAC: one on the Lough Talt River (from 2013) and one on the Sonnagh River (from 2016); this suggests that the crayfish population in the eastern part of the SAC has been in decline for a number of years.

At some of the sites where crayfish were detected, abundances were low (based on the population abundance grades of Peay (2003)) but other sites had apparently healthy populations, with abundances ranging from moderate to very high (Appendix 3, Table A3.14), with a good range of body sizes (Figure 27) and the presence of high proportions of juvenile crayfish in those populations (Figure 27; Appendix 3, Table A3.14). However, when considering the SAC as a single monitoring unit, crayfish abundance within the SAC is low overall (CPUE = 0.79).

Crayfish were detected at nine of the 21 sites that were surveyed (*i.e.* approx. 43% of sites occupied). A simple single season model with constant probability of detection, and survey patches classified as repeat surveys (MacKenzie *et al*., 2002) gave an estimate of occupancy probability, psi = 0.4301 (SE = 0.1084, 95% CI = 0.2408–0.6422).

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey sites.

3.15.3 Habitat quality

Water quality was assessed based on the most up to date EPA water quality status scores for rivers (2010–2015). At all the sites surveyed in the SAC for which the EPA have assigned a water quality status, water quality was classified as Moderate or higher, meeting the target value for crayfish sites (Appendix 3, Table A3.14). Considering the River Moy SAC as a whole, the majority of river stretches within the SAC, for which the EPA have assigned a water quality status, were classified as Moderate or higher; the single exception was a small stretch of the Mullaghanoe River at Charlestown which was classified as Poor.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For the River Moy SAC, habitat heterogeneity ranged from 0.08–0.68 (Appendix 3, Table A3.14).

Mean habitat heterogeneity was 0.44 (SD= 0.15, N = 21) suggesting that, overall, there was a high level of habitat heterogeneity at the sites surveyed in the River Moy SAC.

3.15.4 Assessment of trends

Of the 21 sites surveyed in the River Moy SAC, 13 had previous records of crayfish (according to NBDC datasets, accessed 21 August 2018). Crayfish were detected at five of those 13 sites (*i.e.* approximately 38% of previously occupied sites) during the present survey (Appendix 3, Table A3.14). A McNemar's test on the 2017 presence/absence data for the 13 sites that had previous records of crayfish indicated a statistically significant decrease in the number of occupied sites in 2017 (Estimated Decrease = 0.615, 95% CI = 0.274–0.957, P = 0.008). However, this result should be interpreted with caution, as due to a lack of detailed past data (*e.g.* on the absence of crayfish from sites), non-random sampling and small sample sizes, along with differences in survey methods over years, it is difficult to draw definite conclusions or to calculate robust statistical trends.

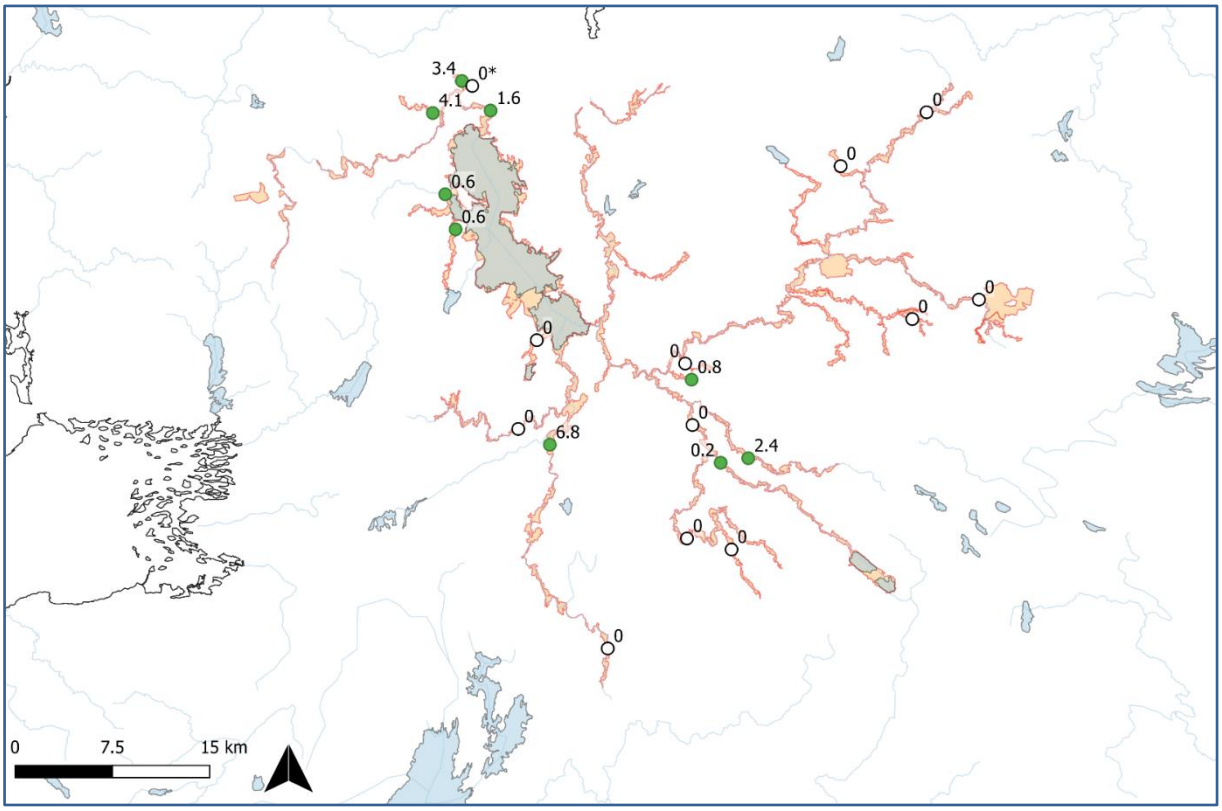

Figure 26 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in the River Moy SAC between 26 July and 2 August 2017. Green dots signify sites where crayfish were detected, and white dots signify sites where crayfish were not detected (the asterisk signifies a site where no crayfish were detected, but a crayfish moult was found during the survey). CPUE values are included on the map.

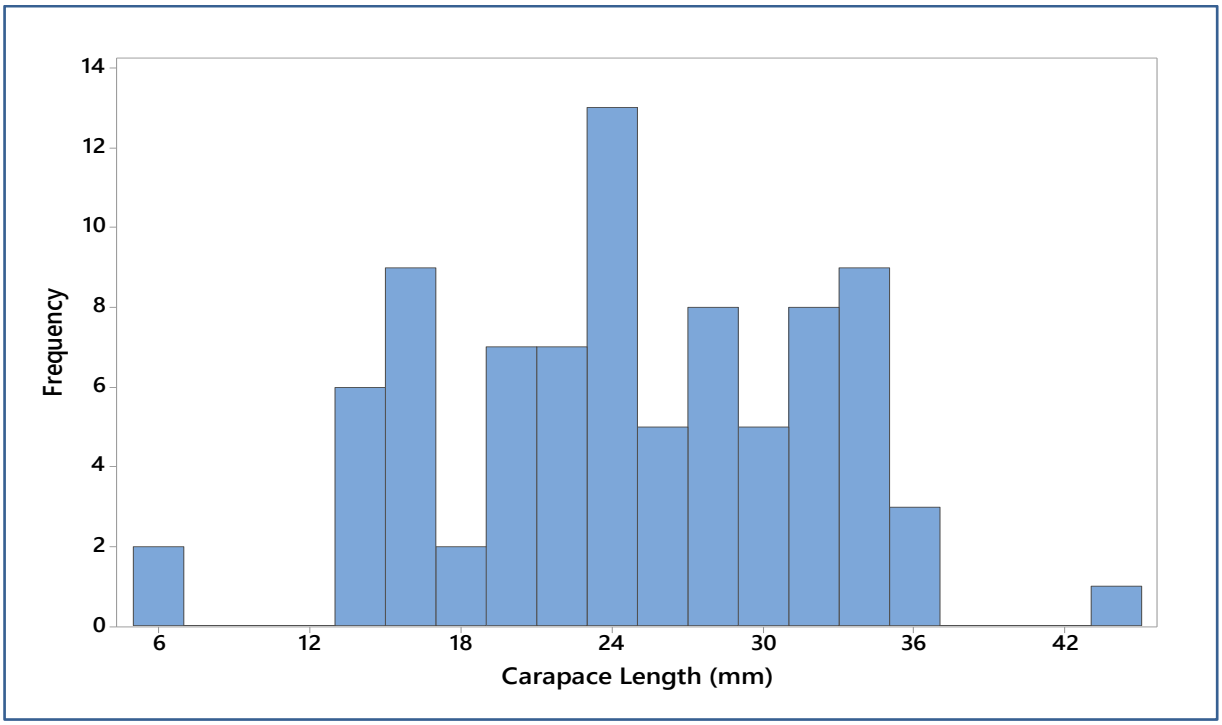

Figure 27 Frequency distribution of body size (carapace length in mm) of White-clawed Crayfish *Austropotamobius pallipes* from survey sites within the River Moy SAC with moderate to very high abundances, *i.e.* the survey sites on the Rathnamagh, Deel, Toreen, Manulla and Trimoge Rivers (N = 85).

3.16 White Lough, Ben Loughs and Lough Doo SAC

3.16.1 Overview

Surveys were carried out on 20 July 2017 at three sites, two sites on White Lough, and one site on Lough Doo (Figure 28). A survey had also been planned for Ben Lough, but suitable access to the lake could not be found on the day.

3.16.2 Range and abundance

Crayfish were detected at both survey sites on White Lough and at the survey site on Lough Doo (Figure 28; Appendix 3, Table A3.15). White Lough appears to hold a relatively good population of crayfish; one survey site had very high abundance, and one had low abundance (based on the population abundance grades of Peay (2003)). When the result of both sites on White Lough are considered together, crayfish abundance is moderate overall (CPUE = 1.43). When the results for all three sites (including the site on Lough Doo) are considered together, crayfish abundance for the SAC is low overall (CPUE = 0.79); it should however be noted that the two sites with low abundance were surveyed using the sweep netting method due to unsuitability for hand searching, which may have negatively impacted CPUE values (and hence abundance grades). A majority of the captured crayfish were juveniles (Figure 29; Appendix 3, Table A3.15). The high proportion of juvenile crayfish (>96% at both sites on White Lough; only one crayfish, a juvenile, was detected in Lough Doo) suggests a healthy level of recruitment in the SAC, although it should be noted that this high proportion may also be a reflection of the survey conditions. Sweep netting was used at two sites, which is likely to result in the capture of a higher proportion of smaller individuals, and only three patches (instead of the usual 10) were surveyed using hand searching at one site on White Lough, due to a lack of refuges at the survey site.

No non-indigenous crayfish species were detected during the survey, and there was no evidence of Crayfish Plague at the survey sites.

3.16.3 Habitat quality

In the most up to date EPA water quality status scores for lakes (2010–2015) White Lough, is classified as Good, meeting the target value for crayfish sites. It should be noted that on the day of the survey, water levels in the lake were low, resulting in dense charophyte beds being exposed; this may suggest a possible water quality problem in relation to water levels in the lake. Other lakes within the SAC, including Lough Doo and Ben Lough, have not been assigned a water quality status by the EPA.

A simple measure of habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. For White Lough, Ben Loughs and Lough Doo SAC, habitat heterogeneity ranged from 0.15–0.38 (Appendix 3, Table A3.15). Mean habitat heterogeneity was 0.28 (SD = 0.12, N = 3) suggesting that, overall, there was a low level of habitat heterogeneity at the sites surveyed in White Lough, Ben Loughs and Lough Doo SAC.

