Monitoring of white-clawed crayfish *Austropotamobius pallipes* in Irish lakes in 2007

Irish Wildlife Manuals No. 37

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

Monitoring of white-clawed crayfish *Austropotamobius pallipes* in Irish lakes in 2007

William O'Connor[1], Gerard Hayes[1], Ciaran O'Keeffe[2] & Deirdre Lynn[2]

[1]Ecofact Environmental Consultants Ltd.,
Tait Business Centre,
Dominic Street,
Limerick City.

t. +353 61 419477
f. +353 61 414315

e. info@ecofact.ie
w. www.ecofact.ie

[2]National Parks and Wildlife Service, 7 Ely Place, Dublin 2

Citation:
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.

Cover photo: Surveying for crayfish in Lough Glenade, Co. Sligo (© W. O'Connor).

Irish Wildlife Manuals Series Editors: F. Marnell & N. Kingston

ISSN 1393 – 6670

SUMMARY

- This report outlines the findings of a study of the Annex II listed white-clawed crayfish in 26 selected Irish lakes. The white-clawed crayfish is Ireland's only crayfish species and Ireland is thought to hold some of the best European stocks of this species, under least threat from external factors. Lake populations of white-clawed crayfish are rare in Britain and across Europe so this adds to Ireland's unique position in harbouring populations in lime-rich lakes. The current study sought to add to the body of existing knowledge on crayfish stocks in Irish lakes and provide a baseline reference for future studies. The study was carried out during the period June to October 2007 by ECOFACT Environmental Consultants Ltd. on behalf of the National Parks and Wildlife Service.

- Initially, difficulties were encountered with identifying the location of many of the lakes selected for the project, particularly the historical/anecdotal records. It is clear that many of the existing records for crayfish need to be reviewed and updated and an evaluation of the accuracy of some of the existing records should also be undertaken. Ireland had an extremely wet summer in 2007 and this caused difficulties for the current investigation. However, supplementary work was carried out in September and early October, when water levels had dropped back to normal.

- Overall, a total of 26 lakes were surveyed and crayfish were recorded in 13 of these (50%). A total of 359 crayfish were captured, measured, sexed and weighed during the survey. While in some cases different surveying techniques were applied to different lakes, it was concluded that Loughs Kilrooskey, Labe, Gowna, Owel and Talt were the most important lakes for crayfish, of those surveyed. Hand searching using snorkel gear was found to be the most successful method overall and is recommended as the monitoring method of choice for many of the lakes assessed during 2007. Sweep netting was carried out in soft or vegetated areas, but this method proved unsuccessful for many lakes. This was especially found to be the case in stretches of shore containing rocky areas. Trapping was successfully undertaken at four lakes and was confirmed to be a useful, but not consistently effective method. Modifications of mesh sizes on the traps were found to improve catch efficiency. Night searching was found to be useful in some instances, but may often not be practical, particularly due to safety considerations. As part of this study, some electrical fishing was carried out at a number of lakes on an experimental basis. However, the results from these assessments were very variable and catch efficiency was found to be determined by lake conductivity. Overall, the efficiencies of the various survey methods employed were found to vary greatly between habitats.

- The current survey was carried out at a time of year that is considered optimal for crayfish surveying. In June and July, crayfish had already hatched and all crayfish were fully active. By early October, when the survey ceased, crayfish had just begun to mate and two females were noted to have a spermatophore attached to their underside, but egg laying had yet to begin. No berried females were encountered during the current survey. During this survey, a disproportionately small number of hatchling crayfish were recorded. Crayfish are known to hatch in June or July and so hatchlings were expected to have been caught in significant numbers during the current survey. The low numbers of hatchlings captured may have been due to high water levels on some lakes. Overall, the size range and characteristics of crayfish recorded during the current survey was similar to that report from previous studies of Irish lakes. Of the 308 crayfish which were sexed conclusively, 163 were males and 145 were females. A total of 19 crayfish were found to have recently moulted. In lakes such as Loughs Labe and Talt, recent recruitment was detected and these lakes were found to contain a

particularly good range of sizes, thus indicating a healthy population. However, most of the lakes where good catches were realised, had a good range of crayfish sizes present.

- In the lakes where they were found, the average crayfish catch was 16 per 100 refuges. The greatest density of crayfish caught was 50 from a hand-search of 100 refuges in Lough Owel. The least dense crayfish population was indicated from White Lake where only two crayfish per 100 refuges were recorded. The most crayfish caught from any one lake was 85 individuals, at Lough Kilrooskey, Co. Monaghan.

- No non-native crayfish were recorded during the current survey. Moreover, no evidence of crayfish plague or other diseases was detected during the current survey. It is clear that more effort needs to be made to prevent the transport of signal crayfish, crayfish plague and non-native aquatic species into or around the island of Ireland. The re-introduction of crayfish into lakes where they are known to have occurred, or into isolated lakes with suitable habitat, should continue to be considered. A re-introduction project targeting isolated lakes, which are not used for angling, would be especially useful. Isolated populations of white-clawed crayfish are especially valuable in the event of a spread of crayfish plague or alien crayfish species in Ireland. There are also opportunities for habitat enhancement in some of the lakes where crayfish occur.

- The results of the current survey confirm that some Irish lakes still contain excellent stocks of crayfish. White-clawed crayfish remain widely distributed in the Irish midlands where they are locally abundant. The lakes that were found to be important for crayfish varied widely in terms of size, available refuges, substrates present, vegetation cover and water quality. However, the conservation status of crayfish in Ireland may be threatened by the introduction of non-native species, diseases and other factors such as the spread of the zebra mussel. No crayfish were recorded in lakes containing zebra mussels in the current survey.

- Indicative assessments of conservation status are provided for the crayfish populations in each lake. It is considered too early to assign definitive assessments because of insufficient knowledge of the history of crayfish populations in lakes, and/or lack of certainty of status in lakes in this survey where few or no crayfish were caught. It is likely that crayfish occur in some lakes even though they were not recorded in this survey. It is recommended that further work be commissioned by NPWS to enable a more conclusive assessment in the future.

- A manual for crayfish monitoring in lakes is published separately (Reynolds *et al*. in prep.).

TABLE OF CONTENTS

1. INTRODUCTION

This report outlines the findings of a study of white-clawed crayfish (*Austropotamobius pallipes*) in Irish lakes. The study was undertaken during the period June to October 2007. Twenty-six lakes were surveyed and these were widely distributed around the Irish Midlands and West. Some lakes were surveyed on more than one occasion, due to high water levels, which persisted during July and August 2007.

The white-clawed crayfish is protected under both European and Irish legislation. It is protected by the Wildlife Act, 1976 and has been classified as vulnerable in the IUCN Red List. It is also listed under Appendix III of the Bern Convention and Annexes II and V of the EU Habitats Directive (1992). The white-clawed crayfish is Ireland's only crayfish species. Ireland is understood to hold some of the best European stocks of this species, under least threat from external factors. Irish stocks are therefore of substantial conservation importance (Reynolds, 1998). Throughout its natural range across Western Europe, the distribution and abundance of white-clawed crayfish has been dramatically reduced in the last 150 years due to human disturbances such as overfishing, habitat destruction, pollution and the introduction of foreign crayfish species (Reynolds, 1998). In Britain, the North American signal crayfish (*Pacifastacus leniusculus*) was introduced for aquaculture and subsequently escaped into the wild, where it has had a devastating effect on white-clawed crayfish populations. While this species has not been recorded in Ireland, there is a real threat that this alien crayfish species will reach this country. The crayfish plague, which was transmitted by introduced crayfish species and is caused by the fungus *Aphanomyces astaci*, has been found in Ireland since the late 1980s.

Lake populations of white-clawed crayfish are rare in Britain and across Europe, so this adds to Ireland's unique position in harbouring populations in lime-rich lakes. In Ireland's largest lakes, crayfish may be restricted to the areas near the mouths of inflowing rivers, but they have been found to occur throughout many smaller lakes.

The current study sought to add to the body of existing knowledge on crayfish stocks in Irish lakes and provide a baseline reference for future studies. The aims of this investigation were:

- To establish the presence and abundance of white-clawed crayfish in a selection of lakes where there were previous records of this species
- To determine the population structure of white-clawed crayfish in these lakes
- To evaluate various survey techniques for crayfish studies in Irish lakes

The study was carried out by ECOFACT Environmental Consultants Ltd. on behalf of the National Parks and Wildlife Service.

1.1 The white-clawed crayfish

1.1.1 Life-cycle and characteristics of the white-clawed crayfish

Crayfish are large, mobile, freshwater crustaceans and are considered keystone species wherever they occur. They are slow growing compared to other astacids and reach a total length of 9cm and a weight of 40g in five or more years. Their ultimate length is perhaps 12cm (Holdich, 2003). Crayfish grow by moulting their shell and increasing by about 10% in length before the new one hardens. Immature crayfish may moult several times each year, but mature males usually moult twice, in early and late summer. Reproductive females moult only once, in late summer (Reynolds, 1998).

The body is smooth, generally brown to olive in colour, and has a pitted appearance. White-clawed crayfish have a sharp spine on the shoulder of the carapace that does not occur in signal crayfish and is a good way of distinguishing between the two species. Adult males have larger claws than females and are more territorial, especially in the mating season. Females develop a broader abdomen, which accommodates the brood. Males can also be distinguished from females by the specialised first two pairs of appendages on the undersides of the abdomen. The appendages function like a plunger to introduce a white spermatophore onto the underside of the female during mating (Reynolds, 1998).

In Ireland, mating occurs in October to November at a water temperature of around 10°C (Reynolds, 1998), during which males immobilise females with their claws and deposit a white spermatophore on the base of their walking legs. The female's abdominal appendages are more hairy than those of the male and are used to support the mass of eggs, which is glued to them after laying. The number of eggs carried may range from 20 to 160, but is usually less than 100 (Holdich, 2003). Such females are described as "berried" and will over-winter with their clutch. About 50% of the eggs survive to hatch in June or July. The hatchlings remain attached to the mother until their second moult, when they become independent. The female can then resume feeding and moult herself (Reynolds, 1998). The presence of juveniles would indicate a healthy breeding population of white-clawed crayfish. Crayfish can live for more than 10 years and usually reach sexual maturity after three to four years (Holdich, 2003; Reynolds, 1998, Reynolds, 2006).

Plate 1 Male (right) and female white-clawed crayfish from Blessington Lake.

1.1.3 Habitat

White-clawed crayfish can occur in a variety of habitats such as rivers, canals, millraces and lakes (Demers *et al.*, 2005). They occur in a wide range of substrata, once suitable refuges are available. Refuges such as boulders, rocks and cobbles, tree roots, vegetation etc. are used. Juveniles typically occur between weeds and debris in shallow water (Reynolds, 2006). The white-clawed crayfish is largely nocturnal, although it can be seen foraging in the shallow margins of lakes as dusk approaches on warm summer evenings. Freshwater crayfish require relatively hard water with high calcium levels (Gallagher *et al.*, 2006; Reynolds, 1998). Crayfish in Ireland can tolerate some pollution and the species is classified as a 'Group C' (or pollution tolerant) organism by the Environmental Protection Agency (EPA) (Toner *et al*, 2005). A recent report found that "*crayfish were most often found in unpolluted waters but were also found in slightly polluted and moderately polluted waters. Some populations were even found at sites with very low water quality*" (Demers *et al.*, 2005). However, the relationship between water quality and crayfish populations is not fully understood and there have been some cases of crayfish populations being lost from rivers which deteriorated from slightly (Q3-4) to moderately polluted

(Q3) conditions (Reynolds, 2007). It is therefore considered sensible to consider them as a species that is vulnerable to water quality changes.

The grazing impacts of crayfish on aquatic macrophytes have long been known. Such grazing checks primary productivity and in their absence, luxuriant macrophyte growth may occur (Reynolds, 1998). In Irish lakes the white-clawed crayfish prey on a wide variety of benthic invertebrates including snails, crustaceans and insect larvae (Reynolds, 1998). Crayfish of all species seem to prefer animal to plant food (Reynolds, 1998). In White Lake, Co Westmeath, where white-clawed crayfish were re-introduced, sub-yearlings fed chiefly on small entomostracan crustacea and insect larvae. Larger crayfish in this lake fed predominantly on stoneworts, while the largest specimen recorded was feeding on both dead terrestrial vegetation and juvenile crayfish (Reynolds & O'Keeffe, 2005). Dragonfly nymphs and large crayfish may be significant predators of juvenile white-clawed crayfish. Other predators include herons, salmonids, eels, perch and pike. Crayfish are important in the diet of otters (Reynolds, 1998).

Plate 2 Specimen from Lough Kilrooskey.

1.1.2 Conservation Status

The white-clawed crayfish is susceptible to predation and competition by larger, faster-growing and more aggressive introduced species, particularly the North American signal crayfish (*Pacifastacus leniusculus*) (Holdich *et al.*, 1995). Although this American species has not yet reached Ireland, it is a vector of the crayfish plague caused by the (fungi) oomycete *Aphanomyces astaci.* This disease has managed to reach Irish waters and has decimated previously known stocks of white-clawed crayfish

Demers *et al.* (2005) reported that white-clawed crayfish are still widespread in the rivers of the Irish midlands, where the geology is predominantly limestone. However, these authors also report that the distribution of white-clawed crayfish in rivers has been restricted since the mid-1980s. This was attributed in part to an outbreak of the crayfish plague. Demers *et al.* (2005) also reported that crayfish populations in the lakes and rivers of the Boyne catchment were likely to have been affected by crayfish plague, but are currently recuperating, according to Reynolds (2007). However, this effect is geographically isolated (Gallagher *et al.*, 2006). Large unexplained mortalities of crayfish have occurred in some waterbodies including Lough Owel (Demers *et al.*, 2005). Recent data from the EPA suggests a decline in crayfish populations in the north midlands (Reynolds, 2006).

Reynolds (2007) considered crayfish plague the most serious threat to Irish crayfish and listed further pressures, including loss of water quality, loss of habitat through drainage and construction, and introduction of predators and other alien species.

European crayfish possess no resistance to the *Aphanomyces astaci* "plague" fungus that has the potential to eradicate complete stocks of crayfish in a matter of weeks. This fungus attaches to thin areas of cuticle as a spore and then grows through the tissues, leading to death in around two weeks. The swimming spores then transmit directly from the infected or recently dead crayfish (Reynolds, 1998). This disease has caused the eradication of crayfish from Irish lakes including Lough Lene and White Lake. White-clawed crayfish were reintroduced to White Lake by National Parks and Wildlife Service and Trinity College Dublin in 1999 (Reynolds *et al.*, 2000) and were confirmed breeding in 2003 (Demers *et al*., 2005).

Ongoing drainage maintenance on arterially drained rivers in Ireland has also been identified as having an adverse effect of this species (CFB, 2007; O'Connor & McDonnell, 2008). Reynolds (2007) noted that approximately 30% of the river length in Ireland where crayfish occur are currently within SACs, these populations were not being protected from drainage maintenance which has been extensively undertaken in many SAC catchments (i.e. Moy, Boyne and Corrib) (O'Connor & McDonnell, 2008). Although he noted that there have been declines in the populations of crayfish in drained rivers such as the River Clare (Corrib) and tributaries of the Moy in recent years, despite generally improving water quality in these areas (Clabby *et al*, 2008).

The Office of Public Works (OPW), which is charged with maintenance of drainage on most arterially-drained Irish rivers, commissioned an Ecological Impact Assessment of the effects of drainage maintenance activities on crayfish. This study will be published in Summer 2009. As a result of this study and the associated series of recommended mitigation measures, OPW are currently introducing Standard Operating Procedures for operational staff and Environmental Management Protocols for management staff in respect of Crayfish. In addition, there will be ongoing long term studies conducted on Crayfish and Lamprey as part of a longer term Environmental River Enhancement Programme by CFB on behalf of the OPW (N.Gilligan, pers. comm.)

2. STUDY AREA

2.1 Selection of Sites

This study assessed a selected number of lakes for the presence of the white-clawed crayfish. The National Parks and Wildlife Service supplied a list of twenty-five lakes that were to be surveyed. This list was chosen based on information given in Reynolds (2006). The selected lakes were mainly located in the midlands, where the geology is primarily limestone. A variety of lake types and sizes were included on the list, to reflect the diversity of lacustrine habitats in which crayfish occur.