3.16.4 Assessment of trends

Because there is limited data on crayfish populations from White Lough, Ben Loughs and Lough Doo SAC it is not currently possible to statistically assess trends in this population over time. Low numbers of crayfish (a total of two using hand searching) were detected at one site in White Lough in 2007 (O'Connor *et al.*, 2009); higher numbers (a total of 24 using hand searching) were detected in this same area (west shore) of the lake in the 2017 survey. A total of nine crayfish were detected at a second site (south shore of the lake) in White Lough in the 2017 survey; no crayfish were detected in this area of the lake in 2007 using hand searching (O'Connor *et al.*, 2009).

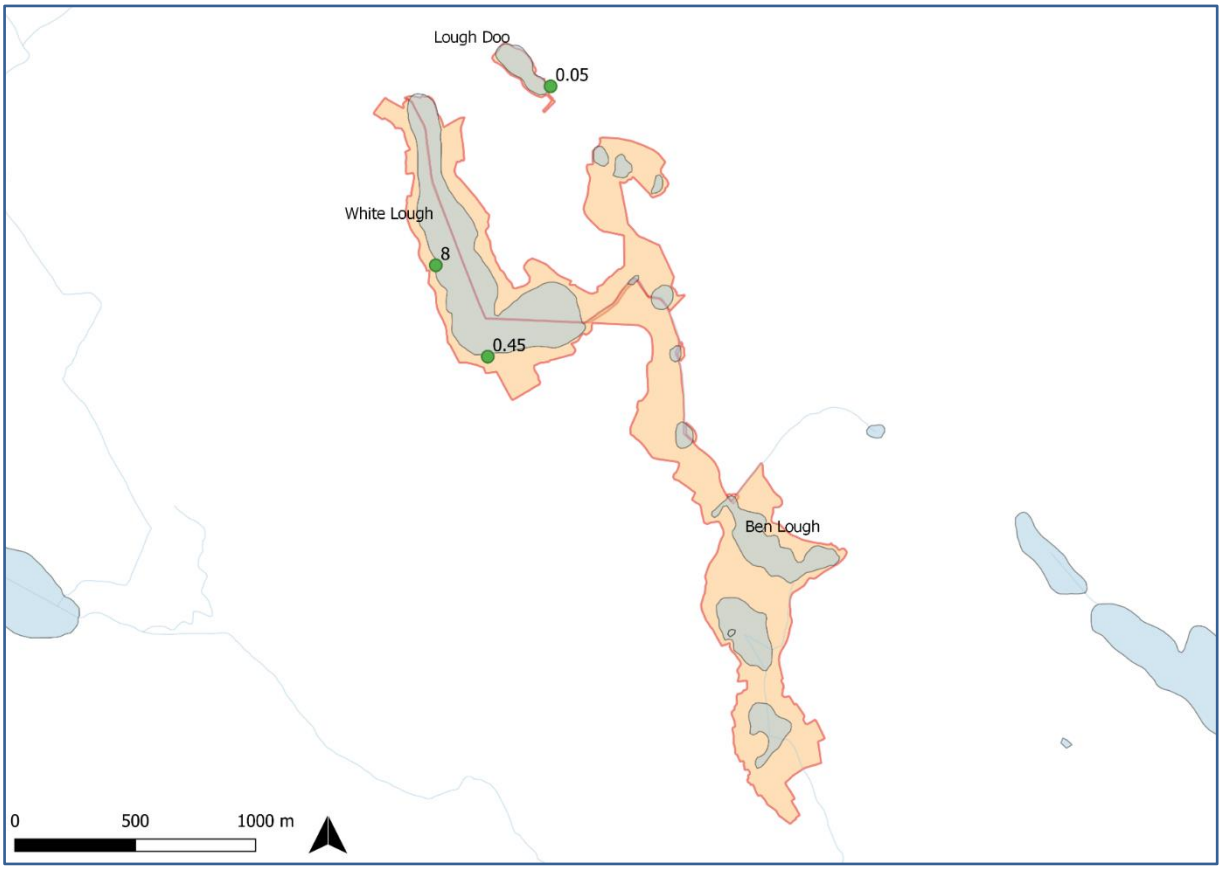

Figure 28 Sites surveyed for White-clawed Crayfish *Austropotamobius pallipes* in White Lough, Ben Loughs and Lough Doo SAC on 20 July 2017. Green dots signify sites where crayfish were detected. CPUE values are included on the map.

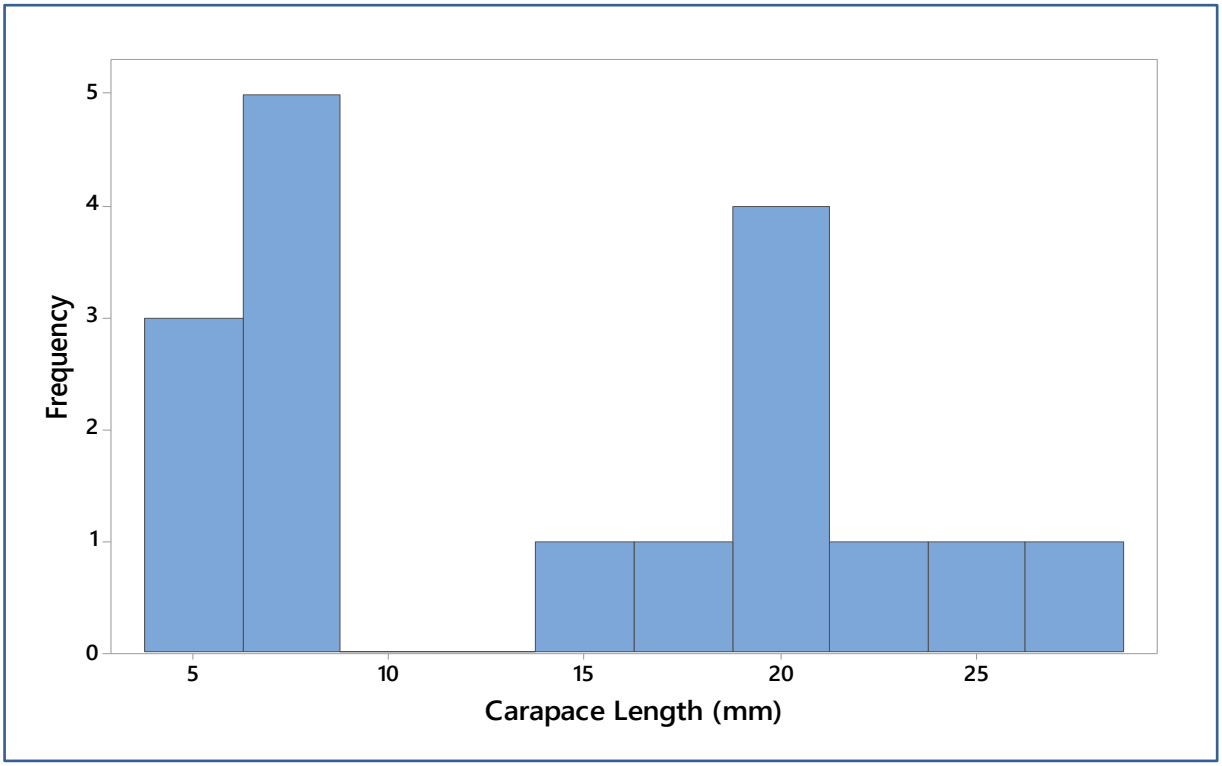

Figure 29 Frequency distribution of body size (measured as carapace length in mm) of White-clawed Crayfish *Austropotamobius pallipes* from White Lough, Ben Loughs and Lough Doo SAC (N = 17).

3.17 Summary results for all 15 SACs

3.17.1 Crayfish abundance, range and populations trends

Abundance estimates for each SAC are presented in Table 4, including CPUE values (calculated as the number of crayfish detected, divided by the number of patches surveyed) and their equivalent population abundance grades (as proposed by Peay (2003), also see Table 1). Calculations were carried out for each SAC in two ways: (i) using data from all surveys conducted in the SAC, and (ii) using data from only those surveys in which the hand search method was used, because that is the survey method for which Peay (2003) proposed the population abundance grades. In most cases, the population abundance grade calculated using either of these approaches was the same, although there were some exceptions where the abundance grade increased when only data from hand search surveys were used (Table 4); this was mainly due to a higher proportion of sweep net survey data being eliminated from the calculations. When all survey sites/methods were included in the calculations, most SACs were assigned a population abundance grade of Low. When only hand search surveys were used, some of those Low grades increased to Moderate, and in one case (White Lough, Ben Loughs and Lough Doo SAC) the abundance grade increased to Very High (this result is considered below). Also, crayfish were not detected in two SACs, and these were assigned a population abundance grade of Absent/Undetected (Table 4); these were the SACs from which crayfish populations disappeared in the 1980s following presumed outbreaks of Crayfish Plague (NPWS 2013b, c).

Overall, crayfish abundance within the 15 SACs was generally Low to Moderate; the two exceptions to this are the Bricklieve Mountains and Keishcorran SAC (specifically Lough Labe within that SAC), and Lough Owel SAC, which were both assigned a population abundance grade of Very High, although it should be noted that in both cases this grade was based on a small number of surveys. White Lough, Ben Loughs and Lough Doo SAC was also assigned a population abundance grade of Very High when only data from hand searches were used, but this Very High grade was based on a restricted hand search (three patches only, instead of the usual 10) at one site. Moreover, it should be noted that sample size (*i.e.* the number of sites/patches surveyed) in some SACs is low, and that it may not be entirely appropriate to combine data from different survey sites within one SAC, so results should be interpreted with some caution. That said, when all of these results are considered, the SACs with the highest crayfish population abundances appear to be the Bricklieve Mountains and Keishcorran SAC, and Lough Owel SAC, while the SACs with the lowest population abundances appear to be Lough Corrib SAC, Lough Gill SAC, Lough Nageage SAC and the River Barrow and River Nore SAC.

Results on the range of the crayfish populations within each SAC are also presented in Table 4; this includes an assessment of whether crayfish were occupying their expected range within each SAC. For three SACs this was difficult to determine due to limited data, and the assessment of whether crayfish were occupying their expected range was classified as Uncertain. For six SACs, crayfish were considered to be occupying their expected range within the SAC, although for some of those SACs the assessment was based on small sample sizes so should be interpreted with caution. For six SACs, crayfish were considered not to be occupying their expected range within the SAC. In Lough Corrib SAC, crayfish were found at only 29% of survey sites (N=14), and there was a statistically significant 75% estimated decline in their range. In the River Moy SAC, crayfish were found at only 43% of survey sites (N=21), and there was a statistically significant 62% estimated decline in their range. In the River Barrow and River Nore SAC, crayfish were found at only 52% of survey sites (N=23), and there was a statistically significant 50% estimated decline in their range; crayfish populations were also lost from some parts of their expected range within this SAC due to an outbreak of Crayfish Plague in 2017. In the Lower River Suir SAC, crayfish were considered not to be occupying their expected range within the SAC because crayfish populations were also lost from some parts of this SAC due to an outbreak of Crayfish Plague in 2017. Crayfish were considered not to be occupying their expected range within Lough Bane and Lough Glass SAC, and within Lough Lene SAC, as these were the SACs from which crayfish

populations disappeared in the 1980s following presumed outbreaks of Crayfish Plague (NPWS, 2013b, c).