Initially, difficulties were encountered with identifying the location of some of the lakes on the original selected list. In many cases, the names of lakes supplied varied from those shown on the OS maps. Moreover, many of the grid references, catchments and counties on the list were also incorrect. Some lakes such as "Lough Sheehan, Co. Cavan" could not be found, and Loughs Corrib and Mask were added to the list to compensate for this. These two lakes were also included in the above mentioned list of lakes historically known to hold crayfish stocks (Reynolds, 2006). Loughaunwillian in Co. Galway, was the most westerly of the sites surveyed. The original record for this lake was given as "Lough Carraroe (L9475)". However, there is no such lake in this OS area. Loughaunwillian Lake (L9325) is located in the village of Carraroe, so it was considered that this record might relate to this water body.

2.2 Lakes Surveyed

For the purpose of this report, the lakes are discussed on a catchment basis, using the EPA hydrometric maps (Toner *et al.,* 2005). Figure 1 presents the known distribution and range of white-clawed crayfish in Ireland and gives the location of the 2007 survey sites. The location of each of the 26 lakes investigated is given in Figure 2. Table 1 indicates the nature designation and water quality status of each of the subject lakes. The individual lakes and their respective catchments are described in this section.

2.2.1 Ballysadare Catchment

The Ballysadare catchment (EPA Hydrometric Area 35) drains a predominantly lowland area of County Sligo. The rivers in this catchment are the Owenbeg, Owenmore, Douglas, Unshin and Alteen Rivers. These rivers combine to form the Ballysadare River, which drains into the sea at Ballysadare Bay. The soil in this catchment is dominated by acid brown earths and gleys and is underlain in the centre of the catchment by an area of limestone, which runs south-west to north-east. The catchment consists mainly of pasture; peat bogs, natural grassland, small areas of forestry and transitional woodland scrub are also present.

Lough Labe

Lough Labe is a small lake to the east of Kesh Corann in Co. Sligo, located approximately 6km south-east of Ballymote. It has a surface area of approximately 0.06km^2. Lough Labe receives water from a stream that flows from nearby Lough Gowra, approximately 1km to the south of Lough Labe and discharges to groundwater. O'Reilly (1998), reports that this lough is stocked with brown trout *Salmo trutta* and rainbow trout *Oncorhynchus mykiss* for angling purposes. The EPA does not monitor water quality in Lough Labe. Crayfish were observed in the lake in 2006 (Reynolds, 2006). Lough Labe is included in the Bricklieve Mountains and Kesh Corran Special Area of Conservation (SAC),.

2.2.2 Blackwater Catchment

The Blackwater catchment (EPA Hydrometric Area 03) in north County Monaghan is drained mainly by the Blackwater River (EPA Code 03/B/01), a tributary of Lough Neagh. The Cor River and Mountain River (EPA Code 03/M/01) are tributaries of the Blackwater River. The soil in this catchment is composed mainly of surface water gleys with acid brown earths also being important. A small amount of blanket bog is present in the west of the catchment.

Lough Glaslough

Lough Glaslough is located adjacent to the town of Glaslough, 7km northeast of Monaghan town and drains into the Mountain River. It has a surface area of approximately 0.4km^2. Water quality was assessed three times in Lough Glaslough (EPA lake number 255) by the EPA between 2001 and 2003 and was rated as 'Moderately Eutrophic' (Toner *et al.,* 2005).

2.2.3 Boyne Catchment

The Boyne catchment (EPA Hydrometric Area 07) is one of Ireland's larger river catchments, draining a mainly lowland area of approximately 2,500km^2, in the central and eastern part of Ireland. It discharges to the Irish Sea, north of Dublin City. Limestone formations dominate almost the entire catchment. As might be expected in a limestone catchment, the water is alkaline in nature. The effects of peatland excavation, an arterial drainage scheme and eutrophication have impinged on the ecology

of the Boyne catchment since the 1960's (O'Grady, 1998). The original arterial drainage scheme is known to have resulted in the loss of a number of lakes in the catchment and reduction in the size of others (O'Grady, 1998).

Crayfish populations in lakes and rivers of the Boyne catchment are thought to have been decimated by crayfish plague (Reynolds, 1988). Drainage maintenance works in the Boyne catchment have been identified as posing a significant ongoing threat to crayfish stocks in this catchment (O'Connor & McDonnell, 2008).

White Lake

White Lake, noted for its white marl bottom and the clarity of its water, is a small lake located approximately 4.7 km northeast of Castlepollard, Co. Westmeath. It has a surface area of around 0.02km². It is connected to nearby Oldtown and Carrick Loughs by a small stream. The lake is stocked with rainbow trout and some brown trout. Water-quality in White Lake (EPA lake number 491) was sampled 11 times between 2001 and 2003 and was rated as 'Oligotrophic' (Toner *et al.,* 2005). In the 1970s and 1980s White Lake held a very large population of crayfish (O'Keeffe, 1986). However, White Lake was one of the lakes on the Boyne catchment which was affected by crayfish plague. Crayfish were re-introduced into the lake in 1999 (Reynolds *et al.,* 2000) and were confirmed breeding in 2003. White Lake is designated as an SAC.

Plate 3 White Lake, Co. Westmeath.

2.2.4 Corrib Catchment

The Corrib Catchment (EPA Hydrometric Area 30) is located in Counties Galway, Mayo and Roscommon. It has a total catchment area of 3,101 km² (McGinnity *et al.*, 2003). The catchment is drained by a total of 469km of main river channels. The geology of the Corrib catchment, to the east of Lough Corrib, Lough Mask and Lough Carra is dominated by Carboniferous limestone, whereas the geology to the west and north-west of Lough Corrib and to the west of Lough Mask consists of Silurian quartzite, schists and gneiss, with smaller outcrops of granite (Gargan *et al.*, 2002). Overall, the water quality of the Corrib catchment is just above the national average with 73.3% of the river channel classified as satisfactory (Toner *et al.,* 2005). The Corrib catchment, with the exception of some western tributaries of Lough Corrib, was also subjected to a major arterial drainage scheme. This scheme had a major impact on the hydrology and fisheries of the catchment and resulted in the reduction in size of Loughs Corrib and Mask. Significant ongoing impacts on the rivers in this catchment continue as a result of drainage maintenance. Lough Corrib is the premier brown trout fishery in Ireland and has a prolific salmon run, while Lough Mask and Lough Carra are important brown trout fisheries.

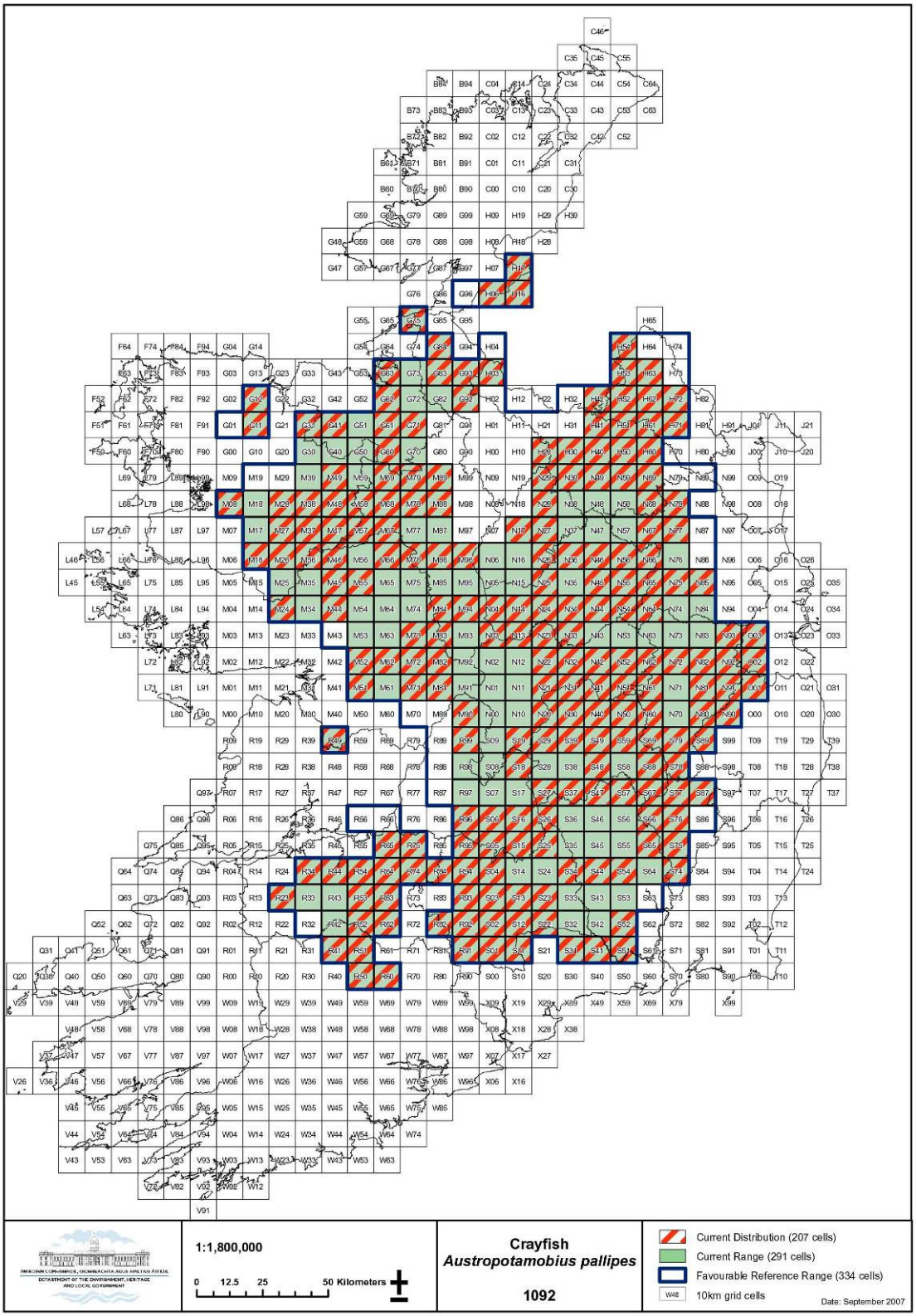

Figure 1 Distribution, range and favourable reference range of white-clawed crayfish in Ireland (for discussion on "favourable" range see p.32.)

.

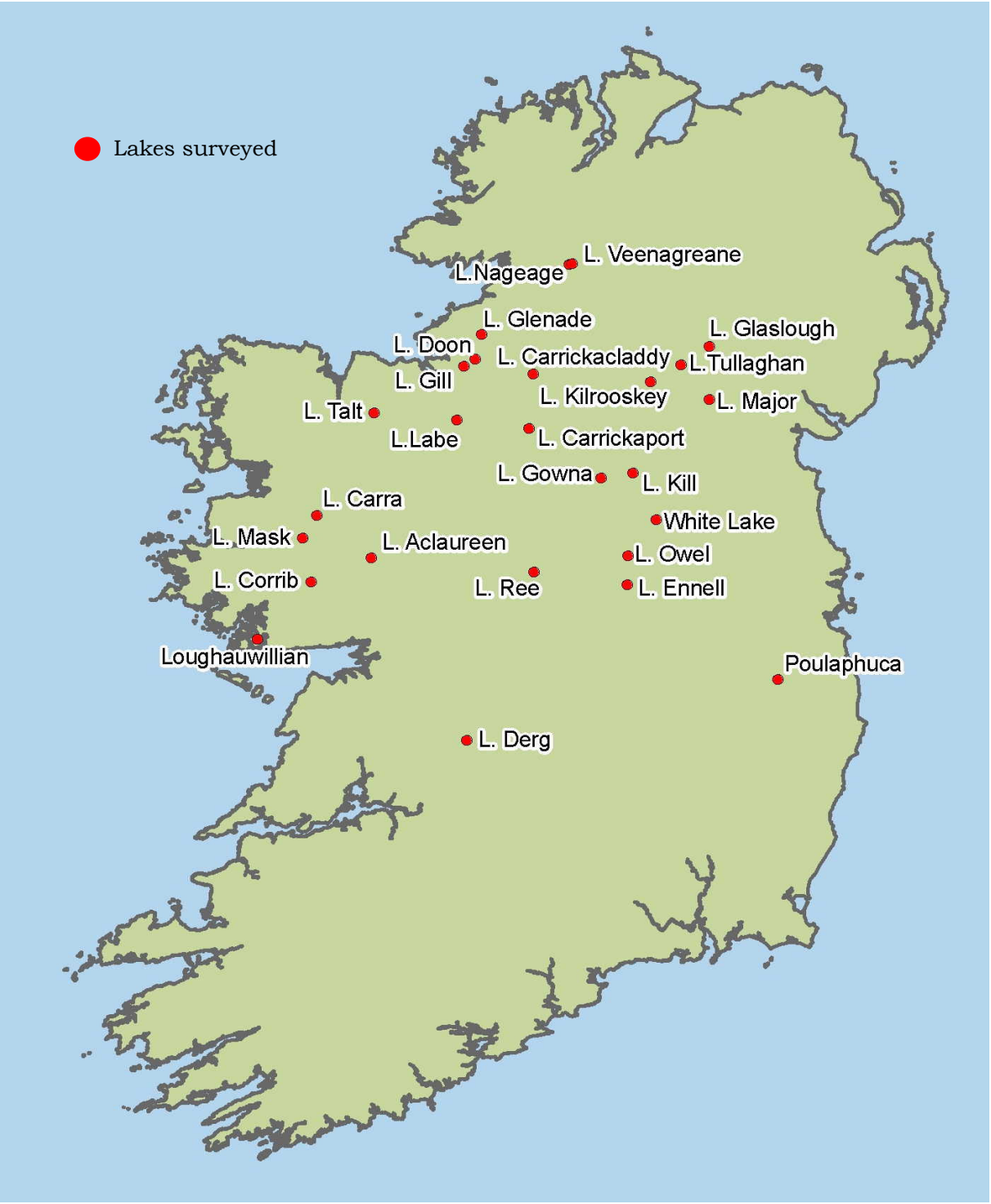

Figure 2 Location of the lakes investigated during the 2007 survey of white-clawed crayfish.

Lough Aclaureen

Lough Aclaureen (or Castlegrove Lake) is a small lowland lake located 5km north-west of Tuam, Co. Galway. The lake has a surface area of 0.01km². The lake drains into the River Clare (EPA code 30/C/01), which is the largest tributary of Lough Corrib. The lake is maintained as a coarse fishery and the EPA does not monitor water quality in Lough Aclaureen.

Plate 4 Lough Aclaureen (or Castlegrove Lake), near Tuam, Co. Galway.

Lough Carra

Lough Carra is a large, gently sloping lake located in southern Mayo. It is connected to Lough Mask by the Keel Canal, but is predominantly spring fed. The lake has clear water and a marl bottom. It has a surface area of approximately 7.5km². Lough Carra's ragged shoreline contains many promontories and islands and it is described as a great trout lake (O'Reilly, 1998). Water quality was assessed in Lough Carra (EPA lake number 114) a total of 35 times between 2001 and 2003 and was rated as 'Oligotrophic' (Toner *et al.*, 2005). Lough Carra is designated as an SAC and a Special Protection Area (SPA).

Lough Corrib

Lough Corrib is the second largest lake on the island of Ireland. It stretches to the north-west of Galway City for over 50km. The lake has a ragged shoreline and contains many islands. It has a surface area of approximately 85km² (O'Reilly, 1998). Water quality at Lough Corrib (EPA lake number 148) was assessed a total of 40 times between 2001 and 2003 and was rated as 'Mesotrophic' (Toner *et al.*, 2005). There are a number of records of crayfish occurring in the lake, including at the mouth of the River Clare (Reynolds, 2006). Lough Corrib is designated as an SAC and an SPA with Crayfish listed as a qualifying interest.

Lough Mask

Lough Mask, a limestone lake, is located in southern Mayo and spans the Galway border. It has a surface area of approximately 80km². Lough Mask is a noted brown trout fishery and also contains arctic char (*Salvelinus alpinus*). Water quality in Lough Mask (EPA lake number 350) was assessed a total of 38 times between 2001 and 2003 and was rated as being 'Mesotrophic' (Toner *et al.*, 2005). Lough Mask is designated as an SAC and an SPA.

2.2.5 Erne Catchment

The Erne catchment (EPA Hydrometric Area 36) has a total catchment area of approximately 4000km² and straddles the border between the Republic of Ireland and Northern Ireland. The main lake basins are underlain principally by carboniferous limestone. There are also important areas of Devonian and carboniferous sandstones and the water chemistry of the lakes reflects the mixture of carbonate-rich water from the limestone and acid water from the sandstone. Crayfish are reported as being locally abundant in the Erne catchment (Gibson, 1998). The Erne system is an important eel fishery and is also one of the few sites in Ireland where the Irish pollan (*Coregonus autumnalis*) occurs. The catchment was significantly affected by a hydroelectric scheme in the 1960's when two generating stations were constructed in the lower reaches of the river.