When the results from all SACs are considered together, crayfish were detected at 65 of the 123 sites surveyed (*i.e.* approx. 53% of sites occupied). A simple single season model with constant probability of detection, and survey patches classified as repeat surveys (MacKenzie *et al.*, 2002) gave an estimate of occupancy probability, psi = 0.5368 (SE = 0.0457, 95% CI = 0.4469–0.6243). A similar result was found when only those sites that were surveyed using the hand search method (N = 92) were analysed; crayfish were detected at 50 of the 92 sites that were surveyed using the hand search method (*i.e.* approx. 54% of sites occupied), and a simple single season model with constant probability of detection, and survey patches classified as repeat surveys (MacKenzie *et al.*, 2002) gave an estimate of occupancy probability, psi = 0.5445 (SE = 0.0520, 95% CI = 0.4421–0.6432). Of the 123 sites surveyed, 74 had previous records of crayfish (National Biodiversity Data Centre, 2018). Crayfish were detected at 43 of those 74 sites (*i.e.* approximately 58% of previously occupied sites) during the 2017 survey. A McNemar's test on the 2017 presence/absence data for the 74 sites that had previous records of crayfish indicated a statistically significant decrease in the number of occupied sites in 2017 (Estimated Decrease = 0.419, 95% CI = 0.293–0.545, $P < 0.001$; *i.e.* an estimated decline of approximately 42%). Of those 74 sites, 52 were surveyed using the hand search method; crayfish were detected at 30 of those 52 sites (*i.e.* approximately 58% of previously occupied sites). A McNemar's test on the 2017 presence/absence data for the 52 hand search sites that had previous records of crayfish also indicated a statistically significant decrease in the number of occupied sites in 2017 (Estimated Decrease = 0.423, 95% CI = 0.270–0.577, $P < 0.001$; *i.e.* an estimated decline of approximately 42%). Both analyses indicate a significant decline in occupied sites in 2017 when all SACs are considered together. However, these results should be interpreted with some caution, as due to a lack of detailed past data (*e.g.* on the absence of crayfish from sites), non-random sampling, differences between SACs, and differences in survey methods over years, it is difficult to draw definite overall conclusions about declines in site occupancy.

The overall proportions of juveniles found in each SAC are presented in Table 5. Peay (2003) stated that a healthy crayfish population should consist of approximately 40% juveniles, and that if the percentage is less than 20% this could indicate a recruitment problem (or a problem with the survey method used). For all SACs in this survey (with the exception of the two SACs that lost their crayfish populations in the 1980s) the overall proportion of juveniles in the SAC was calculated as the number of identified juveniles divided by the total number of individuals that could be assigned to an age class, either adult or juvenile (for all individuals, *i.e.* those that were captured, but also those that evaded capture if they could be confidently assigned to an age class). For all SACs the proportion of juvenile crayfish was >20%, and for the majority of SACs it was greater than 40% (Table 5), suggesting that, overall, there is a healthy level of recruitment in the SACs. The lowest proportion of juveniles (0.22) was found in Glenade Lough SAC, which may be an indication of a potential issue with recruitment, although it is difficult to draw strong conclusions about recruitment in this SAC based on three surveys on a single date in 2017.

Table 4 Summary results on the abundance and range of White-clawed Crayfish *Austropotamobius pallipes* in all 15 SACs surveyed in 2017.

SAC	Abundance All Methods[1]				Abundance Hand Search Only[1]				Range		
	No. of patches surveyed	Total no. of crayfish	CPUE	Population abundance grade	No. of patches surveyed	Total no. of crayfish	CPUE	Population abundance grade	% sites occupied	% decline in occupancy[2]	Expected range occupied
Blackwater River (Cork/Waterford)	85	51	0.6	Low	25	45	1.8	Moderate	88 (N=8)	14 (N=7)	Yes
Bricklieve Mountains and Keishcorran	10	67	6.7	Very High	10	67	6.7	Very High	100 (N=1)	-	Yes
Glenade Lough	30	68	2.27	Moderate	30	68	2.27	Moderate	100 (N=3)	-	Yes
Kilroosky Lough Cluster	60	41	0.68	Low	0	-	-	-	67 (N=3)	-	Uncertain
Lough Bane and Lough Glass[3]	10	0	0	Abs/Undet	10	0	0	Abs/Undet	0 (N=1)	-	No
Lough Corrib	101	78	0.77	Low	85	76	0.89	Low	29 (N=14)	75 (N=8)*	No
Lough Gill	115	29	0.25	Low	55	23	0.42	Low	33 (N=12)	50 (N=6)	Uncertain
Lough Hoe Bog	30	88	2.93	Moderate	30	88	2.93	Moderate	100 (N=3)	-	Yes
Lough Lene[3]	30	0	0	Abs/Undet	30	0	0	Abs/Undet	0 (N=3)	-	No
Lough Nageage	60	7	0.12	Low	20	7	0.35	Low	50 (N=4)	-	Uncertain
Lough Owel	20	182	9.1	Very High	20	182	9.1	Very High	100 (N=2)	-	Yes
Lower River Suir[4]	193	102	0.53	Low	73	100	1.37	Moderate	59 (N=22)	20 (N=15)	No
River Barrow and River Nore[4]	220	66	0.3	Low	80	20	0.25	Low	52 (N=23)	50 (N=16)*	No
River Moy	155	123	0.79	Low	95	123	1.29	Moderate	43 (N=21)	62 (N=13)*	No
White L., Ben Loughs and L. Doo	43	34	0.79	Low	3	24	8.0	Very High	100 (N=3)	-	Yes

[1]Abundance calculations are presented using data from all surveys, and using data from only those surveys carried out using hand searching (the recommended method (Peay 2003)). The assigned population abundance grades are those proposed by Peay (2003) for river hand search surveys. [2]% Decline in Occupancy was analysed for all SACs in which at least eight sites were surveyed, by carrying out a McNemar's test on the 2017 presence/absence data for those sites that had previous crayfish records according to the National Biodiversity Data Centre dataset for White-clawed Crayfish (https://maps.biodiversityireland.ie/Species/17487). [3]Crayfish populations disappeared from these SACs in the 1980s following presumed outbreaks of crayfish plague. [4]There were confirmed outbreaks of crayfish plague in these SACs in 2017. * signifies a statistically significant decline in occupancy.

Table 5 Summary results on the proportion of juvenile White-clawed Crayfish *Austropotamobius pallipes* detected in all 15 SACs surveyed in 2017.

SAC	Total detections of known age classes[1]	Total detections of juveniles	Proportion of juveniles
Blackwater River (Cork/Waterford)	45	26	0.58
Bricklieve Mountains and Keishcorran	55	36	0.65
Glenade Lough	49	11	0.22
Kilroosky Lough Cluster	41	36	0.88
Lough Bane and Lough Glass[2]	0	0	-
Lough Corrib	77	57	0.74
Lough Gill	24	9	0.38
Lough Hoe Bog	66	49	0.74
Lough Lene[2]	0	0	-
Lough Nageage	4	3	0.75
Lough Owel	110	51	0.46
Lower River Suir	96	36	0.38
River Barrow and River Nore	65	46	0.71
River Moy	105	61	0.58
White Lough, Ben Loughs and Lough Doo	34	33	0.97

[1]All individuals detected in the survey that could be classified as either adults or juveniles. [2]Crayfish populations disappeared from these SACs in the 1980s following presumed outbreaks of crayfish plague.

3.17.2 Habitat heterogeneity and water quality

Overall habitat heterogeneity scores for each SAC, including their equivalent habitat heterogeneity grades (according to Table 2) are presented in Table 6. Habitat heterogeneity was calculated based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites. Sites with higher habitat heterogeneity scores tended to have higher CPUE values (Spearman rho = 0.311, N = 115, P = 0.001), suggesting that the habitat heterogeneity score does reflect, to some degree, the suitability of a site for crayfish. Most SACs had an overall habitat heterogeneity grade of Moderate or higher, although for some SACs the assessment of habitat heterogeneity was based on small sample sizes so the results should be interpreted with caution. Two SACs had habitat heterogeneity scores classified as Low: Lough Nageage SAC and White Lough, Ben Loughs and Lough Doo SAC. When all sites surveyed in the 15 SACs were considered together, habitat heterogeneity was classified as Moderate overall (Mean = 0.42, SD = 0.14, N = 121).

Summary water quality status assessments for each SAC are also presented in Table 6. These assessments are based on the percentage of sites surveyed in each SAC that had a water quality status higher than Moderate, the target value for crayfish sites, as well as on an assessment of the water quality status for all parts of the SAC with potential crayfish habitat; water quality assessments were based on EPA data (Environmental Protection Agency, 2018). For most SACs, the majority of survey sites within the SAC that had been assigned a water quality status score by the EPA were of at least Moderate Status (Table 6), and the same was generally the case when the EPA data for all relevant lakes and river stretches within each SAC (*i.e.* not just for the survey sites) was examined. The SACs that appeared to have some water quality problems were Glenade Lough SAC (Glenade Lough was classified as Poor),

Lough Gill SAC (Lough Gill and river stretches close to the lake were classified as Poor), the River Blackwater (Cork/Waterford) SAC (some stretches of the Awbeg River were classified as Poor), and the River Barrow and River Nore SAC (particularly the River Barrow, with some major stretches on the river classified as Poor). Some simple analyses were carried out to investigate the relationship between water quality of a survey site (with sites classified into two water quality categories: High/Good and Moderate/Poor) and crayfish presence and CPUE values at the survey site. There was no obvious relationship between the water quality status of a survey site and the probability of detecting crayfish at the survey site (Chi-Square = 0.255, DF = 1, N = 104, P = 0.614), or between the water quality status of a survey site and calculated CPUE values for the survey site (Mann-Whitney Test [adjusted for ties]: W = 3303.0, N1 = 60, N2 = 44, P = 0.289).

Table 6 Summary results on the quality of White-clawed Crayfish *Austropotamobius pallipes* habitats in all 15 SACs surveyed in 2017.

SAC	Habitat Heterogeneity			Water Quality	
	Range	Mean Score	Grade[1]	% Sites ≥ Moderate Status[2]	Notes about Water Quality in the SACs (based primarily on the most recent EPA data, *i.e.* River and Lake Water Quality Status [2010-2015])
Blackwater River (Cork/Waterford)	0.38–0.80	0.57 (SD=0.12, N=8)	Very High	63 (N=8)	The Awbeg River appears to have some water quality issues, with some stretches of the river classified as Poor status, particularly in the Buttevant area. All stretches of the Blackwater River for which there are recent crayfish records are of at least Moderate status.
Bricklieve Mountains and Keishcorran	-	0.45 (N=1)	High	NA	Lough Labe (the only waterbody in the SAC known to contain White-clawed Crayfish) was not assigned a water quality status by the EPA.
Glenade Lough	0.32–0.48	0.42 (SD=0.09, N=3)	Moderate	0 (N=3)[3]	Glenade Lough was classified as Poor status.
Kilroosky Lough Cluster	0.46–0.54	0.51 (SD=0.05, N=3)	High	100 (N=1)	Summerhill Lough, within the Kilroosky Lough Cluster SAC, was classified as Moderate status. All other lakes within the SAC, were not assigned a water quality status by the EPA.
Lough Bane and Lough Glass	–	0.57 (N=1)	Very High	100 (N=1)	Lough Bane was classified as High status. Lough Glass and Lough Glass North were not assigned a water quality status by the EPA.
Lough Corrib	0.25–0.60	0.40 (SD=0.11, N=14)	Moderate	100 (N=14)[3]	All areas that contain potentially suitable crayfish habitat, and which have been assigned a water quality status score by the EPA, are of at least Moderate status.
Lough Gill	0.16–0.60	0.37 (SD=0.11, N=12)	Moderate	73 (N=11)[3]	Lough Gill was classified as Poor status. Most rivers with potentially suitable crayfish habitat were of at least Moderate status, except most river stretches close to Lough Gill.
Lough Hoe Bog	0.35–0.46	0.39 (SD=0.06; N=3)	Moderate	100 (N=3)[3]	Lough Talt (the only waterbody in the SAC known to contain White-clawed Crayfish) was classified as Good status.
Lough Lene	0.41–0.53	0.48 (SD=0.06; N=3)	High	100 (N=3)[3]	Lough Lene was classified as High status.

SAC	Habitat Heterogeneity			Water Quality	
	Range	Mean Score	Grade[1]	% Sites ≥ Moderate Status[2]	Notes about Water Quality in the SACs (based primarily on the most recent EPA data, *i.e.* River and Lake Water Quality Status [2010-2015])
Lough Nageage	0.16–0.42	0.27 (SD=0.12, N=4)	Low	NA	None of the lakes within the SAC was assigned a water quality status by the EPA.
Lough Owel	0.40–0.49	0.45 (SD=0.06, N=2)	High	100 (N=2)[3]	Lough Owel was classified as Good status. On the day of the survey, water levels in the lake were very low; this may suggest a possible issue with abstraction affecting water levels in the lake.
Lower River Suir	0.08–0.67	0.45 (SD=0.13, N=21)	High	100 (N=21)	All stretches of the River Suir and of the major River Suir tributaries were classified as Moderate status or higher, and most stretches were classified as Good status.
River Barrow and River Nore	0.08–0.67	0.39 (SD=0.15, N=22)	Moderate	82 (N=22)	Most stretches of the upper River Barrow were classified as Moderate status or higher, apart from the River Barrow north of Monasterevin which was classified as Poor status. In the lower stretches of the River Barrow, there are substantial sections of the river between Bagenalstown and Graiguenamanagh that are classified as Poor status. The major River Barrow tributaries were classified as Moderate status or higher, apart from a section of the River Lerr at Castledermot, which was classified as Poor status. Most stretches of the River Nore were classified as Moderate status or higher, apart from the Pococke River, near Kilkenny, which was classified as Poor status.
River Moy	0.08–0.68	0.44 (SD=0.15, N=21)	High	100 (N=19)	Most river stretches within the SAC were classified as Moderate status or higher; the single exception was a small stretch of the Mullaghanoe River at Charlestown which was classified as Poor status.
White L., Ben Loughs and Lough Doo	0.15–0.38	0.28 (SD=0.12, N=3)	Low	100 (N=2)[3]	White Lough classified as Good status. On the day of the survey, water levels in the lake were low; this may suggest a possible water quality problem in relation to water levels in the lake. Other lakes within the SAC, including Lough Doo and Ben Lough, were not assigned a water quality status.

[1]Habitat heterogenity scores (HHS) and their equivalent habitat heterogeneity grades: HHS >0.52, very high; HHS >0.43, ≤0.52, high; HHS >0.33, ≤0.43, moderate; HHS >0, ≤0.33, low. [2]For those sites that were assigned a water quality status (2010-2015) by the EPA (sites that were not assigned a status are not included in the calculation). [3]Signifies that more than one survey site was on the same lake or river; the EPA assigns a single water quality status score to a lake

4 Discussion and conclusions

White-clawed Crayfish *Austroptamobius pallipes* surveys were carried out between June and September 2017 in all 15 SACs with White-clawed Crayfish listed as a qualifying interest. Crayfish were found in all SACs, with the exceptions of Lough Bane and Lough Glass SAC, and Lough Lene SAC; White-clawed Crayfish populations disappeared from both of these SACs in the 1980s due to presumed outbreaks of Crayfish Plague (NPWS, 2013b, c). Based on the results of the current survey, the SACs with the highest crayfish abundances were the Bricklieve Mountains and Keishcorran SAC (specifically, Lough Labe within that SAC) and Lough Owel SAC, while the SACs with the lowest crayfish abundances were Lough Corrib SAC, Lough Gill SAC, Lough Nageage SAC and the River Barrow and River Nore SAC. Juvenile crayfish (<25 mm carapace length) were detected in good proportions at the majority of survey sites, suggesting that there is, in general, a healthy level of recruitment within the SACs. A possible exception to this was Glenade Lough SAC, which had the lowest proportion of juveniles overall, perhaps indicating a potential issue with recruitment.

For six SACs, crayfish were considered to be occupying their expected range within the SAC, while for three (Kilroosky Lough Cluster SAC, Lough Gill SAC, Lough Nageage SAC) the situation was uncertain due to limited data. Crayfish were considered not to be occupying their expected range in six SACs. In three of those (Lough Corrib SAC, River Moy SAC, River Barrow and River Nore SAC) this assessment was based on a low percentage of survey sites with positive detections of crayfish, combined with a significant decline in range in 2017 when compared with detections in previous years. In the River Barrow and River Nore SAC, crayfish populations were also lost from some parts of their expected range due to an outbreak of Crayfish Plague in 2017. In the Lower River Suir SAC, crayfish were considered not to be occupying their expected range because of losses linked to an outbreak of Crayfish Plague in 2017, and crayfish were considered not to be occupying their expected range within Lough Bane and Lough Glass SAC, and Lough Lene SAC, because crayfish populations disappeared from those SACs in the 1980s following presumed outbreaks of Crayfish Plague (NPWS, 2013b, c).

An assessment of habitat quality was carried out for all SACs. This assessment was based on two components: (i) a simple measure of habitat heterogeneity, based on the proportion of different habitat types that have the potential to act as crayfish refuges which were present in the water at the survey sites, and (ii) water quality status assessments based on EPA data (Environmental Protection Agency, 2018). Most SACs had an overall habitat heterogeneity grade of Moderate or higher; the two SACs with the lowest habitat heterogeneity grade overall were Lough Nageage SAC and White Lough, Ben Loughs and Lough Doo SAC. For most SACs, the water quality at the survey sites, and for all relevant lakes and river stretches within the SAC had a water quality status of at least Moderate quality, which is the target value for crayfish sites. The SACs that appeared to have some water quality problems were Glenade Lough SAC, Lough Gill SAC, the River Blackwater (Cork/Waterford) SAC, and the River Barrow and River Nore SAC, although there was no indication that water quality was having a negative effect on crayfish populations in any of those SACs.

When considering the results of this survey, it is important to be aware of some of the limitations that could have affected the interpretation of the data and the analyses. For example, the sample sizes (*i.e.* the number of sites/patches surveyed) for some SACs were low. Some SACs (or the waterbodies that host populations of crayfish within those SACs) are relatively small, which reduces the number of potential survey sites. Also, in some cases it was not possible to carry out all planned surveys due to access difficulties at certain survey sites on the day. Results from those SACs with fewer surveys are unlikely to be as reliable as results from those SACs where more surveys were carried out, and therefore should be interpreted with more caution. Additionally, some survey sites (especially on lakes) were relatively close together, which means that they may not have been independent of each other.

An attempt was also made to assess possible declines in the range of crayfish within SACs. Again, for those SACs with fewer surveys, those assessments should be interpreted with caution; in some cases the only assessments that could be made were basic comparisons between the 2017 survey results and

the results of surveys carried out at some of the same lake sites in 2007 (reported in O'Connor *et al*., 2009). For some of the larger SACs, particularly those that contained river stretches that were regularly monitored by the EPA, it was possible to carry out a basic statistical analysis on a potential decrease in site occupancy within the SACs. However, even those assessments from the SACs with larger sample sizes (*i.e.* those for which there were a larger number of survey sites in 2017 that also had previous records of crayfish) should be interpreted with caution, as due to a lack of detailed past data (*e.g.* on the absence of crayfish from survey sites), non-random sampling, differences between SACs, and differences in survey methods over years, it is difficult to draw definite overall conclusions about apparent declines in site occupancy. However, with those caveats in mind, the statistical analyses in relation to a decline in site occupancy within SACs probably provide some of the most useful results, and suggest that, in at least some of the SACs, there has been a decline in the range of White-clawed Crayfish. Based on those analyses it would seem particularly appropriate to carry out further investigations into apparent losses of crayfish populations from previously occupied areas within Lough Corrib SAC, the River Barrow and River Nore SAC and the River Moy SAC. The reasons for the apparent losses from those SACs are unknown. Based on EPA data, there is no real reason to assume that the losses are linked to major water quality problems in the SACs. However, there are factors other than water quality that can have a negative impact on crayfish populations at a site, such as arterial drainage (O'Connor & McDonnell, 2008). There is also no real reason to assume that Crayfish Plague has had a role to play in the apparent losses of crayfish populations from those SACs. However, Crayfish Plague is an ongoing threat to the species, and it would be appropriate to continue to closely monitor the River Barrow and River Nore SAC, and the Lower River Suir SAC, as there were losses of crayfish from a number of sections within those SACs in 2017 due to outbreaks of Crayfish Plague.

An increase in the number of survey sites in future surveys would facilitate more precise estimates of population parameters, more robust statistical analyses of population trends and more definite conclusions; this would obviously require more resources to be allocated to White-clawed Crayfish surveys. In the 2017 survey, sites were selected with the aim of ensuring that some sites with previous records of crayfish would be included in the survey and that there would be a good geographical coverage of the expected crayfish sites within the SAC, so that basic assessments of population abundance and range could be made in at least some SACs, and to provide baseline data for future surveys. This general approach was an attempt to follow some of the recommendations of Peay (2003) in relation to developing a monitoring programme to detect changes in the abundance and range of White-clawed Crayfish in rivers over a number of monitoring cycles. Again following recommendations in Peay (2003), for future surveys within these 15 SACs, half of the sites selected for surveying should be those that were surveyed previously, and half should be new sites (selected at random from a pool of suitable survey sites); this approach, if carried out over a number of monitoring cycles, will increase the power of analyses to detect changes in the crayfish populations within the SACs.

In the 2017 survey, crayfish abundance at the survey sites was calculated as catch per unit effort (CPUE). We followed Peay (2003) and Reynolds *et al.* (2010) by calculating CPUE as the number of crayfish divided by the number of survey patches. This means that the CPUE values for hand search surveys in lakes reported here are a factor of 10 higher than those reported in O'Connor *et al.* (2009), in which CPUE values for hand search surveys were calculated by dividing the number of crayfish by the number of refuges (10 refuges per survey patch). Calculated CPUE values were subsequently assigned the population abundance grades proposed by Peay (2003). It should be noted that these population abundance grades are somewhat arbitrary, and Peay (2003) suggested that they be reviewed after a monitoring cycle. These population abundance grades were also proposed for CPUEs calculated using data from river hand search surveys, and may not be entirely appropriate for CPUEs that are calculated using other survey methods. This was particularly evident in the 2017 survey, as CPUEs/population abundance grades based on sweep net surveys tended to be lower than those based on hand search surveys; therefore a low population abundance grade based primarily on sweep net surveys should be interpreted with some caution, as should an absence of crayfish detections at a site where sweep netting was the survey method used. An absence of crayfish detections at a site does not mean that crayfish were not present at that site; it is possible that they were present in low numbers. Peay (2003) states, in

relation to calculations of limits of detection for the standard survey method in rivers: "the true abundance has to be below 0.014 (1 in 71 refuges) before there is less than a 50% chance of finding a crayfish". It therefore seems likely that non-detections of crayfish in the 2017 survey when hand searches were used is likely to signify a real absence of crayfish from a site, although this is less likely to be the case for sweep net surveys. Although sweep net surveys are necessary in some situations, and are probably the only feasible method at some sites, and in some SACs (*e.g.* Kilroosky Lough Cluster SAC), hand search surveys should be used whenever possible. If reliable comparisons are to be made at the same site over a number of years, the same survey method should be used at the site each year.