Lough Gowna

Lough Gowna is an extensive and fragmented lake system that crosses the border between counties Longford and Westmeath and is drained by the River Erne (EPA code 36/E/01). The village of Loch Gowna is located on the north-east shore of the lake. The lake has a surface area of approximately 13.5km² (Toner *et al.*, 2005). It is a popular fishery for both game and coarse fishing. While the numbers of trout have decreased greatly in Lough Gowna, the lake "*still holds some fine trout*" according to O'Reilly (1998). Water quality in Lough Gowna (EPA lake number 279) was assessed a total of 65 times between 2001 and 2003 and was rated as 'Highly Eutrophic' (Toner *et al.*, 2005).

Lough Major

Lough Major is located immediately southeast of the town of Ballybay, in the mid-west of County Monaghan and is drained by the Dromore River (EPA code 36/D/02). The Dromore is a tributary of the Annalee River that flows into Lough Oughter. The lake is very accessible, with a dense road network of secondary, tertiary and other roads, as well as a track along the north shore of the lake. Lough Major has an estimated surface area of 0.24km². Water quality at Lough Major (EPA lake number 349) was assessed three times between 2001 and 2003 and was rated as 'Moderately Eutrophic' (Toner *et al.*, 2005).

Lough Carrickaport

Lough Carrickaport is located approximately 10km north-east of Carrick-on-Shannon, Co. Leitrim. The R210 road runs along its south-east border. The lake has a surface area of approximately 0.46km². The lake drains into nearby Lough Scur, which in turn is drained by the Aghacashlaun River (EPA code 36/A/003) and the Ballyconnell Canal. Water quality in Lough Carrickaport (EPA lake number 115) was assessed a total of 3 times between 2001 and 2003 and was rated as 'Mesotrophic' (Toner *et al.*, 2005).

Lough Veenagreane

Lough Veenagreane is one of three lakes - Lough Nageage and Lough Naveane are the other two- located close together, to the west of Lough Derg in Co. Donegal. The lakes are located at approximately 190m OD in a landscape of mainly unimproved grasslands, commercial forestry and heath. Lough Veenagreane has a surface area of approximately 0.1km². The EPA does not monitor water quality in Lough Veenagreane. It is included in the Lough Nageage SAC.

Lough Nageage

Lough Nageage is located half a kilometre from Lough Veenagreane, c. 6 km to the west of Lough Derg in Co. Donegal and around 9km north-east of the town of Pettigo. It is the largest of the three upland lakes located here. Lough Nageage is drained by the River Derg, via a small stream into Lough Derg (Donegal) (EPA lake number 176). It has a surface area of approximately 0.15km². The EPA does not monitor water quality in Lough Nageage. Lough Nageage is designated as an SAC with crayfish listed as a qualifying interest.

Lough Kill

Lough Kill is located around 11 km south of Cavan town, and an estimated 2.5km north-west of Kilnaleck. It has a surface area of approximately 0.1km². Lough Kill is fed by a small stream from the south-east and is drained by a stream which flows into Lough Corglass, which in turn is drained by the River Erne. The EPA does not monitor water quality in Lough Kill, presumably due to its small size.

Lough Kilrooskey

Lough Kilrooskey is a small lake located on the Fermanagh/Monaghan border, around 1km north north-west of Clones. It is one of three small lakes which drain into the Finn River (EPA code 36/F/01), which is a tributary of Lough Erne. It has a surface area of approximately 0.06km². The EPA does not monitor water quality in Lough Kilrooskey. Crayfish were observed here in 2006 (Reynolds, 2006). Lough Kilrooskey is an SAC with crayfish listed as a qualifying interest.

Plate 5 The south-western shoreline of Lough Kilrooskey.

Lough Tullaghan

Lough Tullaghan, the smallest of all the lakes examined for the presence of crayfish during the current survey, is located an estimated 4km west of Monaghan town centre and drains into the Finn River (EPA code 36/F/01). It has a surface area of approximately 0.002km². It is surrounded by improved agricultural grassland, yet the water quality here appeared to be good during the current survey. The EPA does not monitor water quality in Lough Tullaghan.

2.2.6 Garvoge Catchment

The Garvoge River (EPA Hydrometric Area 35) drains a catchment of approximately 1,000km² of Counties Sligo and Leitrim. The Bonet River (EPA code 35/B/06) drains much of this catchment and the Shanvaus, Owenbeg, Lattone and Straduffy, Skeanda and Scardaun Rivers drain into the Bonet along its upper section. In turn, the Bonet River feeds into Lough Gill. Lough Gill is then drained by the Garvoge River which has a short channel length and drains into the Atlantic Ocean at Sligo Town.

The catchment has a geology of sandstone and shales with some peat bogs in the north, west and south of the catchment. This is overlain predominantly with acid brown earths and surface water gleys, with some peaty podzols in the centre of the catchment. The land cover of the catchment consists of pasture with transitional woodland scrub, peatbogs and small areas of natural grassland also present.

Lough Doon

Lough Doon is a small lake located at 117m OD, seven kilometres east of Sligo Town. It discharges via a small, unnamed stream into Lough Gill. Lough Doon has a surface area of approximately 1km². The EPA does not monitor water quality in Lough Doon, which is included in Lough Gill SAC with Crayfish listed as a qualifying interest

Plate 6 Lough Doon in Co. Sligo.

Lough Gill

Lough Gill is located in County Sligo and crosses the county border into west Leitrim. It is located 2km southeast of Sligo City and west of Sligo Harbour and Ballisadare Bay. Lough Gill is a large lake, about 10km in length (east to west) and 3km at its widest. The R286 road runs adjacent to the lake on its northern shore for approximately 2km. Lough Gill has a surface area of 14.3km². Water quality in Lough Gill (EPA lake number 252) was assessed once in 2001 and was rated as 'Mesotrophic' (Toner *et al.,* 2005). Lough Gill is designated as an SAC with crayfish listed as a qualifying interest. White-clawed crayfish are described in the Lough Gill NPWS site synopses as being well established in the lake. The lake is now infested with zebra mussels (*Dreissena polymorpha*).

Lough Glenade

Lough Glenade is located approximately 10km north-west of Manorhamilton, Co. Leitrim and drains into the Bonet River. Lough Glenade has a surface area of approximately 0.74km². Water quality in

Lough Glenade (EPA lake number 260) was assessed 11 times between 2001 and 2003 and was rated as 'Mesotrophic' (Toner *et al.*, 2005). It is designated as an SAC with Crayfish listed as a qualifying interest. The NPWS site synopsis for Lough Glenade (see www.npws.ie) states that the lake holds a large population of white-clawed crayfish.

2.2.7 Liffey Catchment

The River Liffey (EPA code 09/L/01) flows for 129km, but enters the sea only 19km from its source (Moriarty, 1998). Except where the rivers have cut down to bedrock, the entire catchment, to a height of about 300m, is covered with glacial till, derived mainly from limestone carried southwards. Above this there is granite based till, deposited by local mountain glaciers. The upper catchment is largely sheep pasture, with some conifers also planted. In the middle and lower catchments, mixed farming predominates, as well as suburban housing.

Poulaphuca Reservoir

Poulaphuca Reservoir (also known as Blessington Lake) is located in the upper catchment of the River Liffey. It is a large, man-made lake which was created in 1944 by the ESB, as part of a hydro-electricity scheme. It has a surface area of approximately 12km². The lake holds some natural trout, but is heavily dependent on artificial stocking (O'Reilly, 1998). Water quality in the Poulaphuca Reservoir (EPA lake number 428) was assessed once in 2001 and again in 2003 and was rated as 'Mesotrophic' (Toner *et al.*, 2005). Crayfish naturally colonised Poulaphuca Reservoir and were first noted here from fish traps in 1958 and from the stomach contents of trout and perch (Reynolds, 1998). Poulaphuca Reservoir is designated as an SPA.

2.2.8 Moy Catchment

The Moy catchment (EPA Hydrometric Area 34) is located in the northwest of Ireland and has a total catchment area of 2,100km² (McGarrigle *et al*, 1998). The River Moy (EPA code 34/M/02) is the most important river in the catchment and has a main channel length of 90km. The Moy catchment is located primarily on carboniferous limestone, but there is a swath of harder sedimentary and metamorphic rocks with a small amount of granite, running from the south-west to the north-east along the line of the Ox Mountains. Grassland based agriculture is the dominant land-use in the catchment, with most of the remainder comprising large areas of natural or semi-natural vegetation. Thus, the proportion of the catchment that is not actively farmed is quite high in Irish terms; which is likely to account for the generally high water quality of the rivers and lakes of the Moy catchment (McGarrigle, 1998). The Moy was subjected to a particularly severe arterial drainage scheme in the 1950's and is subjected to regular ongoing drainage maintenance works.

Lough Talt

Lough Talt is located at 135m OD and 16km southeast of Ballina, Co. Mayo and is drained by the Lough Talt River, which discharges into the River Moy. It has a surface area of approximately 0.97km². It holds a large stock of small brown trout (O'Reilly, 1998). Water quality at Lough Talt (EPA lake number 468) was assessed 12 times between 2001 and 2003 and was rated as 'Oligotrophic' (Toner *et al.*, 2005). Crayfish were observed here in 2006 (Reynolds, 2006). Lough Talt is included in the Lough Hoe Bog SAC with Crayfish listed as a qualifying interest. The NPWS site synopses for Lough Talt (see www.npws.ie) states that the lake supports a population of white-clawed crayfish, as well as arctic char.

Plate 7 North-western shoreline of Lough Talt, Co. Mayo.

2.2.9 Shannon Catchment

The Shannon (EPA Hydrometric Areas 25, 26) is the principal river of Ireland. Its freshwater reach extends southwards from the Cavan-Fermanagh border to Limerick, which is a distance of approximately 250km. The total catchment area is over 14,000km² and drains 12 counties completely or in part. The western boundaries of the catchment are defined by the Rivers Lung, Suck and Graney in counties Sligo, Roscommon and Clare respectively; while its eastern limits are the headwaters of the Inny, Brosna, Little Brosna, Nenagh and Mulkear Rivers (Bowman, 1998). Agriculture is the principal land use in the catchment, with 60% under grassland, 5% under tillage and 5% afforested. Approximately 20% of the catchment is covered by peat bogs. The majority of the catchment is underlain by Carboniferous limestone of varying age. Lesser amounts of shales and sandstones occur near the glacially formed Lough Allen; while upper Silurian shales are the dominant rocks at the southern end of the catchment, in the vicinity of Lough Derg (Bowman, 1998). The lower Shannon was subjected to a hydroelectric scheme in the 1920s and several sub-catchment level arterial drainage schemes have also been completed.

Lough Ennell

Lough Ennell is a large, open, steep-sided lake, located around 3km south of Mullingar, Co. Westmeath. The lake bottom is of limestone with a marl deposit and is drained by the River Brosna (EPA code 25/B/09). The lake has a surface area of approximately 14km². Lough Ennell is described as a fishery of note and produces some of the finest brown trout in the country (O'Reilly, 1998). The lake was significantly lowered during the arterial drainage scheme of the River Brosna.

The lake has a history of pollution. Water quality in Lough Ennell (EPA lake number 218) was assessed 26 times between 2001 and 2003 and was assessed as being 'Mesotrophic' (Toner *et al.*, 2005). There are historical records of crayfish occurring around influents in Lough Ennell. Lough Ennell is designated as an SAC and an SPA.

Lough Carrickacladdy

Lough Carrickacladdy is a small lake located at 69m OD, approximately 5km northeast of the village of Dowra, Co. Cavan. Lough Carrickacladdy is drained by the Black River, which subsequently discharges into the upper River Shannon (EPA Code 26/S/02). It has a surface area of around 0.06km². The EPA does not monitor water quality in Lough Carrickacladdy.

Lough Derg

Lough Derg, one of Ireland's largest lakes and the largest lake on the River Shannon, extends into counties Galway, Tipperary and Clare. It has a surface area of 118km² and is regulated by the Shannon scheme. O'Reilly (1998) describes it as "*a great mixed fishery with salmon, trout, pollan and coarse fish all caught*". However, salmon are now becoming increasingly rare in the River Shannon upstream of Parteen Weir. Water quality on Lough Derg (EPA lake number 175) was assessed a total of 12 times between 2001 and 2003 and was rated as 'Mesotrophic' (Toner *et al*., 2005). Lough Derg is designated as an SAC and an SPA.

Lough Ree

Lough Ree is a regulated lake located 2km north of Athlone town and is the second largest lake on the River Shannon. It has a surface area of 105km² (Bowman, 1998). Lough Ree is a coarse and brown trout fishery (O'Reilly, 1998) and the lake also contains one of the few remaining Irish pollan populations. Water quality on Lough Ree (EPA lake number 433) was assessed 23 times between 2001 and 2003 and was rated as 'Mesotrophic' (Toner *et al*., 2005). Lough Ree is designated as an SAC and an SPA.

Lough Owel

Lough Owel is a spring fed lake located 1.5 km north-west of Mullingar town and is drained by the River Brosna. It has a surface area of 9.5km². It holds a good stock of wild brown trout, as well as being stocked annually with brown trout. Water quality was assessed in Lough Owel (EPA lake number 423) 28 times between 2001 and 2003 and was rated as 'Mesotrophic' (Toner *et al*., 2005). Lough Owel is designated as an SAC.

2.2.10 Minor coastal

Loughaunwillian is a part of a minor coastal catchment situated north of Carraroe, in the west of County Galway (EPA Hydrometric Area 31). The soil in this area consists of peaty gleys and renzinas. The Carraroe road (R343) runs alongside the southeast side of the lake for over a kilometre. Loughaunwillian has a surface area of approximately 0.4km². A large area of this catchment consists of peat bogs and urban fabric but the catchment is dominated by pasture. The geology in this small catchment consists of granite. This small catchment consists of a first order stream, which flows from the south of Carraroe village and into Loughaunwillian, which in turn is drained by a first order stream into the sea at Carraroe Quay. The total channel length of the two streams in this catchment is less than 2km. Water quality in Loughaunwillian (EPA lake number 53) was assessed in 2001 and 2003 and was rated as 'Oligotophic' (Toner *et al*., 2005). However, recently there have been a number of water quality problems in the lake and it is planned to stop using it as a municipal supply.

Plate 8 Loughaunwillan Lake, Carraroe, Co. Galway.

Table 1 List of the 26 lakes surveyed with their nature designation and water quality status indicated.

Lake	NATURA Site Name	Site codes		Water quality**
		SAC	SPA	
Lough Labe	Bricklieve Mountains & Keishcorran	1656		
Lough Glaslough				M-E
White Lake	*White Lough Ben Loughs & Lough Doo	1810		O
Lough Aclaureen				
Lough Carra	Lough Carra/Mask complex	1744	4051	O
Lough Corrib	*Lough Corrib	0297	4042	M
Lough Mask	Lough Carra/Mask complex	1744	4062	M
Lough Carrickaport	Lough Carrickaport	1920		M
Lough Gowna	Lough Gowna	0992		H-E
Lough Kill				
Lough Kilrooskey	*Kilrooskey Lough cluster	1786		
Lough Major				M-E
Lough Nageage	*Lough Nageage	2135		
Lough Tullaghan				
Lough Veenagrane	*Lough Nageage	2135		
Lough Doon	*Lough Gill	1976		
Lough Gill	*Lough Gill	1976		M
Lough Glenade	*Lough Glenade	1919		M
Poulaphuca	Poulaphuca		4063	M
Lough Talt	*Lough Hoe Bog	0633		O
Lough Carrickacladdy				
Lough Derg	Lough Derg	2241	4058	M
Lough Ennell	Lough Ennell	0685	4044	M
Lough Owel	Lough Owel	0688		M
Lough Ree	Lough Ree	0440	4064	M
Loughaunwillian				O

*Site selected for white-clawed crayfish

**O: Oligotrophic; M-E: Moderately Eutrophic; M: Mesotrophic; H-E: Highly Eutrophic. From Toner *et al*. (2005).

3. METHODOLOGY

3.1 Introduction

The methodology used in this survey was based on that described in the report '*Manual for monitoring of Irish lake stocks of white-clawed crayfish* Austropotamobius pallipes' by Reynolds (2006). In this manual four survey methods were outlined: hand searching, sweep netting, night searching and trapping. These methods are described below in relation to their implementation in the current survey. Adopting a combination of these approaches reduces sampling bias, which may arise when using one method alone when assessing the density of crayfish and structure of population present (Reynolds, 2006). Therefore, a minimum of two survey methods were used at each lake during the current survey.

Reynolds (1998) recommended that crayfish surveys should avoid the months of November to June, when female crayfish are likely to be 'berried', and the winter months when crayfish tend to be inactive and may move to deeper water. The current survey was undertaken during the period July to early October, so was considered to have taken place at the correct seasonal window.

All equipment used during the current study was carefully treated using a bleach spray, and where possible allowed to dry fully before being employed at another lake. Any vegetation or other debris present on equipment was removed prior to transport. These measures were necessary to prevent the possible spread between lakes of any disease such as crayfish plague, or alien species such as zebra mussels. Standard field forms utilised in the current survey are provided in Appendix 1.

Plate 9 Hand-searching in Lough Doon, Co. Sligo using snorkelling gear.

3.1.1 Health and safety

Appropriate health and safety risk assessments need to be undertaken prior to crayfish surveys and precautions taken to minimise potential risks. Site-specific risk assessments are required before any survey work commences. Potential risks identified prior to the current survey and control measures implemented are shown in Table 2.

3.1.2 Limitations of the current survey

Reynolds (2006) recommended that periods of high water and heavy rain should be avoided when surveying crayfish. However, this was often not possible due to the very wet summer recorded in Ireland during 2007. This high level of rain resulted in an increased water level in many lakes, as well as increased turbidity, which reduces visibility and sampling efficiency. In an attempt to compensate for these conditions, a selection of lakes were resurveyed during September and early October when lakes were at normal water levels. Resurveyed lakes included Loughs Gowna, Kill, Nageage, Veenagreane, Kilrooskey, Major and Labe.

Table 2 Examples of risks associated with crayfish surveying in lakes.

Risk	Control measures
Traffic accidents	• Park in suitable locations away from roads. • Wear high visibility clothing when walking along roads to access sites.
Farm animals	• Assess the presence of farm animals before entering fields. • Do not enter fields with bulls or other potentially dangerous animals.
Falls, trips	• Do not work at night in areas which have not been previously surveyed. • Take care when crossing field boundaries and rough ground.
Accidental entry into water	• Take extreme care when working on, over or adjacent to water. • Avoid lone working – always work in pairs and maintain contact. • Use relevant personal protective equipment (PPE). • Limit night work to areas of the shore that have been surveyed during the day and are considered to be safe.
Waterborne disease (i.e Leptospirosis, Hepatitis B, Poliomyelitus, Tetanus).	• Ensure all staff have up to date vaccinations for waterborne diseases. • Avoid water that is obviously contaminated. • Wear PPE (i.e., wetsuit, gloves, face mask). • Limit emersion time in water • Avoid water entering mouth or eyes. • Wash hands as soon as possible after working around watercourses and always before touching food. • Protect any cuts and grazes using dressings or gloves. • Alert safety officer if you develop flu like symptoms within 3 days of working near water.
Cuts, biological and chemical pathogens	• Avoid physical contact with areas where sharp items/contaminants may exist.

3.2 Survey Methodology

3.2.1 Hand-searching

Hand-searching was carried out at all lakes surveyed during the current survey. At least 100m of shoreline was examined, depending on lake size, but access ultimately determined which sites could be surveyed. A total of 10 suitable patches in each stretch were selected. Then 10 refuges were

investigated per patch. As per Reynolds (2006), where stony stretches were continuous, the whole lakeshore was treated as a stretch and patches were defined at a distance of around 10m apart. Where crayfish were found in abundance, just one stretch per lake was surveyed.

Reynolds (2006) recommended the use of a clear-bottomed viewing basin or plastic aquarium during hand-searching to cut out surface glare. In the current survey, this approach was modified slightly by including the use of snorkelling gear. While the survey technique remained essentially the same as that described in Reynolds (2006), the main advantage of the use of snorkel gear, is the increased visibility and manoeuvrability underwater. The fact that the surveyor is submerged also means that he/she is nearer to the crayfish and this was found to result in increased catch efficiency. This method allowed deeper or more inaccessible areas to be searched, as the surveyor is often swimming over the area being surveyed, as opposed to standing in it. The use of snorkel gear also helps reduce the amount of soft debris disturbed from the lake bed.

3.2.2 Sweep-netting

According to Reynolds (2006), sweep-netting is a useful sampling method where there are no or few stones, or when weed, algae or debris obscure the lake bottom. During the current survey, this method was carried out at most of the lakes investigated. This technique involves using a hand-held pond net and sweeping and re-sweeping a 1m² area of shore. Each standard 1m² sweep of the net was recorded as a sampling unit. A minimum of 20 sweeps were completed at each lake during the current survey. These sweeps were located a distance of 5-10m apart (or further if habitat was patchy). Reynolds (2006) noted that the results of hand-searching and sweep-netting are not directly comparable.

Plate 10 Examining the sweep net catch, Lough Aclaureen, Co. Galway.

3.2.3 Night-searching

According to Reynolds (2006), if the edge shelves abruptly, or the bottom is soft marl or mud which may swirl up if disturbed and obscure vision, night viewing should be considered as an alternative to the other methods. Reynolds (2006) noted that an estimate of lake margin length and width viewed in each area and a count of animals seen will give a semi-quantitative abundance of crayfish moving around in the area. However, it is noted in this report that algal growth may limit usefulness of this method. This method also has limitations, in that it has safety considerations, especially where access is limited or difficult. The use of snorkelling hand searches during the current survey meant that the hand search method could also be undertaken in areas with soft substrates. However, night searching was employed at a number of sites, and with success at Kilrooskey Lake.

3.2.4 Daytime visual assessments

General visual searching of habitat can be undertaken during the day and was undertaken at all lakes investigated. Visual searching can be an important first means of identifying presence of crayfish, as often when turning boulders or sweeping, crayfish may escape capture, but will have their presence visually verified. Similarly, by walking along the lake shore it is possible to confirm crayfish presence by examining for crayfish remains (e.g. moulted carapaces, crayfish remains within otter spraints).

3.2.5 Trapping

Trapping was recommended by Reynolds (2006) for use where the terrain was not ideal for hand-search, sweep-netting or night searching. Baited traps can attract crayfish from an unknown area, probably in a radius of several metres from the traps. Reynolds (2006) recommended setting the baited traps before dusk, and retrieving them early the following day. During the current survey, the August 'Trapy' plastic mesh traps, as recommended by Reynolds (2006) were used. These were set out in two lines of ten traps each. Traps were attached to a light rope, every four metres and as the traps are pre-weighted, no further weights were necessary. The traps were baited with a tinned liver cat-food, which was contained in small plastic mesh boxes.

Plate 11 Setting up traps at Lough Kilrooskey.

Previous studies have found that these traps may benefit from the use of additional mesh, by being able to contain smaller crayfish (e.g. Byrne *et al.*, 1999). In order to test this, 10 traps were modified by the application of 10mm mesh on the outside of the trap. Reynolds (2006) found that night search and trapping will chiefly locate larger crayfish, while hand-searching and sweep-netting methods may find both juveniles and adults but no single method proved suited to all situations. Trapping was described as a time-consuming method, requiring separate visits to set and lift traps, and there are safety considerations and risks of interference by the public. Trapping will produce larger individuals and possibly introduce a sex-bias (Reynolds, 2006; Gallagher, 2006).

3.2.6 Electrical fishing

During the current survey an evaluation of the application of littoral lake electrical fishing as a sampling method for crayfish was undertaken. A Smith Root LR-24 microprocessor-controlled portable electrical fishing unit was employed in this assessment. The electrical fishing was carried out by selecting 10 patches x 10 refuges and fishing each refuge for 20 seconds.

Following completion of this exercise, the same refuges were searched using the hand search method. In general, this method was found suitable for quickly indicating the presence of crayfish in moderate to high conductivity lakes (i.e. Lough Owel). However, crayfish were not affected by the electrical field in low conductivity lakes such as Lough Talt. Overall, it was concluded that this method is unsuitable for application as a crayfish survey methodology.

Plate 12 Electrical fishing at Lough Talt, Co. Sligo.

3.3 Data analyses

Data analyses was undertaken using the data analyses pack provided on Excel 2007 along with Minitab 15. The main data analyses techniques used were correlation (Spearman's Rank) and Principle Components Analyses (PCA). These methods are described in detail in Sokal & Rohlf (1995).

4. RESULTS

4.1 Introduction

A total of 26 lakes (33 sites) were surveyed, and crayfish were recorded in 13 of these (50%). Crayfish were recorded from the Ballysadare, Boyne, Erne, Garvoge, Liffey, Moy and Shannon catchments. A total of 359 crayfish were captured during the survey, while a further 19 crayfish were observed during night-searching. A number of hatchlings recorded during some of the sweep net investigations were not measured. A summary of the sites surveyed, methods used and overall results is provided in Table 3.

The results of the surveys are presented in the following sections and in the series of figures and tables provided at the end of this chapter. The survey sites varied in substrate composition from sites such as those at Lough Aclaureen and Lough Kilrooskey in which the substrate was composed entirely of dead organic matter and vegetation, to lakes such as Lough Talt and Lough Labe, that had rocky shores with exposed bedrock in some cases. Marl lakes such as Lough Corrib, White Lake and Lough Carra were also surveyed. The substrate composition of the sites investigated in terms of rock, cobble, gravel, sand, clay and silt content is shown in Figure 3. Figure 4 shows the relative composition of

potential crayfish refuges from all the sites examined during the 2007 survey. Figure 5 shows the relative composition of crayfish refuges at sites that were found to contain crayfish. The catch per unit effort (CPUE) for the lakes surveyed is provided in Table 4. The percentage distribution of males and females caught and sexed during the current survey is shown in Table 5.

The overall percentage frequency distributions of the carapace lengths (mm) for male and female crayfish caught during the current survey are respectively shown in Figures 6 and 7. Figures 8 and 9 respectively show the overall percentage frequency distribution of the total lengths (mm) for male and female crayfish. The overall weight (g) percentage frequency distributions for male and female crayfish are shown respectively in Figures 10 and 11. The summary statistics for the carapace lengths (mm) of crayfish caught and measured during the current survey are shown in Table 6. Table 7 and 8 provides summary statistics for the total lengths (mm) and weights (g) respectively of crayfish caught during the current survey.

Plate 13 Measuring carapace length using a digital callipers.

Tables 9, 10 and 11 show the results of the mean, minimum and maximum values of the carapace lengths (mm), total lengths (mm) and weights (g) of male and female crayfish. Tables 12, 13 and 14 provide a breakdown by sex, site and month of capture, of the mean carapace lengths (mm), total lengths (mm) and weights (g) of crayfish caught.

Using the Analyses Tools on Excel 2007, untransformed data was analysed to show the correlations between carapace and total length (mm) and carapace length (mm) and weight (g), for male and female crayfish. The mean, minimum and maximum carapace lengths (mm), total lengths (mm) and weights (g) for crayfish caught by various methods are presented in Tables 15, 16 and 17. The Data Analyses Tool pack on Microsoft Excel was used to illustrate the relationships in the data. This analysis found that there is a positive linear correlation between carapace length and total length in both males and females ($y = 2.094x + 0.779$, $R^2 = 0.99$); while a positive exponential correlation was also recorded between carapace length and weight in males and females ($y = 0.000x^{3.023}$, $R^2 = 0.99$). Some outliers were removed during the analyses. These results provide verification that the carapace length is a sufficient measurement for crayfish during field monitoring. The measurement of the carapace length is also the most convenient method, as measuring the total weight requires drying the specimen before using the scales and measuring total length can often be difficult with a live specimen.

Due to prevailing wet weather conditions during the summer of 2007, a number of lakes were resurveyed during the autumn, when lake levels had returned to normal. These lakes were Loughs Gowna, Kill, Nageage, Veenagreane, Kilrooskey, Major and Labe. In Lough Kill, Lough Kilrooskey and Lough Major, the stretch surveyed in the autumn survey (September or early October) was

located in a different area of the lake from that surveyed in the summer. In line with the surveying protocol, these stretches were chosen with considerations for accessibility and habitat. In Lough Kill, Lough Nageage and Lough Major, crayfish were recorded during the autumn survey only. In the case of Lough Kill, most of the crayfish were caught in a small area of cobbles and rock, at the opposite side of the lake to the sites previously surveyed. In Lough Major, the stretch surveyed during autumn survey was considered a more suitable site to the earlier site in terms of substrate and available refuges. In Lough Nageage the same stretch was surveyed in both surveys, but crayfish were only caught during the autumn survey.

Plate 14 Juvenile crayfish from Lough Kilrooskey.

Of the resurveyed lakes in which the same stretch was surveyed in both summer and autumn, only Lough Veenagreane yielded similar results. Substantially significant different results were obtained from Lough Labe and Lough Gowna. In Lough Labe, a total of 21 crayfish were caught from 100 refuges in the summer survey, while 39 crayfish were caught in the equivalent autumn survey. These trends were repeated in Lough Gowna, with 3 crayfish caught during the summer and 23 caught in the autumn. Lough Gowna was surveyed for the first time in August and was reported by local anglers to be "*at least two feet*" above normal water levels. Underwater visibility was poor during the summer survey. The combination of these two factors meant that it was not possible to survey much of the cobble and rock that was present at 3 to 4 metres from the shore during the summer survey. Consequently, only three crayfish were caught by hand-searching at Lough Gowna during the August survey compared to the 22 caught in the autumn. These results give an indication of the influence of lake levels on catch efficiency and the difficulties presented by the prevailing conditions during the summer of 2007.

4.2 Distribution of white-clawed crayfish among the lakes surveyed

Crayfish were caught in 13 of the 26 lakes surveyed. The results were surprising considering that the list of lakes provided all had records of crayfish present. No crayfish were caught at the sites assessed within the Corrib catchment (Loughs Aclaureen, Carra, Corrib and Mask), although crayfish were recorded in Loughs Corrib and Mask in 2004 and 2006 respectively, and may well still be present, but not detected on this survey. As with previous studies, this survey found that the Erne catchment is important for crayfish, as six of the eight lakes surveyed contained crayfish. No crayfish were caught at Lough Carrickaport and Lough Gill despite relatively recent records from these lakes. However, both are now infested with zebra mussels. Indeed, crayfish were not found to be present in any of the lakes where zebra mussels were also present.

The largest lake in which crayfish were found to be present was Lough Gowna in the Erne catchment, which has a surface area of 13.5km^2. The mean surface area of the lakes in which crayfish were caught

was 2.96km²; while the mean surface area of lakes where no crayfish was found was significantly larger, at 32.7 km². This indicates that crayfish were more likely to be found in smaller lakes. According to Reynolds (2006), crayfish are generally limited to smaller lakes although they may occur in medium sized lakes in suitable shallows. Reynolds (1998) also comments that Ireland's largest lakes contain crayfish only near the mouths of inflowing rivers. Crayfish were not recorded from the seven largest lakes surveyed during the current survey.

In all of the 13 lakes in which crayfish were found, hand-searching was the main method employed. Sweep-netting was also widely used and was an important method in lakes such as Lough Kilrooskey, which has a very soft substrate. Trapping also proved useful in certain situations. As would be expected from the results of previous studies, such as Reynolds (2006), the largest crayfish were caught using trapping, with the smallest crayfish caught using sweep-netting.

Plate 15 Zebra mussels on the shoreline of Lough Derg.

4.3 Characteristics of white-clawed crayfish in lakes surveyed

Of the 359 white-clawed crayfish caught, 314 were sexed and 53.5% of these were male while 46.5% were female. The presence of a number of different age groups is suggested by the length and weight data and there was evidence of recent recruitment in most of the lakes surveyed. This recent recruitment which occurred in most lakes indicates a healthy population.

The heaviest crayfish were caught in White Lake. However, only two individuals were caught here. Relatively high mean carapace lengths, total lengths and weight values were recorded in Loughs Glenade and Kilrooskey and in Poulaphuca Reservoir, while relatively low values were recorded in Loughs Kill, Major and Talt. Male crayfish were found to be both larger and heavier than females. There was a strong correlation between carapace and total length in males and females, as well as a strong correlation between carapace length and weight in males and females. Of the 359 crayfish which were recorded during the current survey, a total of 19 (5.29%) were found to have recently moulted and were soft to the touch. A total of 4.1% of crayfish examined during the summer surveys were found to have recently moulted, compared to 6.1% of crayfish examined during the autumn survey. A total of 16 crayfish collected during the current survey were found to be damaged, usually with chelepids missing, or one which was significantly smaller than another. One crayfish had both chelepids missing. Of the damaged crayfish, 56.3% were female.

4.4 Relationship between crayfish catch and habitat

As can be seen from Figures 4 and 5, large cobbles were the main crayfish refuge investigated (25.18% of 3,280 refuges in all lakes surveyed)) and the main refuge which were found to be used by crayfish

(29.28% of 1,400 refuges in lakes where crayfish occurred). Small cobbles and rocks were also very important and together accounted for 37.74% of the refuges assessed and 33.92% of the refuges where crayfish were found. Cobbles and rocks are the main potential refuges available on the shoreline of Irish lakes. Other refuges of importance to crayfish included vegetation such as *Chara* spp.