In conclusion, based on the results of the 2017 survey, White-clawed Crayfish populations appear to be in decline in at least some SACs. In particular, there appear to have been losses from Lough Corrib SAC, the River Barrow and River Nore SAC and the River Moy SAC; the reasons for those losses, and the time periods over which they have occurred, are not known. Also, it should be noted that there may be issues affecting crayfish populations in other SACs that were not detected in this survey; small sample sizes in the 2017 survey, as well as limited past data on crayfish populations in some SACs, meant that it was difficult to come to definite conclusions in some cases. There is also an ongoing threat from Crayfish Plague, as evidenced by outbreaks of this disease in the Lower River Suir SAC and in the River Barrow and River Nore SAC in 2017. Future surveys should be designed with the aim of ensuring that there is an increase in the number of sites within each SAC that have data on crayfish presence and abundance, while also ensuring that repeat data is gathered at some sites to facilitate the calculation of robust population trends.

5 Bibliography & Relevant Literature

Demers, A., Lucey, J., McGarrigle, M.L. & Reynolds, J.D. (2005) The distribution of the white-clawed crayfish, *Austropotamobius pallipes*, in Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy* **105B**, 65-69.

Demers, A. & Reynolds, J.D. (2002) A survey of the white-clawed crayfish, *Austropotamobius pallipes* (Lereboullet) and of water quality in two catchments of Eastern Ireland. *Bulletin Français de la Pêche et de la Pisciculture* **367**, 729-740.

Demers, A., Reynolds, J.D. & Cioni, A. (2003) Habitat preferences of different size classes of *Austropotamobius pallipes* in an Irish river. *Bulletin Français de la Pêche et de la Pisciculture* **370-371**, 127-137.

Environmental Protection Agency (2018) Lake Water Quality Status and River Water Quality Status, 2010-2015 at: https://gis.epa.ie/EPAMaps/ (Accessed July-August 2018).

Füreder, L., Gherardi, F., Holdich, D., Reynolds, J., Sibley, P. & Souty-Grosset, C. (2010) *Austropotamobius pallipes*. The IUCN Red List of Threatened Species 2010: e.T2430A9438817. http://dx. doi.org/10.2305/IUCN.UK.2010-3.RLTS.T2430A9438817.en

Gallagher, M.B., Dick, J.T.A. & Elwood, R.W. (2006) Riverine habitat requirements of the white-clawed crayfish, *Austropotamobius pallipes*. *Biology and Environment: Proceedings of the Royal Irish Academy* **106B**, 1-8.

Holdich, D.M. (2002) Distribution of crayfish in Europe and some adjoining countries. *Bulletin Français de la Pêche et de la Pisciculture* **367**, 611-650.

MacKenzie, D.I., Nichols, J.D., Lachman, G.B., Droege, S., Royle, J.A. & Langtimm, C.A. (2002) Estimating site occupancy rates when detection probabilities are less than one. *Ecology* **83**, 2248-2255.

McFarlane, A., O'Brien, J., Gammell, M. & Nelson, B. (2019) Estimating the population size of the endangered white-clawed crayfish, *Austropotamobius pallipes*, using mark-recapture at three special areas of conservation (SACs). *Biology and Environment: Proceedings of the Royal Irish Academy* **119B**, 75-91.

National Biodiversity Data Centre (2018) Biodiversity Maps. Online database at: https://maps.biodiversityireland.ie/Species/17487 (Accessed July-August 2018).

NPWS (2011) Conservation Objectives: River Barrow and River Nore SAC 002162. Version 1.0. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht.

NPWS (2012) Conservation Objectives: Blackwater River (Cork/Waterford) SAC 002170. Version 1.0. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht.

NPWS (2013a) The Status of EU Protected Habitats and Species in Ireland. Species Assessments Volume 3. Version 1.0. Unpublished Report, National Parks & Wildlife Services. Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

NPWS (2013b) Site Synopsis: Lough Bane and Lough Glass SAC 002120. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht.

NPWS (2013c) Site Synopsis: Lough Lene SAC 002121. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht.

NPWS (2016) Conservation Objectives: River Moy SAC 002298. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs.

NPWS (2017a) Conservation Objectives: Lough Corrib SAC 000297. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs.

NPWS (2017b) Conservation Objectives: Lower River Suir SAC 002137. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs.

NPWS (2018) Conservation Objectives: Lough Owel SAC 000688. Version 1. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht.

O'Connor, W., Hayes, G., O'Keeffe, C. & Lynn, D. (2009) Monitoring of white-clawed crayfish *Austropotamobius pallipes* in Irish lakes in 2007. *Irish Wildlife Manuals*, No 37. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin.

O'Connor, W. & McDonnell, D. (2008) Report for the Ecological Assessment of the Significance of Impacts of proposed scheduled Arterial Drainage Scheme channel and embankment maintenance works on SACs & SPAs. A Report to the Environment Section of the Office of Public Works.

Peay, S. (2003) Monitoring the white-clawed crayfish *Austropotamobius pallipes*. Conserving Natura 2000 Rivers Monitoring Series No. 1, English Nature, Peterborough.

Reynolds, J.D. (1998) Conservation management of the white-clawed crayfish, *Austropotamobius pallipes*. Part 1. *Irish Wildlife Manuals* No. 1. Dúchas, The Heritage Service, Department of Arts, Heritage, Gaeltacht and the Islands, Dublin, Ireland.

Reynolds, J.D., O'Connor, W., O'Keeffe, C. & Lynn, D. (2010) A technical manual for monitoring white-clawed crayfish *Austropotamobius pallipes* in Irish lakes. *Irish Wildlife Manuals* No 45, National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin.

Appendix 1 Crayfish survey methods

These have been adapted from Peay (2003) and Reynolds *et al*. (2010).

Preferred Crayfish Survey Method – Quick Guide Rivers

- When you arrive at the river site, start at the downstream end of the 500 m survey stretch. Assess channel conditions in the first 100 m for suitability for survey (*i.e.* channel is accessible from the banks, no obvious hazards, water shallow enough [<0.5 m] for manual survey, reasonably clear water, presence of potential refuges that can be searched, suitable flow [note: do not survey during increasing or high river flow]).
- Identify the 5 most favourable looking and accessible survey patches in the first 100 m (note: they are unlikely to be evenly spread, but different patches should be at least 5 m apart). If there are some suitable patches, but fewer than 5, extend the sampling site to 200 m and select what appear to be the best 5 patches in 200 m. If there are fewer than 5 habitat patches worth surveying in 200 m, start at the next 200 m site upstream and search for 5 patches in this site. If the 400 m section is unsuitable for survey complete the evaluation of crayfish habitat for that 400 m and go to another 500 m stretch.
- Select 10 potential refuges in each patch (big enough to fully cover the crayfish, relatively stable and resistant to high flows, in flow that is slow enough for a crayfish to walk in, not too silted). If soon after starting a chosen patch you find it to be much less suitable than it appeared, either for refuges or for manual survey, you can leave it and select another patch if there are others that are obviously better (note: the absence of crayfish in an apparently suitable patch is not a reason for leaving that patch). Enter and exit the water as close as possible to the selected patches to minimise the likelihood of damaging refuges and/or crayfish during surveys.
- Work facing upstream to minimise disturbance of soft substrate. Search stones that are mainly in a single layer on a small-grained substrate whenever possible. Wet the clear base of the viewing aid with just enough water to cover the bottom. Find a suitable refuge to search. Move the viewing aid upstream or to the side of the refuge. Lift or turn each refuge in a downstream direction. Move the viewing aid over the exposed area and watch as any disturbed sediment clears. Hold a net in any rush of water that occurs when the stone is lifted, in case a crayfish is washed free. If there are any stones beneath the boulder or large cobble, lift these too, counting all as a single refuge. Crayfish will usually be on the gravel, sand or other soft substrate beneath the stones, and should stay there for a time before starting to walk towards a new refuge. Always work down to the base substrate (and watch out for burrows). Where possible, replace refuges after searching, putting them back vegetated side up. Put a few pebbles under the stone to keep a void open so crayfish can use it again.
- When a crayfish is visible, the best method for catching it is a cautious approach from above and behind, then a sudden grab for the carapace, pressing the crayfish down on the bed, gently but firmly, until a good hold is obtained and it can be lifted out of the water. For juveniles it may be necessary to position a net downstream in a clear area about 10 cm from the crayfish and bring a finger slowly towards the front of the crayfish to encourage it to back away, but not escape-swim. Once it enters the net, lift the net immediately. Look carefully at the exposed area after catching a crayfish - there may be other crayfish, including those emerging from hidden refuges.
- You should count any escaped crayfish, but never record/count an escaped crayfish unless you positively identify it as a crayfish (fast escaping organisms are likely to be fish). If you observe an escaped crayfish settling in an area that you are planning to search, you may still be able to catch it manually although it is likely to swim again. Avoid double-counting – remove the escaped crayfish from the count if you catch it subsequently.
- Avoid handling any berried females close to the time of release of the young, as the hatchlings may be shed and lost. Hold any berried/young-carrying female carefully, keeping the tail tucked underneath; release it carefully, preferably directly into the entrance of a potential refuge. If hatchlings are accidentally shed, release them into favourable habitat in the margins.
- Hold all crayfish captured from a patch in a container with some river water prior to processing. Record the catch separately for each patch on the crayfish record card, placing crayfish that have been processed into another container until you are ready to release them back into the patch. Then return the crayfish to the area from which they came. Record the habitat features of the patch on the habitat record card. Then move to the next patch in that survey stretch.
- Record the location of the survey site (at the downstream end, at the start of the area in which habitat patches were surveyed) using GPS, and take a picture of the site looking upstream.
- Before leaving each patch, and each site, check that all necessary information has been recorded in full.

Preferred Crayfish Survey Method – Quick Guide Lakes

- When you arrive at the lake site, check access and examine the available substrate at the lake shore, estimating the extent of the most suitable habitat. Look for a stretch that has rocks and cobbles consisting of one layer only, *i.e.* rock and cobble not on top of other loose rock and cobble (you are looking for a 2-dimensional shore line). Also look for surrogate information revealing the presence of crayfish (*e.g.* cast carapaces, remains in otter spraints, *etc.*). Where vertical banks are visible, look for burrows with flattened oval entrances about 5-10 cm across. Take a GPS reading and a photo of the site.
- Aim to examine at least 100 m of shoreline at a site, centred on known crayfish hotspots where possible. Select 10 patches of stony habitat in the 100 m survey stretch and ideally search 10 refuges in each patch. If stony stretches are continuous, define patches at a suitable distance apart (i.e. 10 m). Enter and exit the water as close as possible to the selected patches to minimise the likelihood of damaging refuges and/or crayfish during surveys.
- Stones (boulders/cobbles) selected for searching should be flattish and at least 10 cm long. Lift and turn over each stone carefully towards your body (to avoid disturbing silt into your line of view). If there is a slight drift in the lake, work against the direction of the drift so that sediment will be taken away from your line of view. In places where the lake shelves off quickly, work in a position facing the shore.
- Catch any crayfish underneath the refuges by hand (following the method for hand catching in a river using a viewing aid) or using a hand-net where water is deep or conditions difficult. Replace each stone carefully into the position from which it was originally displaced. When moving larger rocks, try to lift when possible, so as to reduce the possibility of injury to crayfish. Use slow movements to increase the chance of crayfish capture.
- Hold all crayfish captured from a patch in a container with some lake water prior to processing. Record the catch for each patch on the crayfish record card, placing crayfish that have been processed into another container until you are ready to release them back into the patch. Then return the crayfish to the area from which they came. Record the habitat features of the patch on the habitat record card. Then move to the next patch in that survey stretch.
- Before leaving each patch, and each site, check that all necessary information has been recorded in full.