The results of the Principle Components Analyses (PCA) of selected habitat data found that components 1, 2 and 3 explain 44.2%, 27.4% and 15.2% of the variability in the data. Crayfish CPUE (hand searching) was found to be significantly positively correlated (R^2=0.022, p=0.000) with Component 1, which reflects decreasing depth and shore gradient and increasing vegetation cover (%). No other statistically significant relationships between crayfish CPUE and habitats were found during the current analyses.

Plate 16 Shoreline of Lough Kilrooskey.

4.5 Assessment of the conservation status of crayfish in lakes surveyed

The list of lake sites surveyed during the current survey was derived from a list of lakes from which white-clawed crayfish had previously been recorded. This survey resulted in positive records for 13 of the 26 lakes surveyed. While crayfish may have been present but not found, it seems likely that crayfish may have disappeared from some lakes, although the records for a number of the lakes are considered to be questionable.

As crayfish are listed on Annex II and Annex V of the EU Habitats Directive , Ireland is obliged to maintain, or if necessary, restore, the species at "favourable conservation status". This particularly applies in SACs designated for the species. According to Reynolds (2007), the crayfish range has decreased over the past number of years and coupled with the ongoing pressures to this species' requirements and the threat of disease outbreaks ,the current conservation status is regarded as unfavourable/inadequate. A decrease in the range of lake populations of crayfish has been demonstrated in this survey. Furthermore populations in many lake sites were found to be below favourable levels, based on reference CPUE values for lakes with good abundances of crayfish (i.e. Lough Owel and Lough Talt).

The conservation status of a species may be taken as favourable when:

- Through monitoring, the population has been shown to be self-maintaining in the long term within its natural habitat
- The natural range and habitat of the species is currently favourable, i.e. not in decline or in threat of decline.

- Favourable habitat for the species is assessed as being available in terms of area, over the long-term (Peay, 2003).

The determination of the conservation status of white-clawed crayfish is derived from a number of factors including:

- Crayfish abundance within a site – expressed as CPUE.
- Size distribution and presence of juveniles – reflecting the health of the population.
- The potential for threats to the population to become realized in the future (e.g. spread of disease)

The average catch numbers for the 13 lake sites where crayfish were recorded during the current survey was n=21; lowest catches were from White Lake (n=2) and the highest catch was recorded from Kilrooskey Lough (n=81), following the prescribed methodologies for hand-searching, sweep-netting, trapping and night surveys. Although not all lakes will support the same population densities, due to variations in environmental and physical characteristics, it is possible to establish a CPUE figure to represent a healthy population density, corresponding to a favourable conservation status based on the CPUE figures from this report (Table 4). The occurrence of crayfish in a lake demonstrates the suitable nature of that water body to support a crayfish population and a favourable conservation status is considered to reflect the higher range of CPUE values recorded during this survey.

Plate 17 Surveying at Lough Doon, Co. Leitrim.

Lough Owel returned the highest CPUE for hand-searching (CPUE = 0.5), while Lough Talt returned the highest CPUE for sweep-netting (CPUE = 2.15). Kilrooskey returned the highest CPUE for both trapping and night-survey (1.95 and 1.2 respectively) and as there were high numbers of crayfish recorded from this lake, these figures are taken to infer a favourable conservation status.

The selection of the sampling methodology varies on a lake by lake basis and the use of an inappropriate methodology will result in poor CPUE results, which may affect future assessments of conservation status within the lakes. The advantages of each methodology and the relative suitability to each lake are set out in Appendix 2. Standardisation of recording methodologies will make future monitoring of conservation status more efficient. In order to establish the conservation status of crayfish in Irish lakes, further baseline data on crayfish distribution and population densities will be required; in addition to a monitoring protocol to assess the population trends over time. During ongoing monitoring, threats affecting the crayfish population will require management action. Threats or signals of threats to crayfish will be primarily identified by a reduction in abundance; the reasons for any reductions will require further investigation. This investigation will be aided by the availability of information on water quality records for the site; pollution risks; siltation and

alterations in land use surrounding the water body; and potential risk of introduction of non-native crayfish species or associated transmission of crayfish plague (Peay, 2003). Introduction of non-native crayfish species remains the single most important threat to Irish white-clawed crayfish populations, as these non-native species carry disease which can be detrimental to Irish crayfish populations (Reynolds, 2007).

Plate 18 Lough Glenade, Co. Leitrim

Overall, it is considered that at this stage it is too early to assign definitive assessments of conservation status to the population in each lake, because of insufficient knowledge of the history of populations in lakes, and/or lack of certainty of status in lakes in this survey where few or no crayfish were caught in samples. However, an indicative assessment is presented in Table 18. This assessment broadly follows the EU guidelines for assessing conservation status: (http://circa.europa.eu/Public/irc/env/monnat/library?l=/habitats_reporting/reporting_2001-2007/guidlines_reporting/notesguidelines_2/_EN_1.0_&a=d). However it must be treated with caution and it is recommended that further work be commissioned by NPWS to enable a more conclusive assessment in the future.

4.6 Results from the individual lakes

4.6.1 Ballysadare Catchment

Lough Labe

Approximately 100m of the western shoreline of Lough Labe was surveyed during August 2007. The grid reference of the site investigated was G 72654 12489. This lake was surveyed using both hand-searching, trapping and sweep net sampling. Due to the high water levels during the initial summer survey, this lake was resurveyed at the same site in early October. Trapping was carried out using 10 mesh-modified (10mm) traps. Good numbers of crayfish were present at the site investigated and most of the shoreline areas of this lake would be suitable for use by crayfish. The substrate at the site investigated consisted of rock (5%), cobble (60%) and gravel (35%). Vegetation cover was generally low, but algae occluded much of the substrate. The refuges investigated included small cobbles, large cobbles and small numbers of boulders in some patches. Towards the eastern end of the surveyed stretch, it was noted that rocks had been introduced to the lake, probably when the existing pump house was being constructed. These rocks were piled on top of one another and formed a steep underwater bank. Crayfish were not captured in this area. However, crayfish may be present under these rocks.

Plate 19 Otter spraint with crayfish remains (Lough Labe).

Overall, a total of 68 crayfish were caught in Lough Labe during the current survey; a total of 21 in the August survey (hand-search) and a total of 47 during the site visit in early October (8 in traps and 39 by hand searching). The mean carapace length of those caught in August was 27.7mm (range = 7.5 – 47.7mm). The mean carapace length of the 39 caught during hand searching in October was 27.6mm (range = 11.5 – 41.1mm). The mean carapace length of the 8 crayfish caught using trapping in October was heavier at 31.1 mm (range= 24.7 – 36.6mm). The largest crayfish recorded during the current survey was a male with a carapace length of 47.7mm and was caught during hand searching in August. Sweep-netting was also carried out in the vegetated margins of the shore, and one specimen was captured in 20 sweeps. Macro-invertebrates recorded in the sweep samples included freshwater shrimp, northern caddisfly larvae (Limnephilidae), Glossosomatidae caddisfly larvae, and the Nerite snail *Theodoxus fluviatilis.* Several otter spraints were present in the stretch of shoreline surveyed and they contained a large amount of crayfish remains.

4.6.2 Blackwater Catchment

Lough Glaslough

Lough Glaslough is a small marl lake with a variety of habitats present. No crayfish were recorded during the current survey. Initially, a site located on the western shore (Grid reference H 72193 41400) was accessed through a housing estate. However, reeds encroached the lakeshore and access was very difficult. In addition, an unstable substrate of dead organic matter and reed roots shelved off abruptly into deep water. It was decided to relocate to a more suitable site on the northern shore, where two stretches of shoreline were surveyed, in the grounds of the Castle Leslie estate (Grid reference H 72626 41852). This site was accessed via a small road to the north of the lake that runs between the R185 and a third class road to the northeast of Glaslough.

During this survey, two stretches were hand-searched and ranged between 2 and 9 metres from the shore. Mean and maximum water depths at the time of the survey were 50cm and 80cm respectively. The substrate consisted of cobble (5%), sand (60%) and clay (35%). Due to the shortage of suitable crayfish refuges, searching was concentrated on the borders of the vegetated areas. However, no crayfish or signs indicating their presence were recorded. The vegetation at the site consisted mainly of bulrush, common rush and common club rush with areas of *Chara* spp. also present. The only macro-invertebrate recorded in a sweep net sample was the lesser water boatman (Corixidae). Three juvenile pike (*Esox lucius*) were observed at the site during hand-searching. The shoreline of this area of the lake is affected by horse riding activities. It is recommended that this lake is resurveyed in the future using traps deployed from a boat.

Plate 20 Specimen from Lough Kilrooskey.

4.6.3 Boyne Catchment

White Lake

White Lake is a small marl lake with some good patches of suitable crayfish habitat. This lake was hand-searched during August 2007 and lake levels were considered high in relation to season. However, the lake was clear at the time of the survey and visibility was excellent. The lake was accessed by means of a track that branches off the R195 leading to the southern shore (N 50979 73080). A stretch to the east of the slipway on the southern shore did not produce any crayfish; however, two specimens were caught along the western shore near a small swallow hole. The carapace lengths of these crayfish were 37.12mm and 32.62mm. Another two crayfish were seen at the site but escaped capture.

The substrate at the site where the crayfish were present consisted of approximately 15% rock, 30% cobble, 5% gravel and 25% for each of sand and clay. Approximately 20% of the area surveyed had vegetation cover. The low densities of crayfish meant that those present had a good choice of refuge and were found only under rock and large cobble. Other available refuges recorded included *Chara* spp., discarded tyres and small cobble. The sub-sites searched ranged from 5m to 10m from the shore with mean and maximum water depths of 4cm and 100cm, in that order. A large number of discarded (by anglers) heads and viscera of filleted rainbow trout were present near the slipway area. These were examined for signs of crayfish scavenging, but there was no evidence of crayfish foraging. This indicates that crayfish are present in low numbers in the lake, as some of the rainbow trout remains were quite old. Large shoals of perch were seen during the survey, along with a number of juvenile pike. Large numbers of zooplankton were recorded in the sweep net samples. Other macoinvertebrates recorded were the lesser water boatman and the common bithynia snail *Bithynia tentaculata*.

4.6.4 Corrib Catchment

Lough Aclaureen

Lough Aclaureen is small lake with a soft substrate and heavily vegetated margins. The lake was accessed on foot from the third class road to the north and was surveyed at two sites, using hand-searching and sweep-netting. The outflow stream was also examined qualitatively for crayfish presence. However, no crayfish were recorded in either the lake or the outflow stream.

The lake was surrounded by encroaching reed swamp vegetation. The depth of the lake around the shore was approximately 2m and dropped off quickly at the edge of the reedbeds. The first site, located at the northern protrusion of the lake (M 38621 57863), had a substrate which was comprised completely of dead vegetation and was very soft. The substrate was repeatedly sweeped, sometimes to a depth of 20cm into the substratum and the contents of the net examined for crayfish. Extensive sweep netting was also carried out in the shallow water among the reeds. No crayfish were found, so another site to the south-west, near the outflow was examined (M 38851 57697). A wide range of other invertebrates were recorded during the sweep-net sampling, including pea mussels, damselfly nymphs, whirligig beetles, bithynia snails, hoglouse, greater water boatmen and leeches. Significant numbers of swan mussel (*Anodonta* sp.) shells were found, but no live specimens were recorded.

Lough Carra

Lough Carra was surveyed during June 2007. The survey site was located on the western shore of the lake to the east of the Kilkeeran – Portroyal third class road (M 16667 69192). Both hand-searching and sweep-netting were employed at this site. The substrate of Lough Carra consists mainly of limestone with a marl deposit. The substrate at the 150m stretch of shoreline surveyed consisted overall of 40% rock, 25% cobble, 10% gravel, 20% sand and 5% silt. The potential crayfish refuges searched included small cobble, large cobble, rock and some boulders. The patches searched ranged from 10cm – 70cm in depth, with a mean depth of 43.5cm. The distance of the sites from the shore ranged from 4m – 20m. A large area of common reeds (*Phragmites australis*) was growing to the south of the study site and this area was sampled using sweep-net searches. Areas of *Chara* spp. were also sweep-net sampled.

No crayfish were recorded during the survey work in this area of Lough Carra. Invertebrates recorded in the sweep net samples included diving beetle larvae, freshwater shrimp, northern caddisfly larvae (*Limnephilidae*), lesser water boatman, leeches, orb mussels (*Sphaeridae*) and the wandering snail.

Lough Mask

The site surveyed on Lough Mask was located on the eastern shore of the lake near Ballinrobe. The grid reference of the area investigated was M 14389 65066. The site was accessed via a small gravel road, running through the townland of Curramore and linked to Ballinrobe by a third class road. No crayfish were present.

Plate 21 Lough Mask shoreline near Ballinrobe, Co Mayo

Hand-searches and sweep-net sampling for crayfish were carried out in optimal conditions of high visibility and full sunlight in June. The substrate of the sampled area consisted on average of 25% rock, 55% cobble, 17% gravel, 2% sand and 1% silt. A variety of potential refuges for crayfish were present in the form of small cobble, large cobble, rock, boulders and woody debris. There was a sharp increase in water depth a short distance offshore. The patches searched were not more than 3m from the shore. The water depth at the patches hand searched was on average 35cm deep. Patches of common club-rush were growing in the more sheltered areas and these were surveyed by sweep-netting. Macro-invertebrates recorded in the sweep-net included the Nerite snail, orb mussels, the ramshorn snail (*Planorbis planorbis*), the great pond snail (*Lymnaea stagnalis*) and the common Bithynia. The freshwater shrimp and northern caddisfly larvae (Limnephilidae) were also recorded.

Crayfish were however recorded at Curramore on Lough Mask in September 2006 (C. Peppiatt, pers. comm.).

Lough Corrib

A total of 200 metres of western shoreline of Lough Corrib was surveyed for crayfish during June 2007. No crayfish were recorded at the two selected sites. Methods used were hand-searching and sweep-netting.

The first site was located on the western shore of the lake, 7km west of Headford (M 18864 47591). It was accessed from a gravel road, to the south of the third class road, just before the bridge to Inchiquin. The shoreline to the southern side of the pier was surveyed. The substrate consisted of rock, cobble and gravel with some sand and marl. The potential refuges searched included small cobble, large cobble, rock, boulders and woody debris and ranged in distance from 0.5 to 30m from the shore, with a mean water depth of 40cm. The site was devoid of aquatic vegetation and a small amount of disturbance is likely to be caused in the area by small pleasure boats occasionally travelling to and from the nearby pier. No crayfish were caught at this site on Lough Corrib. The only macro-invertebrates found in the sweep-net samples were larvae of the northern caddisfly, the wandering snail and the orb mussel.

Site 2 was located 13km southeast of the above site, immediately north of Annaghdown Pier (M 28394 37951). A further 10 patches (100 refuges) was searched here. Substrate size was larger here than the previous site, with 20% small cobble, 30% large cobble, 40% boulders and 10% gravel. Areas searched were on average 4m from the shore and the water was shallow with the mean depth being only 25cm. At both sites on Lough Corrib, the clarity of the water was optimal for the purpose of hand-searching, but no crayfish were recorded in either of the two sites. Crayfish were recorded however in July 2004 at Kilbeg Pier and Knockferry Pier (C. Peppiatt, pers. comm).

4.6.5 Erne Catchment

Lough Gowna

Lough Gowna is a medium sized lake, with a shallow rocky shore containing some optimal crayfish habitat. This lake was surveyed twice at the same location – the stretch known locally as 'Paddy Brady's' (N29348 92611) – during both August and October. The part of the lake surveyed was approximately 2km north-west of Loch Gowna village and was accessed by means of the third class road from Loch Gowna. An access road, recently built as part of development works at the area by the Northern Regional Fisheries Board, was used to arrive at the shoreline. The substrate at the site consisted of rock (15%), cobble (30%), gravel (15%) and sand (40%). Approximately 10% of the substrate surveyed was vegetated and roughly 50% of the water surface was shaded. Vegetation at the site consisted mainly of spike rush, jointed rush, water mint and lesser spearwort (*Ranunculus flammula*). Perch and roach were caught while sweep-net sampling on this lake. High densities of Cladocerans were present in the first survey of the lake. Other organisms recorded were diving beetles, wandering snail, lesser boatman and green chironomid larvae.

The first survey was during high water levels in August 2007 and employed hand-searching and sweep-net methods. The low density of likely crayfish refuges meant that over 300m of the shoreline was surveyed (10 patches). Potential refuges examined included large cobble, small cobble, rock and vegetation. Only three crayfish were caught in the August survey (mean carapace length 29.0mm, range = 19.4 – 41.9mm).

Due to the high water conditions experienced during the summer survey, the same stretch of Lough Gowna was resurveyed in early October under normal water levels. This time both hand-searching and trapping were employed. In this later survey, a total of 22 crayfish were caught by hand-searching, while trapping produced one crayfish in 20 traps. The latter had a carapace length of 46.9mm, a large male captured in an unmodified trap. The mean carapace length of the 22 crayfish captured by hand searching was 19.1 mm (range = 13.0 – 39mm). In the second survey, sufficient refuges were found in a 100m stretch of lake, implying that the best refuge habitat was in shallow water when the lake was at normal conditions. One of the crayfish was found in what appeared to be a purpose-built chamber under a small cobble.

Lough Carrickaport

Lough Carrickaport is a small lake with a shallow rocky shore, containing some ideal potential crayfish habitat. The lake was surveyed during August 2007 using both hand-searching and sweep-netting and no crayfish were detected. The lake is infested with zebra mussels.

A site located on the southeast shore (H 01625 08700) adjacent to the R210 was investigated. At this point, the lake slopes gently, with a gradient of approximately 10^{o}. The mean water depth at the sites surveyed was 40cm while the maximum water depth was 70cm. The substrate consisted of rock (15%),

cobble (70%), gravel (10%) and sand (5%). Potential crayfish refuges examined included large cobble, small cobble, rocks and some boulders. Filamentous algae and emergent vegetation were present and the general condition of the lake did not appear to be satisfactory. After one stretch yielded no crayfish, another stretch to the south was investigated. However, this site was also negative for crayfish presence. Approximately 15% of the substrate in the sites surveyed was vegetated by common club rush. As well as *Potamogeton* pondweed, the alien species *Elodea canadensis* was present in this Lough. The Lister's river snail (*Viviparus fasciatus*) was abundant on hard surfaces, while zebra mussels were also present in high numbers. Along with the great pond snail, the only other macro-invertebrate recorded during the sweep-netting was the hog louse.

Plate 22 Lough Carrickaport, County Leitrim.

Lough Kill

Lough Kill is a medium-sized lake, with a gently sloping and heavily vegetated shore. This lake was surveyed during the summer and again in the autumn. Conditions were sub-optimal during the summer survey, due to high water levels. Crayfish were recorded during the autumn survey only. The lake is probably important for crayfish, but has some pollution problems.

A total of 200m of the north shore of the lake was surveyed during August, at a site located at N 42107 91582. Hand-searching was carried out in 10 patches (100 refuges) and sweep-net sampling of vegetated areas was also undertaken. The patches surveyed were at an average distance of 3m from the shore and in depths ranging from 30 to 100cm. The substrate consisted of 60% rock, 10% gravel and 30% silt, while 60% of the substrate searched was vegetated. The surveyed area was partially shaded. The lake appeared polluted with poor visibility. The main cause of this was an algal bloom at the time of the survey. Invertebrates recorded in the sweep net samples included red bloodworms, hog louse, lesser water boatmen and freshwater shrimps. A few patches on the channel joining Lough Kill to Lough Corgalass were also examined. This part of the lake appeared to have been dredged at some stage. A kingfisher was seen here. No crayfish were found at this part of the lake during the summer survey.

A second stretch along the eastern shore was surveyed on Lough Kill in the autumn and the water levels in the lake had dropped somewhat since the previous visit. The grid reference for this site was N 42317 91307. The site was accessed via a small road running through a farmyard on the southern side of the lake. This stretch was found to contain a substrate of rock (5%), cobble (20%), gravel (30%), sand (30%), clay (10%), and silt (5%). Approximately 5% of the substrate was found to be vegetated here, with spike rush and Canadian pondweed. Great pond snails (*Lymnaea* sp.) and hoglouse were recorded in the sweep-net samples.

Crayfish were caught in Lough Kill during the October survey (n=15), but not during the summer survey. The mean carapace length of these were 18.9 mm (range= 11.6 – 37.0mm).

Plate 23 Lough Kill, Co. Cavan

Lough Kilrooskey

Lough Kilrooskey is a small lake with a soft substrate and heavily vegetated margins, mostly of common reed. The lake was surveyed during both August and September. Methods used included visual observations, night searching, hand searching, sweep=netting and trapping. The lake was too high and turbid during August for efficient sampling. The survey work was repeated under optimal conditions during September. In the September survey, sweep-netting and trapping were the most effective methods used. Hand-searching is of limited use on this lake due to excessive depth, vegetation and soft substrate. Overall, a total of 85 crayfish were examined at this lake and it is considered to be a very important habitat for this species. A good size range of specimens was recorded, indicating a healthy population.

The lake was surveyed by hand-searching during August 2007, at a site located at grid reference H 49382 27300 (Site 1). There was a very steep drop-off approximately 1m - 2m from the shore. The patches of potential refuges searched ranged from 1 - 10m from the shore and had a mean depth of 1m and a maximum depth of 1.5m. The substrate, where visible, consisted of sand/silt, but was covered with dense stands of *Chara* sp. Only four crayfish were caught at the site investigated during the August survey. However, it should be noted that hand-searching was difficult, due to depth and water levels were also high at the time of assessment. This survey took place in the evening, when crayfish may have been starting to emerge from refuges.

Lough Kilrooskey was surveyed again during September, when lake levels had returned to normal. A stretch located at H 49221 27451 (Site 2) was investigated, as this appeared more suitable than the previous site after water levels had dropped. Hand searching was carried out and 20 standard sweep-net samples were used to survey shallow, heavily vegetated areas at this site. In addition to these methods, overnight trapping was carried out. Two trains of ten traps were deployed, with each trap set four metres apart. One set of traps was modified with a 10mm mesh covering. The traps were set parallel to the shore. The substrate consisted of a soft sandy material.

Plate 24 Lough Glaslough, Co. Monaghan

Night-searching was carried out at Site 1 in September and a total of 19 crayfish were observed along 16m of shore (i.e. 1.2 crayfish per 3m of shore). In total, 85 crayfish were caught in Lough Kilrooskey. A total of 81 crayfish were caught in Lough Kilrooskey in September, using hand-searching, sweep-netting and trapping. The mean carapace length of these was 27.0mm (range 9mm – 47.6mm). Of the 81 crayfish caught in September, seven were caught using hand-searching. The mean carapace length of these was 36.7mm (range 24.8mm – 47.5mm). The mean carapace length of the 35 individuals caught using sweep-netting in the shallow vegetated areas was 13.9mm (range 9mm – 31.1mm). A total of 39 crayfish were caught using traps; 10 were caught in the unmodified traps (33mm mesh) while 29 were caught in the modified traps (10mm mesh). The mean carapace length of crayfish caught in the unmodified traps was 41.9mm (range 36.4mm – 47.4mm) while the mean carapace length of those caught in the modified traps was slightly smaller at 40.3mm (range 27.8mm – 47.6mm).

Other macro-invertebrates recorded during the sweep netting surveys at Lough Kilrooskey included larval damselflies and dragonflies, Gyrinidae (whirligig beetles) and bithynia snails. Larvae of the Great red sedge caddisfly (*Phryganeidae*) and the northern caddisfly (*Limnephelidae*) were also recorded.

Lough Major

Lough Major is a small lake, with a moderately sloped and stony shore and dense stands of reeds. This lake was surveyed during August 2007, but was revisited during the autumn under more suitable environmental conditions. Crayfish were recorded during the autumn visit only.

A total of c.100m of the shoreline of Lough Major was hand-searched during the August survey. This area was also sampled by sweep-netting; however, no crayfish were recorded by either method. The lake was very high at the time of the survey. This lake was revisited during October and a site at grid reference H 72497 20191 was investigated on the southern shore of the lake. The substrate at this site comprised rock (10%), cobble (40%), gravel (30%), sand (10%) and clay (10%). A total of 15 crayfish were recorded during the hand-searching of 100 refuges during the second site visit. The mean carapace length of these individuals was 19.8 mm (range 11.8mm – 33.7mm). Lesser water-boatmen, red worms, hoglouse and great pond snails were noted. An otter spraint was examined at the site and this did not contain any evidence of crayfish remains.

Plate 25 Lough Tullaghan, Co. Monaghan

Lough Tullaghan

Lough Tullaghan was the smallest lake surveyed during the current investigation. It has heavily vegetated margins and a marshy riparian area. Approximately 50m of the shoreline of Lough Tullaghan was surveyed during August, by means of a hand-search together with sweep-netting. The site (H 61135 34212), was accessed by means of an internal farm road joined to the R187 by a third class road. The substrate was composed of soft, un-compacted organic matter and the water was transparent to the maximum depth of 60cm around the surveyed area. The refuges available at the lake consisted 70% of emergent vegetation roots and 30% dead woody material. In addition to bulrush and common rush, other plants growing in the lake were white-water lily (*Nymphaea alba*), and compact rush (*Juncus conglomeratus*). Invertebrates recorded during the sweep net sampling included orb mussels, hoglouse, great pond snails, and bithynia snails. No crayfish were recorded at Lough Tullaghan.

Lough Nageage

Lough Nageage is a small upland lake with a shallow shore, which is heavily vegetated in places. It was inspected during both July and October at the same site, with crayfish only being recorded in the autumn survey. As with the previous lake, conditions were sub-optimal for surveying during the summer visit due to high water levels and poor visibility.

The site surveyed was located at grid reference M16862 73743 and was examined by hand-searching and sweep-netting on both visits. The substrate consisted of a high percentage of fine sand, which contained a lot of dead organic matter. The lake appeared slightly polluted and the substrate was covered with filamentous algae. The substrate of the surveyed area consisted of boulders (5%), rock (10%), large cobble (10%), small cobble (25%), gravel (20%), and sand/silt (30%).

The same stretch of shoreline was resurveyed in October, under normal water conditions and much improved visibility. A total of five crayfish were recorded by hand-searching along a 100m stretch of shore. A total of 20 traps were set overnight and one crayfish was recorded. The carapace length of the five crayfish caught during hand searching ranged from 11.3mm to 28.4mm. The crayfish caught in the trap was caught in a 10mm mesh-modified trap and had a carapace length of 47.6mm.

Great sedge caddisfly (*Phryganeidae*) larvae, green chironomidae, lesser water boatman (Corixidae), 3-spined stickleback *Gasterosteous aculeatus* and freshwater shrimp were recorded during the sweep-net sampling.

Plate 26 High water levels on Lough Veenagreane during July 2007.

Lough Veenagreane

Lough Veenagreane was surveyed both in July and October during this study, at a site located on the southern side of the lake (H 17970 73991). The site was accessed via a small road off the third class road at Tullynamaltra. This road is in poor condition and future surveyors should note that a 4-wheel drive vehicle is necessary. The substrate at the site consisted of rock (15%), cobble (60%), gravel (20%) and sand (5%). The water level was very high when surveyed during the summer but was at normal levels during the autumn survey. The site was surveyed by hand-searching (120m x 100 refuges) and sweep-netting.

A total of 11 crayfish were caught in Lough Veenagreane by the hand-searching method during the August survey. A further nine were recorded during the September assessment. The crayfish caught in August ranged in size from 15.7mm to 34.1mm while those caught in the autumn survey ranged from 12.1mm to 30.1mm.

Sweep-netting proved difficult at this site, given the hard nature of the substrate and was not an effective method for surveying this lake. Crayfish refuges were mainly underneath large cobbles, as this was the main component of the lakebed around the margin. Larvae of both Baetidae mayfly and dragonfly were recorded in this lake during the sweep-net assessment.

4.6.6 Garvoge Catchment

Lough Doon

Lough Doon is a small upland lake located approximately 2km northeast of Lough Gill. It has a shallow rocky shore with some optimal crayfish habitat. During August, a site along the southern shore (G79471 36232) adjacent to the 3rd class road was surveyed using hand searching. The substrate at the site was found to consist of rock (10%), cobble (20%), sand (35%), clay (15%) and silt (20%). The shoreline gradient was estimated at 10°, while the mean depth of sites surveyed was 30cm with a maximum depth of 60cm. The potential crayfish refuges assessed included rock, *Chara* sp. and emergent vegetation, large cobble and urban debris.

A total of eight crayfish were caught using hand-searching, along approximately 200m of shoreline (100 refuges). The mean carapace length of these crayfish was 24.7mm (range 8.3mm – 31.3mm). No crayfish were recorded during the sweep-netting assessment. Other macro-invertebrates recorded were hoglouse and cased caddisfly larvae of the family *Limnephilidae*. Shoals of perch were also seen during the hand-searching survey.

Plate 27 Female with spermatophore attached.

Lough Glenade

Lough Glenade is a small, upland lake, with a gently sloping, shallow, stony shore mainly of small cobble. It was surveyed from a site located on the south-eastern shore, near the River Bonnet outflow, during August. Access was via a third class road off the R280, which led to a small pier (G83157 45694). Survey methods engaged were hand-searching and sweep-netting.

The habitat patches investigated were located on average 4m from the shore, in a mean depth of 50cm of water; the maximum water depth being 70cm. Substrate at the site consisted of rock (20%), cobble (50%), gravel (20%) and sand/silt (10%). Potential refuges searched were large cobble, rock, small cobble, emergent vegetation and a few boulders.

A total of four crayfish were caught at Lough Glenade with a carapace length range of 27.0mm to 33.0mm. Some good trout were seen to be rising to flies around the shore of the lake. Macro-invertebrates recorded on this lake during the sweep-net sampling were the orb mussel, leech (*Glossiphonidae*), bithynia snail and the ramshorn snail (*Planorbis contortus*). No crayfish were recorded in the sweep-net samples.

Lough Gill

Lough Gill is a medium-sized lake, with a shallow rocky shore. No crayfish were recorded from extensive surveying, during both August and September. This lake is now heavily infested with zebra mussels. The August survey concentrated on Annagh Bay, near the Sligo end of the lake (grid reference G 72336 34614). This stretch of lake is used as a docking area for boats and access was easy, along a small road running parallel to the lakeshore. Sweep-net sampling was carried out and ten patches were hand-searched, an average of 2m from the shore. The area of the patches searched measured on average $2m^2$, the shore gradient was approximately 10^o, while the mean and maximum water depths at the sub-sites was 35cm and 50cm, respectively. The substrate on average consisted of rock (5%), cobble (55%), gravel (35%) and sand (5%). Vegetation cover was approximately 10% and consisted mainly of common reeds. Potential crayfish refuges investigated included small and large cobbles, boulders and vegetation. There were plenty of tyres along the stretch and these were also searched. However, no crayfish were found by either of the methods at this site.

Lough Gill was again surveyed in September at a site located on the eastern shore at grid reference G 79450 34173. This site was next to the R288 and access was straightforward. The area was surveyed using hand-searching and sweep-netting in the vegetated margins of the lake. The patches hand-searched were approximately 4m from the shore in 50cm of water. The substrate at this site consisted

of rock (70%), cobble (20%), gravel (5%) and sand (5%). Molluscan invertebrates were prevalent at this site; the zebra mussel was abundant, while the Nerite (*Theodoxus fluviatilis*) and river limpets were both common. Like the other site at the opposite end of the lake, no crayfish were recorded at this site.

Plate 28 Lough Gill, Co. Sligo / Co. Leitrim

4.6.7 Liffey Catchment

Poulaphuca Reservoir

Poulaphuca Reservoir is a large, artificial reservoir with a mixture of sandy and rocky shores. The reservoir was surveyed during August, at a site located at grid reference N 98015 08179. The site was along the shore to the south of the western end of Valleymount Bridge. The substrate at the site surveyed consisted of 10% rock, 20% cobble, 10% gravel, 25% sand, 20% clay and 15% silt. Potential crayfish refuges investigated here consisted mainly of rocks and cobbles. The shoreline gradient ranged from 10°- 20°. The mean water depth of the surveyed area was 60cm and it was evident that water levels were high at the time of the survey. The sites searched ranged between 3m and 10m from the shore and patch sizes were generally large at over 5m², owing to a scarcity of refuges.

A total of 13 crayfish were caught at this site during the sub-optimal survey conditions. The mean carapace length of these individuals was 29.3 mm (range 18.7 to 42.7mm) and all were caught using hand searching. The only invertebrates found during the sweep-netting were *Gammarus* sp. and green chironomid larvae.

Plate 29 Poulaphuca Reservoir, Co. Wicklow

4.6.8 Moy Catchment

Lough Talt

Lough Talt is a medium sized upland lake with a rocky shore that provides some ideal crayfish habitat. This lake was surveyed twice during August at two sites, located at the southern shore of the lake (both sides of G 39933 14479). It was accessed by a small road off the R294, which follows a course adjacent to the lake. The substrate at the sites surveyed consisted of rock (45%), cobble (30%), gravel (20%) and sand (5%).