Sweep netting and trapping for crayfish – Quick Guide

- **Sweep netting**: Use this method if there are no/few stones along the lake shore (or in the river channel), or the bottom is obscured by weed, algae or debris. Using a hand-held pond net, carry out 20 sweeps per survey stretch. Each sweep consists of drawing the net along one metre of bottom, forward and back once along the same track, as quickly as possible (to prevent disturbed crayfish from escaping). The substrate should be thoroughly disturbed in the first half of the sweeping cycle. The net opening should then be reversed at the end of the first cycle (1 m) and re-swept over the disturbed substrate.
- Empty the contents of the net into a white tray for examination, and remove all crayfish to a container for processing (ensuring that separate counts/measurements are made for each sweep). It is important to examine the contents of the net thoroughly for hatchlings.
- Record the habitat features of the patch on the habitat record card. Then move to the next patch in that survey stretch.
- Before leaving each patch, and each site, check that all necessary information has been recorded in full.

- **Trapping**: Use this method if the lake/river site is unsuitable for hand searching or sweep netting. Use traps modified with 10 mm mesh on the outside to ensure juveniles are retained. Each trap should be baited with liver or fish (a 400 g tin of cat food is sufficient for 10 traps, i.e. approximately 40 g per bait cage).
- At each survey site, use a string of 10 traps, spaced 4 m apart on each rope. Secure one end of the rope to the lakeshore and throw the traps into the water, so that the rope lies parallel to the shore and ideally within 5 m of it, in about 0.5-3 m of water. Record the habitat features of each patch/trap on the habitat record card.
- As early as possible the following morning, haul the traps onto the shore preferably by pulling the rope as you walk along the shore (the less time the trap is moving while submerged in the water the less likely it is that smaller crayfish will be lost – watch for escaping crayfish as traps are hauled).
- Remove crayfish from each trap to a container for processing (ensuring that separate counts/measurements are made for each trap).
- Before leaving each site, check that all necessary information has been recorded in full.

Appendix 2 Crayfish Survey Field Recording Sheets

CRAYFISH HABITAT CARD: RIVER SITES (adapted from Peay (2003) and Reynolds *et al.* (2010))

SAC:_____ Waterbody:_____
Site:_____ Photo taken?_____
Lat/Long:_____
Date:_____ Start/End Time:_____
Surveyors:_____ Method:_____
No. Refuges Searched:_____ No. Sweeps:_____
No. Traps:_____ Crayfish?_____
Site Length & Width:_____
Water Temp:_____pH:_____ DO (%):_____ DO (mg/L):_____
Conductivity (µS/cm):_____ Turbidity:_____

Weather: 1 good (dry, bright, no wind); **2 mod** (overcast, maybe some drizzle/wind); **3 poor** (rain &/or wind, **avoid survey**)	
Flow: 1 normal; **2 low** (reduced width of channel in many areas); **3 falling** (flow reducing after rain); **4 rising** (**avoid survey**)	
Clarity: 1 good (visibility good to 50 cm); **2 mod** (visibility good to 30 cm); **3 poor** (high turbidity, may need other methods)	

	Patch 1	Patch 2	Patch 3	Patch 4	Patch 5
Extent: (l x w; l is distance u/s, w is distance at right angles to bank)					
Depth: average in habitat patch surveyed, or can give a range					
Channel: 1 margin (not more than ¼ of channel from left or right bank, or distinguished by a change in flow); **2 mid channel**; **3 both; 4 other** (specify)					
Feature: 1 marginal deadwater (margins, no flow); **2 pool** (no flow, deep, most of channel); **3 glide** (flowing, no surface disturbance); **4 run** (faster than glide, rippled surface); **5 riffle** (shallow, fast flowing, disturbed surface)					
Refuges in the water: tick all present in patch, ring main types searched					
• Cobble (6.5-15 cm) [will only be used by small crayfish, if at all]					
• Cobble (15-25 cm) [preferred refuge]					
• Boulder (26-40 cm) [do not haul out deeply bedded boulders]					
• Boulder (>40 cm) [do not haul out deeply bedded boulders]					
• Rubble [loose construction material > 15 cm (*e.g.* brick, give typical size)]					
• Woody debris [trees, logs, branches, etc.]					
• Urban debris [any manmade object that is a potential refuge]					
• Tree roots, fine [matted underwater roots, not large roots – see bank]					
• Moss [only record if extensive enough to provide a refuge]					
• Filamentous algae [only record if extensive, *e.g.* trailing/in patches]					
• Other submerged vegetation [if dense enough to provide refuge]					
• Emergents [rooted emergents, *e.g. Rorippa, Phragmites, etc.*]					

Main substrate beneath refuges: tick main type(s)					
• Bedrock					
• Cobble (6.5-15 cm)					
• Pebble (< 6.5 cm)					
• Gravel (< 1.6 cm)					
• Sand (< 2 mm)					
• Clay (sticky, solid surface)					
• Silt (silky, deposited)					
Shading above: (%, any type, trees or shrubs)					
Siltation: tick main type					
• None					
• Low (a little silt trapped in moss/algae, refuges clear)					
• Moderate (silt clouds water on disturbance, clears slowly)					
• High (silt on all surfaces, very slow to clear, may not settle)					
Refuges in bank: potential refuges usually submerged at normal flow (omit if patch is mid-channel only), tick all present					
• None					
• Cobble/Boulder (projecting from bank into water)					
• Tree roots, large (projecting roots, often forearm thick or more)					
• Vertical or undercut bank (usually stable, may be bare/vegetated)					
• Dry stone wall (bank reinforced with unmortared stone)					
• Other reinforced (if provides submerged crevices adjacent to slow flow)					
• Crayfish burrows (holes in banks, 2-6 cm wide, usually wider than high)					
Search time (mins): (excludes time spent processing/recording catch)					

Evaluation of crayfish habitat for whole site: 0 absent; **1 Yes** (< 1/3 of site); **2 frequent** (> 1/3 of site); **3 abundant** (> 2/3 of site); **? unsure** (*e.g.* not visible). Score separately for margins, mid-channel and banks.	Margins	Mid-channel	Banks

Evidence of crayfish (select all that apply): 1 live animals (during survey); **2 body parts** (*e.g.* carapaces in water or on shore); **3 remains** (*e.g.* body parts in spraints); **4 burrows** (flat oval entrances, 5-10 cm across); **5 other** (specify)	
Surveyability: 0 (no access or < 10 refuges); **1** (hard to find patches); **2** (1-5 extra patches); **3** (>5 extra patches)	
Problems (select all that apply): 1 (pollution); **2** (poaching, add E(xtensive) if >33% of site); **3** (alien crayfish); **4 other** (specify)	
Notes:	

CRAYFISH HABITAT CARD: LAKE SITES (adapted from Peay (2003) and Reynolds *et al*. (2010))

SAC:_____ Waterbody:_____
Site:_____ Photo taken?_____
Lat/Long**:**_____
Date:_____ Start/End Time:_____
Surveyors:_____ Method:_____
No. Refuges Searched:_____ No. Sweeps:_____
No. Traps:_____ Crayfish?_____
Site Length & Width:_____
Water Temp:_____pH:_____DO (%):_____ DO (mg/L):_____
Conductivity (µS/cm):_____ Turbidity:_____

Weather: 1 good (dry, bright, no wind); **2 mod** (overcast, maybe some drizzle/wind); **3 poor** (rain &/or wind, **avoid survey**)	
Level: 1 normal; **2 low** (usually submerged substrate extensively exposed); **3 high** (shoreline extensively submerged)	
Clarity: 1 good (visibility good to 50 cm); **2 mod** (visibility good to 30 cm); **3 poor** (high turbidity, may need other methods)	

	Patch									
	1	2	3	4	5	6	7	8	9	10
Patch Area: in m^2										
Mean distance (m) from shore										
Mean Depth: average depth (m) of patch										
Maximum Depth: maximum depth (m) of patch										
Shoreline Type: 1 open (*e.g.* bare ground/short grass); **2 vegetated** (*e.g.* tall reeds/grasses/scrub); **3 woodland; 4 other** (specify)										
Shore Gradient: 1 flat (no real gradient); **2 low** (gradient <10°); **3 mod** (gradient 10-30°); **4 high** (gradient 30-45°); **5 very high** (gradient > 45°)										
Refuges in the water: tick all present in patch, ring main types searched										
• Cobble (6.5-15 cm) [will only be used by small crayfish, if at all]										
• Cobble (15-25 cm) [preferred refuge]										
• Boulder (26-40 cm) [do not haul out deeply bedded boulders]										
• Boulder (>40 cm) [do not haul out deeply bedded boulders]										
• Rubble [loose construction material > 15 cm (*e.g.* brick, give typical size)]										
• Woody debris [trees, logs, branches, *etc*.]										
• Urban debris [any manmade object that is a potential refuge]										
• Tree roots, fine [matted underwater roots, not large roots]										
• Moss [only record if extensive enough to provide a refuge]										
• Filamentous algae [only record if extensive, *e.g.* trailing/in patches]										
• Other submerged vegetation [if dense enough to provide refuge]										
• Emergents [rooted emergent, *e.g. Rorippa, Phragmites*, etc.]										
• Charophytes [if dense enough to provide refuge]										

Substrate Summary: give a percentage (%)										
• Rock/Boulder (>26 cm)										
• Cobble (6.5-25 cm)										
• Pebble/Gravel (< 6.5 cm)										
• Sand (< 2 mm)										
• Clay (sticky, solid surface)										
• Silt (silky, deposited)										
Vegetation cover: (%, any type)										
Shading above: (%, any type, trees or shrubs)										
Siltation: tick main type										
• None										
• Low (a little silt trapped in moss/algae, refuges clear)										
• Moderate (silt clouds water on disturbance, clears slowly)										
• High (silt on all surfaces, very slow to clear, may not settle)										
Search time (mins): (excludes time spent processing/recording catch)										

Evaluation of crayfish habitat for whole site: 0 absent; 1 Yes (< 1/3 of site); 2 frequent (> 1/3 of site); 3 abundant (> 2/3 of site); ? unsure (*e.g.* not visible).	
Evidence of crayfish (select all that apply): 1 live animals (during survey); **2 body parts** (*e.g.* carapaces in water or on shore); **3 remains** (*e.g.* body parts in spraints); **4 burrows** (flat oval entrances, 5-10 cm across); **5 other** (specify)	
Surveyability: 0 (no access or < 10 refuges); **1** (hard to find patches); **2** (1-5 extra patches); **3** (>5 extra patches)	
Problems (select all that apply): 1 (pollution); **2** (poaching, add E if >33% of site); **3** (alien crayfish); **4 other** (specify)	
Notes:	

CRAYFISH RECORD CARD

SAC:_____ WATERBODY:_____SITE CODE:_____LAT/LONG:_____

DATE:_____ SURVEYORS:_____ SHEET NO.:_____ CPUE:_____

Crayfish No.	Patch, Sweep or Trap No.	Sex	CL (mm)	Damage	Breeding	Moult	Disease	Method	Tissue Sample	Mark	Notes
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

SEX	**F**: female	**M**: male	**J**: juvenile (0+ not distinguishable)	**X**: Escaped or released crayfish, not identified							
CL	Carapace length (mm) from tip of rostrum to junction of carapace and tail			**JE**: juvenile escaped/released (estimated < 25mm CL)			**AE**: adult escaped/released (estimated > 25mm CL)				
DAMAGE	**MR**: missing right cheliped	**ML**: missing left cheliped	**MB**: missing both chelipeds	**RR**: regenerating right cheliped (< than left)	**RL**: regenerating left cheliped	**RB**: regenerating both (small for crayfish size)	**AR**: right antenna damaged/missing	**AL**: left antenna damaged/missing	**OM**: one/more other limbs damaged/missing	**OI**: other injury, *e.g.* cracked shell	**Z**: Dead
BREEDING	**B**: ♀ berried	**Y**: ♀ carrying young. **Warning: Handle with care**		**GS**: ♀ with old glair strands		**G**: ♀ with new glair strands forming (autumn)			**S**: ♀ with spermataphore (autumn)		
MOULT	**BM**: pre-moult, crayfish usually dark, carapace deforms easily			**MM**: mid-moult, crayfish feels soft, like gelatin			**AM**: post-moult, light, clean appearance, carapace often feels leathery				
DISEASE	**PD**: porcelain disease, underside of tail is opaque white	**BS**: burnspot disease, discoloured patches on exoskeleton, usually dark in centre and reddish at rim, looks like rust			**CW**: crayfish worms, few mm, white, attached to surface			**CP**: crayfish plague, abnormal behaviour, stiffness in joints, dark patches at junction of legs and tail. **WARNING!!**			
METHOD	**M**: manual search of selected refuges (recommended method)			**N**: netted in vegetation or other refuges, by sweep-netting or kick search					**BT**: baited trap	**UT**: unbaited trap	
MARK	**OLU**: outer left uropod (dorsal view)	**ILU**: inner left uropod	**T**: telson	**IRU**: inner right uropod	**ORU**: outer right uropod		**PML**: paint mark left claw		**PMR**: paint mark right claw		

Appendix 3 Survey data tables

The survey data from all 15 SACS are provided in this Appendix.