An experimental examination of the usefulness of electro-fishing for crayfish sampling was also carried out in this area. This involved electro-fishing of a stretch of the lake and then hand-searching the same stretch afterwards. No crayfish were captured using electrical fishing at Site 1. However a total of 25 crayfish were caught by subsequent hand-searching at this site. Again, no crayfish were caught by electro-fishing at Site 2; however, 22 were caught by hand-searching the same stretch afterwards. It was concluded that the low conductivity of this lake (198 μs cm^{-1}) made electrical fishing redundant. A number of small salmonids were seen swimming away from the electric field during the operation. However, no crayfish were disturbed from the refuges investigated. The mean carapace length of the crayfish recorded by hand searching was 21.1mm ± 6.4mm (range 11.2mm – 34.5mm). A total of 43 hatchlings were recorded during a sweep-netting exercise (20 sweeps) in the shallow part of the shore around vegetation, indicating good recruitment in this upland waterbody. These hatchlings were recorded but not measured, due to time constraints on the evening of the survey.

4.6.9 Shannon Catchment

Lough Carrickacladdy

Lough Carrickacladdy is a small upland lake with a rocky shore. The site (H 02832 30556) was located approximately 150m from the third class road on the eastern shore of the lake. Access to this lake was extremely difficult. Much of the surrounding land was planted with conifers and recent planting had taken place on the land between the lake and the access road. No crayfish were found at Lough Carrickacladdy. Otter spraints were found on a boulder in the study site, but did not contain any evidence of crayfish remains.

A 150m stretch of the south-eastern shore of the lake was surveyed during August 2007. Both hand-searching and sweep-net sampling methodologies were employed. The north-eastern shore of the lake had a steep gradient with bedrock, boulders and overhanging trees. South of this, the shore was more gently sloping with small cobbles offering potential crayfish refuges. The substrate generally consisted of 35% rock, 30% cobble, 15% gravel and 20% silt. Despite full sunshine, visibility was poor underwater, due to peat-tainted floodwaters. There also seemed to be some water quality problems in the lake, possibly caused by runoff of silt and nutrients from the surrounding forestry. Potential crayfish refuges investigated included boulders, large cobbles, rock, small cobble, woody debris, filamentous algae and emergent vegetation.

Plate 30 Lough Carrickacladdy, Co. Cavan

Lough Derg

Lough Derg was surveyed at two locations during June 2007. Methods used were hand-searching and sweep-netting. Site 1 was located in a sheltered inlet, near woodland in the Portumna Demesne (grid reference M83921 02954). The site was accessed by a path from the car parking area. Likely refuges for crayfish examined at this site included mainly rocks and large cobbles. The margins of the lake were vegetated with the common reed and these areas were sweep-sampled. The substrate of the lake in this area had a thick layer of dead filamentous algae and sediment. However, good sunshine and careful surveying enabled effective searching to be carried out. No crayfish were recorded at this site.

Site 2 was located in Portumna Bay, directly south of Portumna and accessed by a third class road leading to a small recreational amenity centre with a docking area (grid reference M 85255 03657). The water in this location was deeper and more heavily vegetated than the previous site. The mean water depth here was 70cm while at least 50% of the water surface was shaded by emergent and floating vegetation. Water lilies and duckweed covered approximately 20% of the water surface at this site. The substrate consisted of approximately 45% rock and cobble and the remainder was silt. Crayfish were searched for under rock, cobbles and woody debris. No crayfish were recorded at this location.

Water quality appeared to be very poor at both sites investigated in Lough Derg. The bed of the lake was covered with zebra mussels. With the exception of cased caddisfly and dragonfly larvae, pollution tolerant macro-invertebrates were the prevalent organisms recorded in the sweep-net samples. These included leeches, freshwater shrimp, bloodworms, hoglouse, orb mussels and the great ramshorn snail (*Planorbarius corneus*).

No crayfish were recorded from the surveyed sites on the northern shore of Lough Derg. However, this does not imply that crayfish are absent from the lake.

Lough Ennell

Lough Ennell was surveyed during June 2007, during normal water levels. The survey site was located on the northern shore at the inflow of the River Brosna (Grid reference N 37649 44453). The substrate of the stretch of shoreline examined consisted of 30% rock, 25% cobble and 25% gravel, 15% sand and 5% silt. The mean depth of the water within the sampled areas was 75cm. Cobbles, rock, boulders, tree roots, *Chara* sp., emergent vegetation and tyres were examined for the presence of crayfish. Emergent vegetation on the lake shore included the common reed, yellow Iris (*Iris pseudacorus*) and reed canary grass (*Phalaris aurudinacea*). An area of common club rush was also

located 30m from the shoreline. Dense *Chara* sp. beds were also present. Both hand-searching and sweep-net sampling were carried out on this lake; however, no crayfish were recorded.

Plate 31 Lough Ennell, Co. Westmeath, at the inflow the River Brosna.

ECOFACT Environmental Consultants Ltd. previously surveyed the western and southern shores of Lough Ennell, during 2004 (O'Connor, 2005). This work was undertaken as part of an Environmental Assessment study for the proposed Royal Canal Water Supply Scheme. No crayfish were found in the lake during this investigation.

A total of eight different macro-invertebrates species were recorded in the sweep-net samples. The community structure suggested ongoing pollution at this lake with leeches, hog louse, freshwater shrimp, orb mussels, and oligochaetes being common. Northern caddisfly larvae as well as the common bithynia *Bithynia tentaculata* were also found.

Lough Owel

Lough Owel was investigated during June 2007. Lakes levels were elevated at the time of survey, however, the water was clear. The survey focused on a 100 metre stretch of the southern shore (N 37621 44429), near the Central Fisheries Board offices. The site was accessed via a third class road leading to a car park and recreational facility. Located to the west of this area is a large wooded plantation of conifers, willows and alders. The shoreline at this area of the lake is intensively utilised for boating and fishing activities. The mean depth of the water in the surveyed area was 80cm and the substrate consisted of 5% rock, 40% cobble, 25% gravel, 25% sand and 5% clay. The potential refuges for crayfish investigated included cobbles, rocks, woody debris, urban debris (tyres) and *Chara* sp. patches. Vegetation on the shoreline consisted of grasses, reed canary grass, Yorksire fog (*Holchus lanatus*), dogs tail (*Cynusorus cristatus*), plantains (*Plantago* spp.) and meadow grasses (*Poa* spp.). The eastern side of this 100m stretch contained dense areas of *Chara* spp.

A total of 50 crayfish were caught during hand-searching during the June survey. The mean carapace length of these crayfish was 29.7mm (range 12.2mm to 43.7mm). The crayfish training day (See Section 4.6 below) was also carried out on this lake on the 4th of September for NPWS staff. Several more crayfish were caught during the training exercise, using hand-searching and sweep-netting. The mean carapace length of these crayfish was 23.0mm (range 18.6mm to 32.4mm). Lough Owel was found to have the highest densities of crayfish in the current survey, based on the hand-searching CPUE.

Plate 32 Shoreline of Lough Owel, Co. Westmeath.

Lough Ree

Two sites were examined on this large lake during June 2007. The shoreline directly in front of the Hodson Bay Hotel was surveyed using hand-searching and sweep-netting (grid reference N 01011 46536). Further investigations were also undertaken at a site located at grid reference N 01399 45390.

Although good crayfish habitat was recorded at both of the surveyed sites, no crayfish were recorded for Lough Ree. Macro-invertebrates recorded in the sweep-net samples included zebra mussel, freshwater shrimp, water skaters, lesser water boatman, bloodworms (Chironomidae) and snails (Lymnaeidae and Hydrobiidae). The absence of crayfish from these two sites does not imply that crayfish are absent from this large lake.

4.6.10 Coastal

Loughaunwillian

Loughaunwillian is a small acidic lake with a stony shore. This site investigated was adjacent to the R343 road at L93958 25435. A total of 150 m of lake shoreline was surveyed by sweep-netting and hand-searched during August, in conditions of good light. This was the only site at this lake that could be accessed and surveyed using these methods. The substrate at the site constituted 20% rock, 50% cobble and 30% gravel. The mean water depth surveyed was 40cm while the maximum was 50cm. There was a sharp fall off at approximately 5m from the shore. The potential refuges searched included large cobble and rock, as well as small cobble and occasional boulders. No crayfish or evidence of this species existence was recorded at this lake. A poor diversity of macro-invertebrates was recorded during sweep sampling; only water mites and two species of snail (Jenkin's spire shell and wandering snail) were found. It is still unclear if this is the "Carraroe Lake" listed in Reynolds (2006). The absence of crayfish from the site investigated in the current survey, combined with the dubious nature of records for Loughaunwillian presents a question over whether this lake held crayfish previously.

4.7 Training day

A training day was provided for the staff of NPWS, at Lough Owel on the 4th of September 2007. This took place at the Shannon Regional Fisheries Board facilities, in Mullingar, Co. Westmeath. Three presentations were made and afterwards a demonstration of the survey techniques used to monitor crayfish populations was given. The first presentations was entitled '*Lifecycle, Ecology and Distribution of Crayfish in Ireland*'.

Plate 33 The demonstration of crayfish survey techniques for NPWS staff carried out at Lough Owel.

Following this, a presentation entitled '*Monitoring of Crayfish in Lakes*' was presented. This outlined the timing and conditions under which crayfish surveying should preferably be carried out and described in detail the survey types which can be used. The proper recording of such surveys was outlined, as well as the measuring and handling of crayfish. Health and safety considerations were discussed and the importance of these was stressed. Finally, the precise methodology of each survey type used was discussed. The third and final presentation was entitled '*Preliminary Results from the Current Survey*'. After the presentations, questions were addressed and a general discussion of white-clawed crayfish conservation in Ireland followed. A practical demonstration of crayfish survey methods (capturing, handling and measurement) was given along the shore of Lough Owel. Following this, participants were invited to try these techniques for themselves and were given the opportunity to see crayfish up close and handle them. The demonstrators again invited any questions or comments from participants.

4.8 Monitoring prescription

A manual for crayfish monitoring in lakes is published separately (Reynolds *et al*. in prep). A summary of crayfish survey methodologies is provided in Table A2.1 of Appendix 2. All of these methods are based on the '*Manual for monitoring white-clawed crayfish,* Austropotamobius pallipes *(Lereboullet)*' by Reynolds (2006). It is hoped that the status of the Irish population will be better understood through future surveying and monitoring. For sustained lake monitoring, the survey methods should be repeated periodically at the same sites and under similar conditions, to ensure accurate monitoring of Irish lake crayfish stocks.

A monitoring prescription for each of the lakes surveyed during the current project is published separately (Reynolds *et al*. in prep). Monitoring is recommended for Lough Labe, White Lake, Lough Gowna, Lough Kill, Lough Kilrooskey, Lough Major, Lough Nageage, Lough Veenagreane, Lough

Doon, Lough Glenade, Poulaphuca Reservoir, Lough Talt and Lough Owel. It is recommended that other lakes not surveyed during 2007 also be selected for ongoing monitoring. In lakes where there are records of crayfish, but where crayfish were not found in the 2007 survey, it is proposed that further surveying be carried out to establish the presence or absence of crayfish. These lakes are Lough Aclaureen, Lough Corrib, Lough Mask, Lough Carra, Lough Gill, Lough Carrickacladdy, Lough Carrickaport, Lough Glaslough, Lough Tullaghan, Lough Derg and Lough Ree. It is considered unlikely that Loughaunwillian ever contained crayfish and the accuracy of the original records for this lake should be reviewed. Lough Ennel should perhaps be checked again in few years time for crayfish.

Plate 34 Specimen from Lough Gowna.

Table 3 A summary of the sites surveyed, methods used and results of the 2007 survey.

Catchment	Lakes	No. of Sites	Grid Ref. of Sites	Sampling Methods†	Crayfish detected
Ballysadare	Lough Labe	1*	G 72654 12489	HS, T	✓
Blackwater	Lough Glaslough	1	H 72626 41852	HS, SN	
Boyne	White Lake	1	N 50979 73080	HS	✓
Corrib	Lough Aclaureen	2	M 38621 57863, M 38851 57697	HS, SN	
Corrib	Lough Carra	1	M 16667 69192	HS, SN	
Corrib	Lough Corrib	2	M 18864 47591, M 28394 37951	HS, SN	
Corrib	Lough Mask	1	M 14389 65066	HS, SN	
Erne	Lough Carrickaport	1	H 01625 08700	HS, SN	
Erne	Lough Gowna	1*	N 29348 92611	HS, T, SN, EF	✓
Erne	Lough Kill	2	N 42107 91582, N 42317 91307	HS, SN	✓
Erne	Lough Kilrooskey	2	H 49382 27300, H 49221 27451	HS, T, NS	✓
Erne	Lough Major	2	H 72315 20615, H 72497 20191	HS, SN	✓
Erne	Lough Nageage	1*	M 16862 73743	HS, SN	✓
Erne	Lough Tullaghan	1	H 61135 34212	HS, SN	
Erne	Lough Veenagreane	1*	H 17970 73991	HS, SN	✓
Garvoge	Lough Doon	1	G 79471 36232	HS	✓
Garvoge	Lough Gill	2	G 72336 34614, G 79450 34173	HS, SN	
Garvoge	Lough Glenade	1	G 83157 45694	HS, SN	✓
Liffey	Poulaphuca Reservoir	1	N 98015 08179	HS	✓
Moy	Lough Talt	1	G 39933 14479	HS, SN, EF	✓
Shannon	Lough Carrickacladdy	1	H 02832 30556	HS, SN	
Shannon	Lough Derg	2	M 83921 02954, M 85255 03657	HS, SN	
Shannon	Lough Ennell	2	N 37649 44453	HS, SN	
Shannon	Lough Owel	1	N 41335 36238	HS, SN, EF	✓
Shannon	Lough Ree	2	N 01399 45390, N 01399 45390	HS,SN	
Minor Coastal	Loughaunwillian	1	L 93958 25435	HS, SN	

*In these lakes, the same sites were surveyed in July/August as in September/October. Initial surveys were undertaken during high water levels so some surveys were repeated.

† HS = hand-searched, T = trapped, SN = sweep-netted, EF = electrofished.

Table 4 Catch Per Unit Effort (CPUE) for crayfish at lakes investigated during 2007.

Lake	Site	Survey time	N	Hand-searching	Sweep-netting	Trapping	Night-Search
Labe	1	August	21	0.21			
	1	September	47	0.39	0.05	0.8	
White	2	August	2	0.02			
Gowna	1	August	3	0.03	0		
	1	October	23	0.25	0	0.05	
Kill	2	October	15	0.15	0		
Kilrooskey	1	August	4	0.04	0		
	2	October	81	0.07	1.75	1.95	1.2
Major	2	October	15	0.15	0		
Nageage	1	October	6	0.05	0	0.05	
Veenagreane	1	August	11	0.11	0		
	1	October	9	0.09	0		
Doon	1	August	8	0.08			
Glenade	1	August	4	0.04	0		
Poulaphouca	1	August	13	0.13			
Talt	1	August	47	0.47	2.15		
Owel	1	June	50	0.50	0.15		

CPUE: Hand-searching: crayfish/refuge; Sweep-netting: crayfish/standard sweep; Trapping: crayfish/trap; Night-searching: crayfish/3 metres of shoreline.

Table 5 Percentage distribution of males and female crayfish by lake (all methods combined, n=314).