In all the Tables in this Appendix, the following applies:

- The date of the most recent previous crayfish record for a survey site was derived from National Biodiversity Data Centre (NBDC) datasets (https://maps.biodiversityireland.ie/Species/17487).
- The water quality status at survey sites was based on EPA data (*i.e.* the River Water Quality Status 2010–2015 layer, or the Lake Water Quality Status 2010-2015 layer, from https://gis.epa.ie/EPAMaps/). When surveys were carried out at a site where there was a transition between two stretches of river with different EPA Water quality statuses, both statuses were assigned to that survey site.
- Habitat heterogeneity scores were based on the proportion of habitat types at a site that have the potential to act as refuges for crayfish (see Appendix 2 Crayfish Habitat Cards: Refuges).
- CL = carapace length
- Population abundance grades were based on those proposed by Peay (2003) for river surveys using hand search: CPUE > 5, very high; CPUE ≥ 3, ≤ 5, high; CPUE ≥ 1, < 3, moderate; CPUE > 0, < 1, low; CPUE 0, absent/undetected (Abs/Undet).

Table A3.1 White-clawed Crayfish *Austropotamobius pallipes* survey data from the Blackwater River (Cork/Waterford) SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 5 patches for river hand search surveys [10 refuges per patch]; 20 patches for sweep net surveys [one 1 m sweep over and back per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 17 July 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Awbeg River	52.300780, -8.684031	2006	22 Aug	Moderate	0.38	Hand search	5	8	0.17	1.6	Moderate
Awbeg River	52.290520, -8.735557	2003	22 Aug	Moderate/Poor	0.55	Sweepnet	20	1	1.0	0.05	Low
Awbeg River	52.288138, -8.697068	NA	22 Aug	Moderate	0.52	Hand search	5	8	0.83	1.6	Moderate
Awbeg River	52.233955, -8.667667	2006	22 Aug	Moderate/Poor	0.52	Hand search	5	9	0.63	1.8	Moderate
Awbeg River	52.218492, -8.580482	2006	22 Aug	Poor	0.80	Sweepnet	20	0		0	Abs/Undet
Awbeg River	52.201884, -8.471243	2006	22 Aug	Moderate	0.63	Hand search	5	15	0.40	3	High
Awbeg River	52.155740, -8.452557	2015	22 Aug	Moderate	0.57	Hand search	5	5	0.75	1	Moderate
Finnow Stream	52.132528, -8.719283	2009	23 Aug	Good	0.57	Sweepnet	20	5	1.0	0.25	Low
SAC Overall							**85**	**51**		**0.6**	**Low**

Table A3.2 White-clawed Crayfish *Austropotamobius pallipes* survey data from the Bricklieve Mountains and Keishcorran SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 10 patches for lake hand search surveys [10 refuges per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 22 July 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Lough Labe	54.060123, –8.419909	2007	17 July	NA	0.45	Hand search	10	67	0.65	6.7	Very High
SAC Overall							**10**	**67**		**6.7**	**Very High**

Table A3.3 White-clawed Crayfish *Austropotamobius pallipes* survey data from Glenade Lough SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 10 patches for lake hand search surveys [10 refuges per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 22 July 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Glenade Lough	54.358920, -8.259916	2007	9 Aug	Poor	0.48	Hand search	10	34	0.19	3.4	High
Glenade Lough	54.360418, -8.259746	NA	9 Aug	Poor	0.32	Hand search	10	13	0	1.3	Moderate
Glenade Lough	54.362262, -8.260799	NA	9 Aug	Poor	0.46	Hand Search	10	21	0.46	2.1	Moderate
SAC Overall							**30**	**68**		**2.27**	**Moderate**

Table A3.4 White-clawed Crayfish *Austropotamobius pallipes* survey data from Kilroosky Lough Cluster SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 20 patches for sweep net surveys [one 1 m sweep over and back per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 23 July 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Kilroosky Lough	54.192266, -7.244821	2007	21 July	NA	0.54	Sweep net	20	12	0.75	0.6	Low
Kilroosky Lough	54.192253, -7.244370	2007	21 July	NA	0.46	Sweep net	20	29	0.93	1.45	Moderate
Summerhill Lough	54.199029, -7.248958	2006	21 July	Moderate	0.54	Sweep net	20	0		0	Abs/Undet
SAC Overall							**60**	**41**		**0.68**	**Low**

Table A3.5 White-clawed Crayfish *Austropotamobius pallipes* survey data from Lough Bane and Lough Glass SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 10 patches for lake hand search surveys [10 refuges per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 31 July 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Lough Bane	53.691114, -7.169217	NA	20 July	High	0.57	Hand search	10	0		0	Abs/Undet
SAC Overall							**10**	**0**		**0**	**Abs/Undet**

Table A3.6 White-clawed Crayfish *Austropotamobius pallipes* survey data from Lough Corrib SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 10 patches for lake hand search surveys [10 refuges per patch]); 5 patches for river hand search surveys [10 refuges per patch]; 8 patches for surveys using baited traps [1 trap per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 17 July 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Lough Corrib	53.420769, -9.150156	2004	23 June	Moderate	0.31	Hand search	10	0		0	Abs/Undet
Lough Corrib	53.393522, -9.136644	NA	23 June	Moderate	0.31	Hand search	10	0		0	Abs/Undet
Lough Corrib	53.426607, -9.146269	2004	27 June	Moderate	0.35	Hand search	10	0		0	Abs/Undet
Lough Corrib	53.416450, -9.060853	2004	27 June	Moderate	0.35	Hand search	10	0		0	Abs/Undet
Lough Corrib	53.386770, -9.076210	NA	27 June	Moderate	0.29	Hand search	10	0		0	Abs/Undet
Mill Stream	53.396103, -8.616108	NA	22 June	Moderate	0.57	Hand search	5	25	0.63	5	High
Abbert River	53.440193, -8.749890	2005	26 June	Moderate	0.45	Hand search	5	0		0	Abs/Undet
Grange River	53.535504, -8.665214	NA	4 July	Moderate	0.60	Hand search	5	0		0	Abs/Undet
Grange River	53.520147, -8.685017	2015	26 June	Good/Moderate	0.36	Hand search	5	0		0	Abs/Undet
Grange River	53.476521, -8.788792	2012	26 June	Good	0.44	Hand search	5	0		0	Abs/Undet
Yellow River	53.629655, -8.640307	NA	28 June	Good	0.38	Hand search	5	25	0.72	5	High
Sinking River	53.614279, -8.823205	NA	4 July	Good	0.25	Baited traps	8	0		0	Abs/Undet
Dalgan River	53.688006, -8.732310	1994	28 June	Good	0.45	Hand search	5	26	0.92	5.2	Very high
Dalgan River	53.625850, -8.861329	2015	4 July	Good/Moderate	0.50	Baited traps	8	2	0	0.25	Low
SAC Overall							**101**	**78**		**0.77**	**Low**

Table A3.7 White-clawed Crayfish *Austropotamobius pallipes* survey data from Lough Gill SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 10 patches for lake hand search surveys [10 refuges per patch]; 5 patches for river hand search surveys [10 refuges per patch]; 20 patches for sweep net surveys [one 1 m sweep over and back per patch]). The date of the most recent crayfish record for a site was derived from ng NBDC datasets accessed on 8 August 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Lough Gill	54.258860, -8.313845	NA	17 August	Poor	0.43	Hand search	10	0		0	Abs/Undet
Lough Gill	54.257933, -8.426517	NA	17 August	Poor	0.28	Hand search	10	0		0	Abs/Undet
Doon Lough	54.274558, -8.315937	2007	17 August	NA	0.28	Sweep net	20	0		0	Abs/Undet
Cartron River	54.273895, -8.326385	NA	17 August	Poor	0.33	Hand search	5	0		0	Abs/Undet
Bonet River	54.351160, -8.247084	2009	9 August	Good	0.60	Hand search	5	19	0.07	3.8	High
Bonet River	54.319859, -8.200970	NA	9 August	Good	0.38	Hand search	5	1	0	0.2	Low
Bonet River	54.266522, -8.221063	NA	18 August	Good	0.42	Hand search	5	0		0	Abs/Undet
Bonet River	54.220935, -8.279264	2006	18 August	Moderate	0.38	Hand search	5	3	1.0	0.6	Low
Shanvaus River	54.288594, -8.209148	1994	9 August	Good	0.17	Sweep net	20	6	0.83	0.3	Low
Owenmore River	54.304174, -8.119850	2006	9 August	Good	0.33	Sweep net	20	0		0	Abs/Undet
Owenmore River	54.301394, -8.188083	2006	9 August	Good	0.33	Hand search	5	0		0	Abs/Undet
Ardakip River	54.211299, -8.309639	NA	18 August	High	0.45	Hand search	5	0		0	Abs/Undet
SAC Overall							**115**	**29**		**0.25**	**Low**

Table A3.8 White-clawed Crayfish *Austropotamobius pallipes* survey data from Lough Hoe Bog SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 10 patches for lake hand search surveys [10 refuges per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 1 August 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Lough Talt	54.076638, -8.918536	2007	17 August	Good	0.36	Hand search	10	42	0.76	4.2	High
Lough Talt	54.086663, -8.923945	NA	17 August	Good	0.46	Hand search	10	19	0.80	1.9	Moderate
Lough Talt	54.077605, -8.920683	NA	17 August	Good	0.35	Hand search	10	27	0.68	2.7	Moderate
SAC Overall							**30**	**88**		**2.93**	**Moderate**

Table A3.9 White-clawed Crayfish *Austropotamobius pallipes* survey data from Lough Lene SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 10 patches for lake hand search surveys [10 refuges per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 1 August 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Lough Lene	54.660453, -7.194888	NA	14 July	Good	0.41	Hand search	10	0		0	Abs/Undet
Lough Lene	53.665647, -7.256079	NA	14 July	Good	0.53	Hand search	10	0		0	Abs/Undet
Lough Lene	53.673383, -7.242622	NA	14 July	Good	0.50	Hand Search	10	0		0	Abs/Undet
SAC Overall							**30**	**0**		**0**	**Abs/Undet**

Table A3.10 White-clawed Crayfish *Austropotamobius pallipes* survey data from Lough Nageage SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 10 patches for lake hand search surveys [10 refuges per patch]; 20 patches for sweep net surveys [one 1 m sweep over and back per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 3 August 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Lough Veenagreane	54.614084, -7.722408	2007	16 August	NA	0.42	Hand search	10	2	0.5	0.2	Low
Lough Veenagreane	54.614167, -7.721389	NA	16 August	NA	0.33	Hand search	10	5	1.0	0.5	Low
Lough Nageage	54.613271, -7.739057	NA	16 August	NA	0.16	Sweepnet	20	0		0	Abs/Undet
Lough Nageage	54.611482, -7.739679	2007	16 August	NA	0.17	Sweepnet	20	0		0	Abs/Undet
SAC Overall							**60**	**7**		**0.12**	**Low**

Table A3.11 White-clawed Crayfish *Austropotamobius pallipes* survey data from Lough Owel SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 10 patches for lake hand search surveys [10 refuges per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 7 August 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Lough Owel	53.570555, -7.406128	NA	11 July	Good	0.40	Hand search	10	105	0.48	10.5	Very high
Lough Owel	53.555975, -7.367273	NA	11 July	Good	0.49	Hand search	10	77	0.45	7.7	Very high
SAC Overall							**20**	**182**		**9.1**	**Very high**

Table A3.12 White-clawed Crayfish *Austropotamobius pallipes* survey data from Lower River Suir SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* usually 5 patches for river hand search surveys [10 refuges per patch]; 20 patches for sweep net surveys [one 1 m sweep over and back per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 9 August 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Owenbeg	52.685097, -7.976237	2007	18 Sept	Good	0.50	Hand search	5	4	0.75	0.8	Low
Clodiagh River	52.689909, -7.933720	2011	18 Sept	Good		Hand search	1	2	0.5	2	Moderate
Clodiagh River	52.628964, -7.924185	2007	18 Sept	Good	0.27	Sweepnet	20	1	1	0.05	Low
River Suir	52.615078, -7.895219	NA	18 Sept	Good	0.67	Hand search	5	10	0.5	2	Moderate
River Suir	52.539643, -7.932007	2014	18 Sept	Good	0.58	Hand search	5	16	0.56	3.2	High
Multeen	52.572778, -8.125820	2007	19 Sept	Good	0.42	Hand search	5	2	1	0.4	Low
Multeen	52.568574, -8.015694	NA	19 Sept	Moderate	0.08	Sweepnet	20	0		0	Abs/Undet
Multeen	52.520057, -8.021972	2006	19 Sept	Good	0.43	Hand search	5	10	0.4	2	Moderate
River Suir	52.459642, -7.996604	2014	19 Sept	Good	0.58	Hand search	5	37	0.18	7.4	Very high
River Aherlow	52.409598, -8.202088	NA	20 Sept	Moderate	0.42	Hand search	5	0		0	Abs/Undet
River Aherlow	52.417213, -7.975441	2011	19 Sept	Good/Moderate	0.52	Hand search	5	1	0	0.2	Low
River Suir	52.310404, -7.879830	2011	19 Sept	Good	0.58	Hand search	2	2	1	1	Moderate
River Duag	52.274991, -7.994701	2008	20 Sept	Good	0.45	Sweepnet	20	0		0	Abs/Undet
River Tar	52.292963, -8.022550	2007	20 Sept	Good	0.37	Sweepnet	20	1	1	0.05	Low
River Tar	52.273516, -7.848962	2007	20 Sept	Good	0.35	Sweepnet	20	0		0	Abs/Undet
River Nier	52.273521, -7.757460	NA	20 Sept	Good	0.47	Hand search	5	0		0	Abs/Undet

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Glenary River	52.325382, -7.747268	NA	21 Sept	NA	0.43	Hand search	5	0		0	Abs/Undet
Clashawley River	52.430510, -7.649319	2014	20 Sept	Good	0.50	Hand search	5	10	0.1	2	Moderate
Anner River	52.468074, -7.608144	2005	20 Sep	Good	0.47	Hand search	5	6	0.33	1.2	Moderate
River Suir	52.355234, -7.508889	NA	21 Sept	Good	0.33	Sweepnet	20	0		0	Abs/Undet
Lingaun River	52.357528, -7.388670	NA	21 Sept	Good	0.52	Hand search	5	0		0	Abs/Undet
Clodiagh Lower River	52.283950, -7.383063	2011	21 Sept	Good	0.48	Hand search	5	0		0	Abs/Undet
SAC Overall							**193**	**102**		**0.53**	**Low**

Table A3.13 White-clawed Crayfish *Austropotamobius pallipes* survey data from River Barrow and River Nore SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* 5 patches for river hand search surveys [10 refuges per patch]; 20 patches for sweep net surveys [one 1 m sweep over and back per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 18 August 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Glenlahan River	53.147469, -7.482868	2006	5 Sept	Good	0.47	Hand search	5	0		0	Abs/Undet
River Barrow	53.155229, -7.368597	2009	5 Sept	Good	0.38	Sweepnet	20	4	1.0	0.2	Low
Owenass River	53.096161, -7.379539	2003	5 Sept	Moderate	0.48	Hand search	5	6	0.33	1.2	Moderate
River Barrow	53.145743, -7.070380	2015	5 Sept	Poor	0.08	Sweepnet	20	12	0.83	0.6	Low
Stradbally River	53.022161, -7.112317	2011	5 Sept	Good/moderate	0.43	Hand search	5	7	0.14	1.4	Moderate
Tully Stream	53.064586, -7.022518	2014	7 Sept	Good	0.67	Sweepnet	20	7	1.0	0.35	Low
River Barrow	52.940759, -6.954147	2014	7 Sept	Moderate	0.40	Sweepnet	20	21	0.76	1.05	Moderate
Lerr River	52.913989, -6.832800	NA	7 Sept	Moderate/poor	0.35	Hand search	5	1	0	0.2	Low
Fushoge River	52.841766, -6.972272	NA	7 Sept	Good	0.22	Hand search	5	3	1.0	0.6	Low
Madlin River	52.728789, -6.983766	2006	7 Sept	Moderate	0.47	Hand search	5	0		0	Abs/Undet
Ballyroughan River	52.566810, -6.876871	NA	7 Sept	Good	0.25	Sweepnet	20	0		0	Abs/Undet
River Barrow	52.539076, -6.955323	2016	7 Sept	Poor	0.32	Sweepnet	20	2	1.0	0.1	Low
Delour River	53.002166, -7.583092	1991	4 Sept	High	0.42	Hand search	5	0		0	Abs/Undet
Mountrath River	52.976273, -7.473939	1995	4 Sept	Good	0.40	Hand search	5	0		0	Abs/Undet
Erkina River	52.853521, -7.461783	NA	4 Sept	Moderate		Sweepnet	20	0		0	Abs/Undet
River Goul	52.846178, -7.461143	2001	4 Sept	Moderate	0.67	Hand search	5	1	1.0	0.2	Low

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Owenbeg River	52.878434, -7.287754	2010	4 Sept	Good/moderate	0.57	Hand search	5	0		0	Abs/Undet
Dinin River	52.805783, -7.205512	2005	6 Sept	Good	0.22	Hand search	5	0		0	Abs/Undet
Dinin River	52.715329, -7.291671	2001	6 Sept	Moderate	0.38	Hand search	5	0		0	Abs/Undet
Pococke River	52.642474, 7.217122	1995	6 Sept	Good/Poor	0.25	Hand search	5	0		0	Abs/Undet
Munster River	52.587734, -7.467413	NA	6 Sept	Good	0.23	Hand search	5	1	0	0.2	Low
King's River	52.552132, -7.532234	NA	6 Sept	NA	0.38	Hand Search	5	1	1.0	0.2	Low
River Glory	52.508567, -7.286353	NA	6 Sept	Good	0.60	Hand Search	5	0		0	Abs/Undet
SAC Overall							**220**	**66**		**0.3**	**Low**

Table A3.14 White-clawed Crayfish *Austropotamobius pallipes* survey data from River Moy SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* usually 5 patches for river hand search surveys [10 refuges per patch]; 20 patches for sweep net surveys [one 1 m sweep over and back per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 21 August 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Rathnamagh River	54.132677, -9.290067	NA	26 July	High	0.68	Hand search	5	17	0.73	3.4	High
Rappa Stream	54.129271, -9.277934	2016	26 July	High/Good	0.30	Sweep net	20	0		0	Abs/Undet
Deel River	54.112458, -9.256609	2016	26 July	Moderate	0.57	Hand search	5	8	0.88	1.6	Moderate
Toreen River	54.110784, -9.323863	NA	26 July	NA	0.53	Hand search	10	41	0.51	4.1	High
Fiddaunglass	54.055278, -9.309444	2005	26 July	NA	0.48	Hand search	5	3	0	0.6	Low
Addergoole River	54.031284, -9.297383	2010	26 July	Moderate	0.27	Hand search	5	3	0.33	0.6	Low
Tobergal River	53.955420, -9.202756	2007	28 July	Good	0.38	Hand search	5	0		0	Abs/Undet
Clydagh River	53.894551, -9.224351	2013	28 July	High	0.45	Hand search	5	0		0	Abs/Undet
Meander River	53.743654, -9.120131	NA	27 July	Good	0.62	Hand search	5	0		0	Abs/Undet
Manulla River	53.883753, -9.187577	2016	27 July	Good	0.43	Hand search	5	34	0.58	6.8	Very high
Cloonlavis Stream	53.811750, -8.975986	2010	2 Aug	Good/Moderate	0.23	Sweep net	20	0		0	Abs/Undet
Geestaun River	53.819346, -9.027879	2010	2 Aug	High	0.48	Hand search	5	0		0	Abs/Undet
Glore River	53.871364, -8.988633	2010	2 Aug	Good/Moderate	0.60	Hand search	5	1	1.0	0.2	Low
Trimoge River	53.874469, -8.956499	NA	2 Aug	High	0.43	Hand search	5	12	0.5	2.4	Moderate
Gweestion River	53.897234, -9.021463	1998	2 Aug	Good	0.60	Hand search	5	0		0	Abs/Undet
Killeen River	53.928356, -9.022517	NA	31 July	Good	0.55	Hand search	5	4	0.67	0.8	Low

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
Spaddagh River	53.939413, -9.029960	1989	2 Aug	Good	0.47	Hand search	5	0		0	Abs/Undet
Mullaghanoe River	53.969891, -8.765491	NA	31 July	Moderate	0.08	Sweepnet	20	0		0	Abs/Undet
Owenlobnaglaur River	53.983218, -8.687927	1989	31 July	High/Good	0.38	Hand search	5	0		0	Abs/Undet
Owenaher River	54.074504, -8.848935	NA	31 July	Good	0.37	Hand search	5	0		0	Abs/Undet
River Moy	54.111305, -8.748897	NA	31 July	Good	0.25	Hand search	5	0		0	Abs/Undet
SAC Overall							**155**	**123**		**0.79**	**Low**

Table A3.15 White-clawed Crayfish *Austropotamobius pallipes* survey data from White Lough, Ben Loughs and Lough Doo SAC. Catch per unit effort (CPUE) is calculated as the total number of crayfish divided by the number of patches surveyed (*i.e.* usually 10 patches for lake hand search surveys [10 refuges per patch] but only 3 patches in this case due to a lack of refuges at the survey site; 20 patches for sweep net surveys [one 1 m sweep over and back per patch]). The date of the most recent crayfish record for a site was derived from NBDC datasets accessed on 7 August 2018.

Waterbody	Latitude, Longitude of Survey Site	Most recent record	Survey Date	Water Quality Status	Habitat Heterogeneity	Survey Method	No. of patches surveyed	Total no. of crayfish	Proportion juveniles (< 25mm CL)	CPUE	Population abundance grade
White Lough	53.705278, -7.228889	2007	20 July	Good	0.38	Hand search	3	24	0.96	8.0	Very high
White Lough	53.701875, -7.225618	NA	20 July	Good	0.15	Sweepnet	20	9	1.0	0.45	Low
Lough Doo	53.711944, -7.221667	NA	20 July	NA	0.31	Sweepnet	20	1	1.0	0.05	Low
SAC Overall							**43**	**34**		**0.79**	**Low**