Lake	(n)	% Male	% Female
Doon	8	50.0	50.0
Glenade	4	75.0	25.0
Gowna	26	53.8	46.2
Kill	15	53.3	46.7
Kilrooskey	85	54.1	45.9
Labe	68	51.5	48.5
Major	15	66.7	33.3
Nageage	6	66.7	33.3
Owel	28	64.3	35.7
Poulaphuca	13	38.5	61.5
Talt	24	45.8	54.2
Veenagreane	20	45.0	55.0
White	2	50.0	50.0

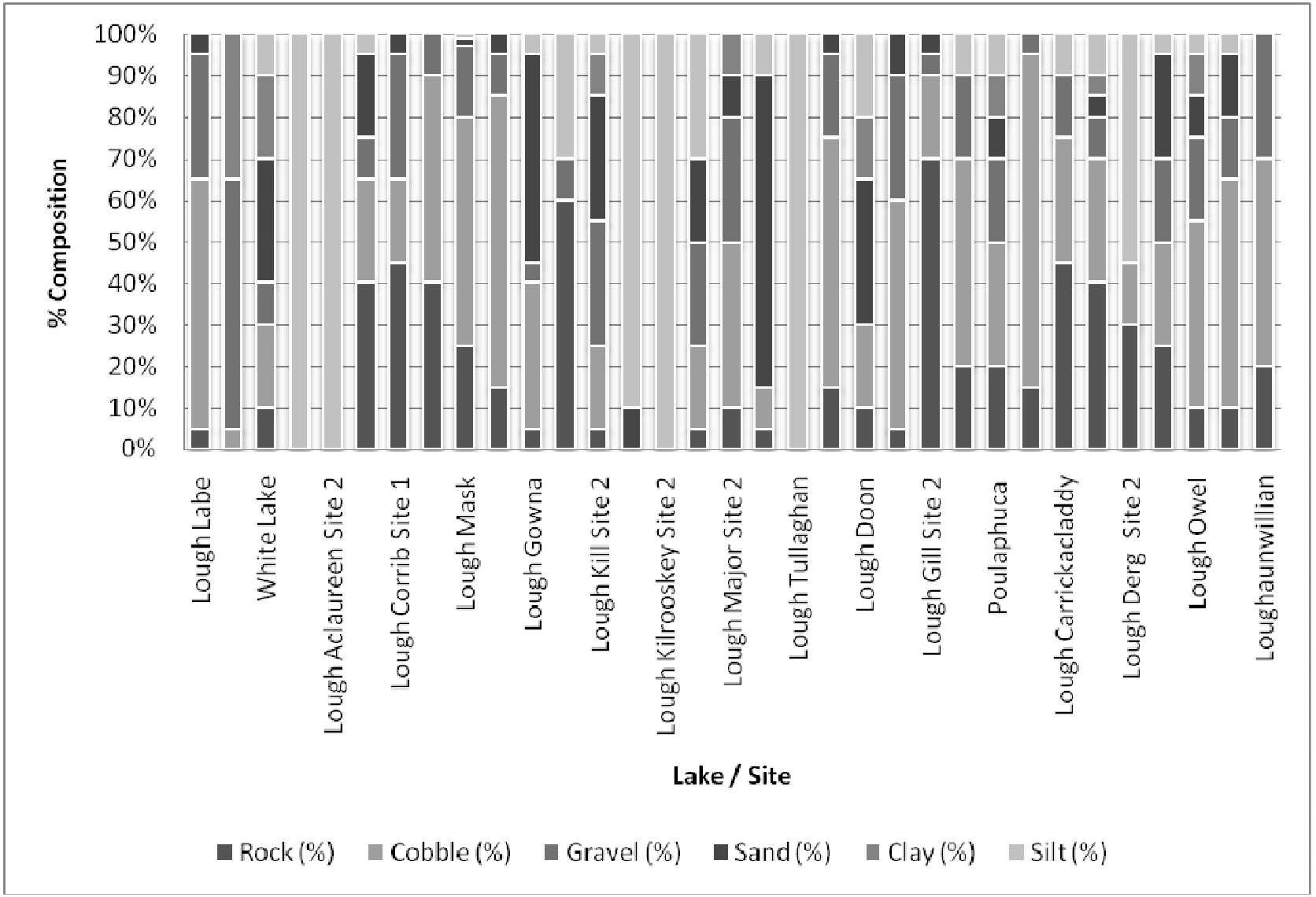

Figure 3 Substrate composition at the 33 sites surveyed during the 2007 crayfish survey.

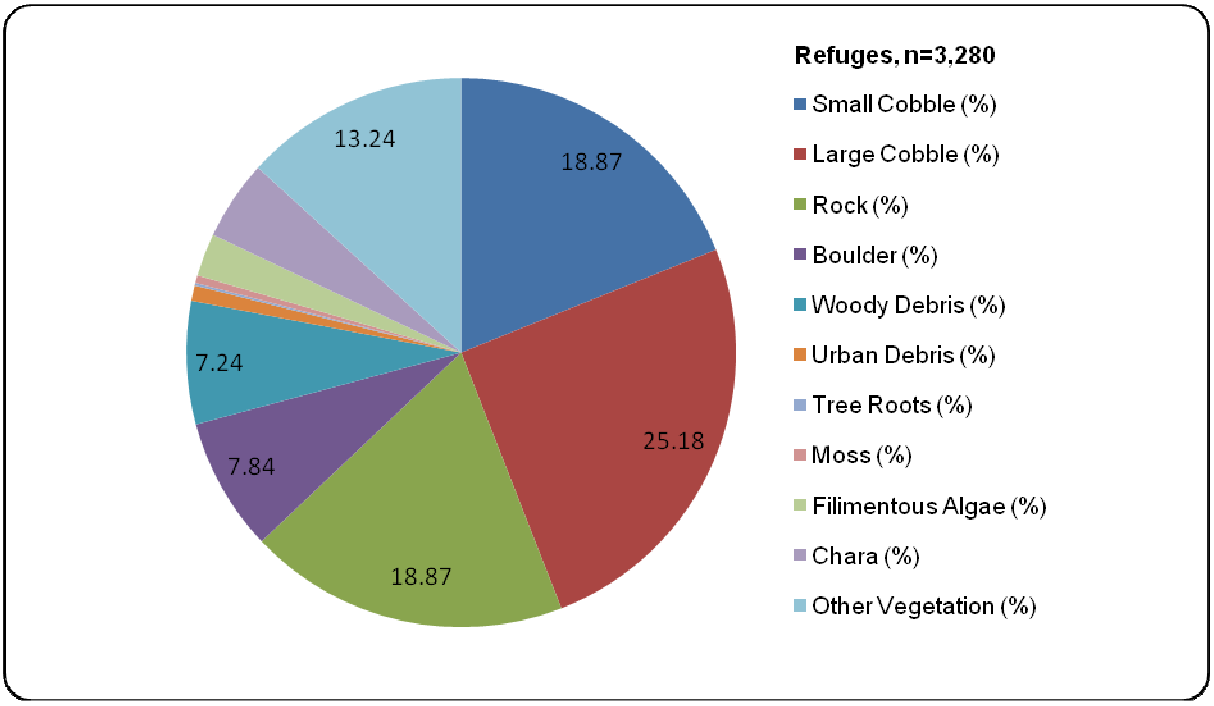

Figure 4 Relative composition (%) of potential crayfish refuges (n=3,280) at all sites examined during the 2007 survey.

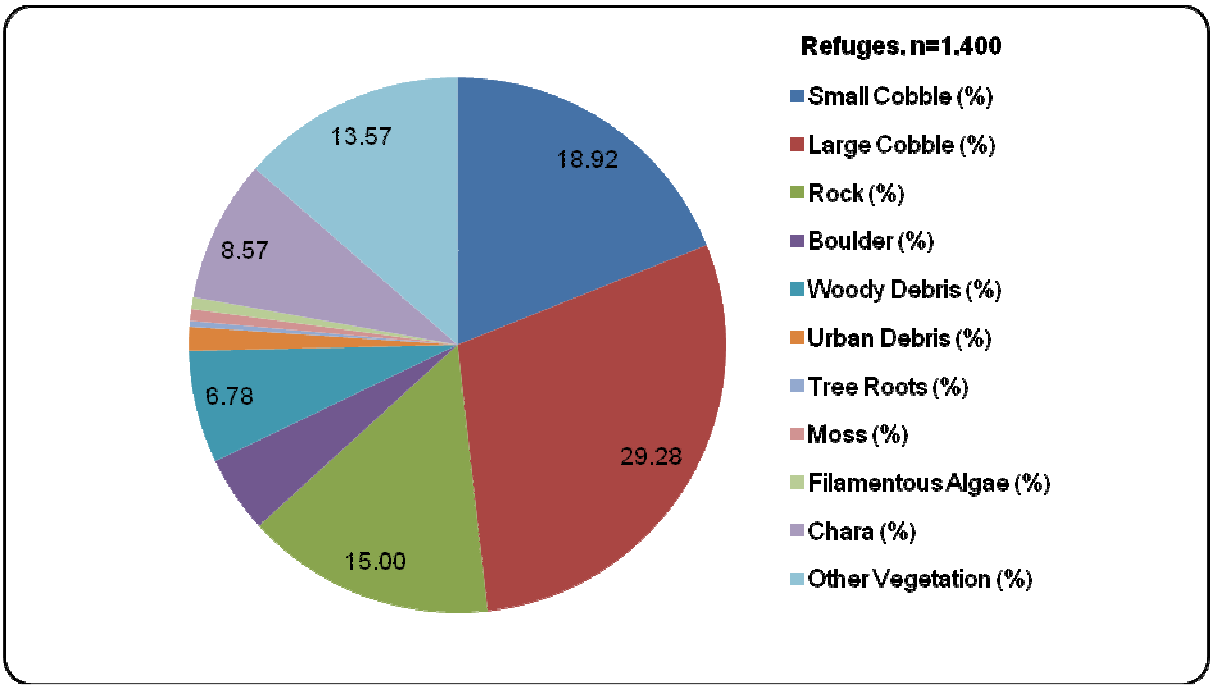

Figure 5 Relative composition (%) of potential crayfish refuges (n=1,400) at sites that contained crayfish during the 2007 survey.

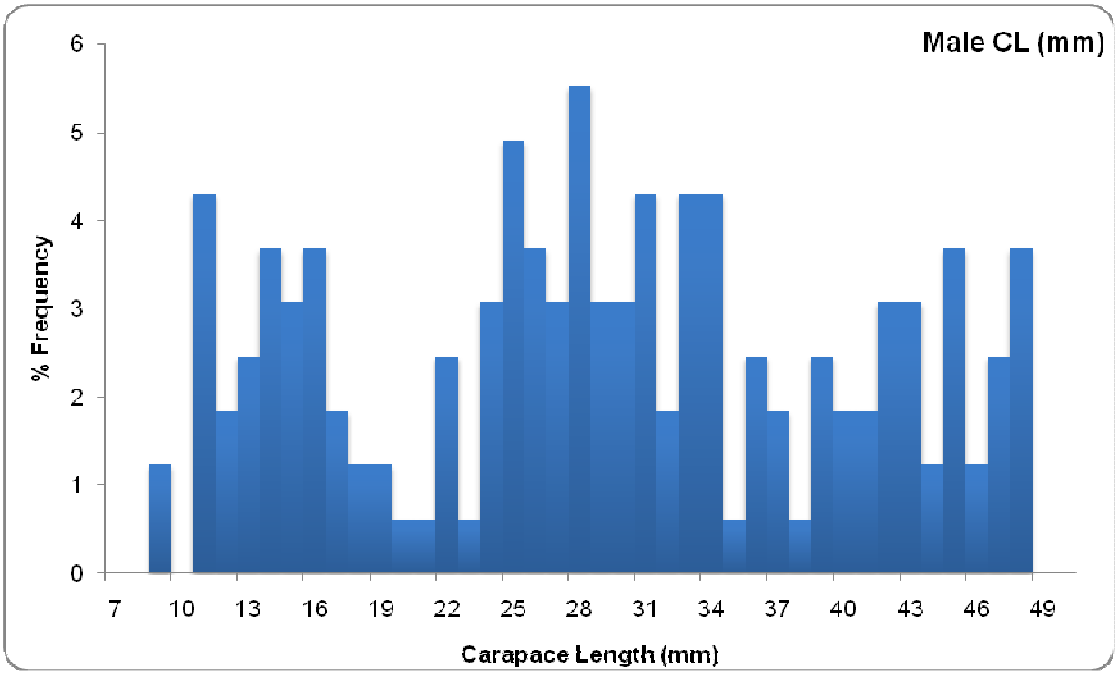

Figure 6 Carapace length (mm) percentage frequency distribution for all male crayfish (n=163) identified during the 2007 survey.

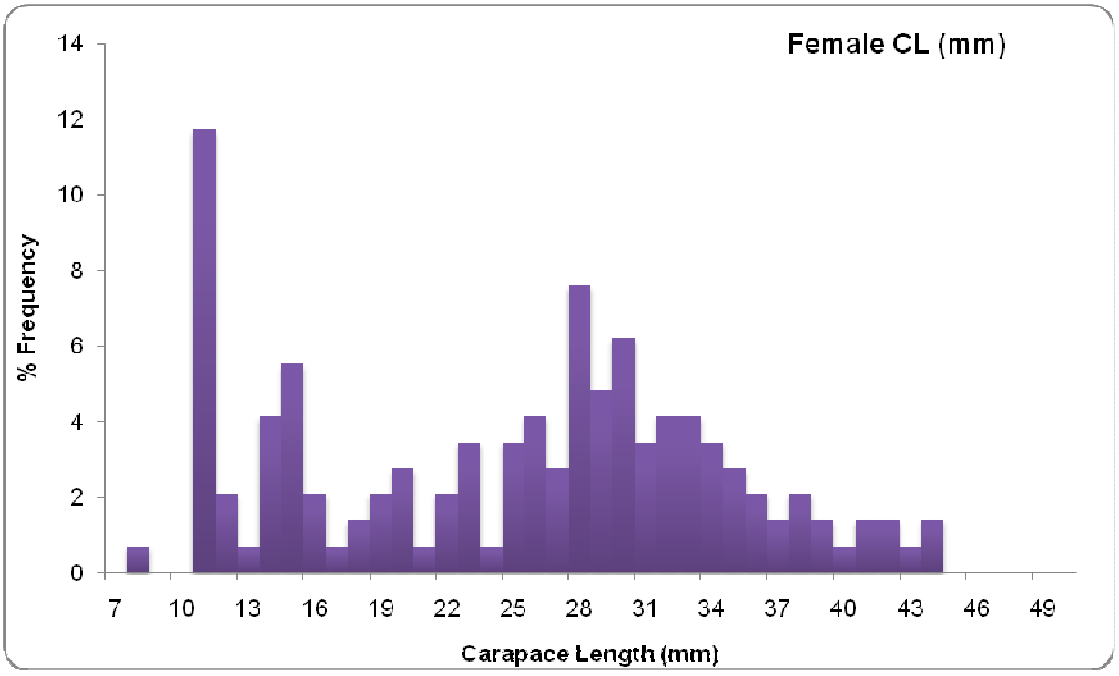

Figure 7 Carapace length (mm) percentage frequency distribution for all female crayfish (n=145) identified during the 2007 survey.

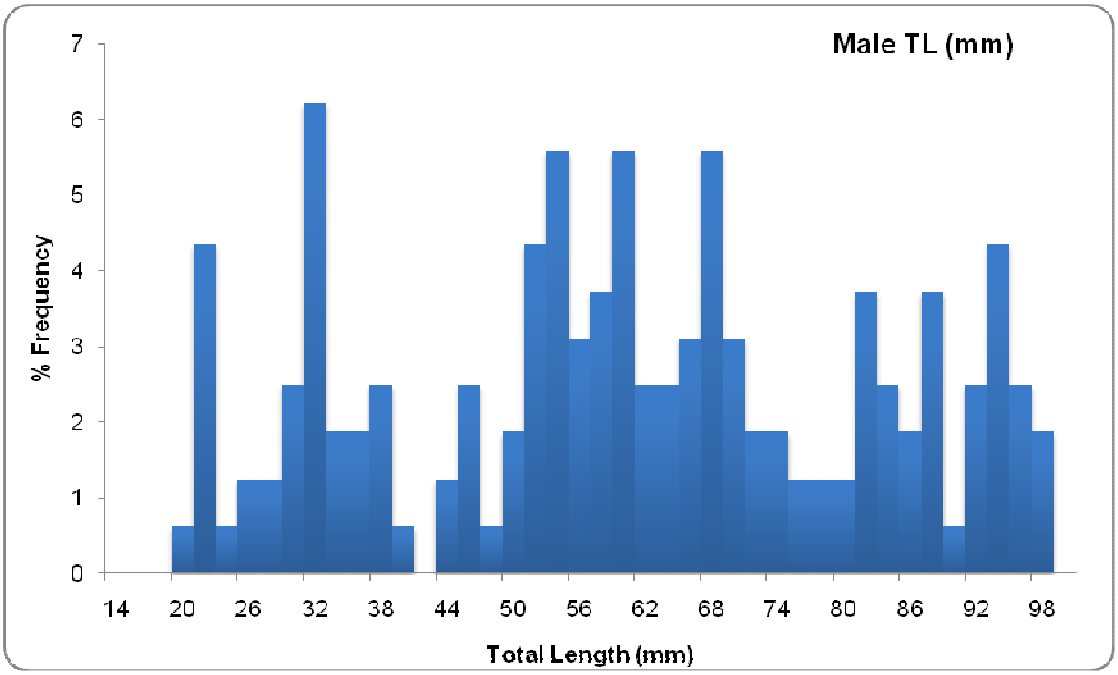

Figure 8 Total length (mm) percentage frequency distribution for all male crayfish (n=163) identified during the 2007 survey.

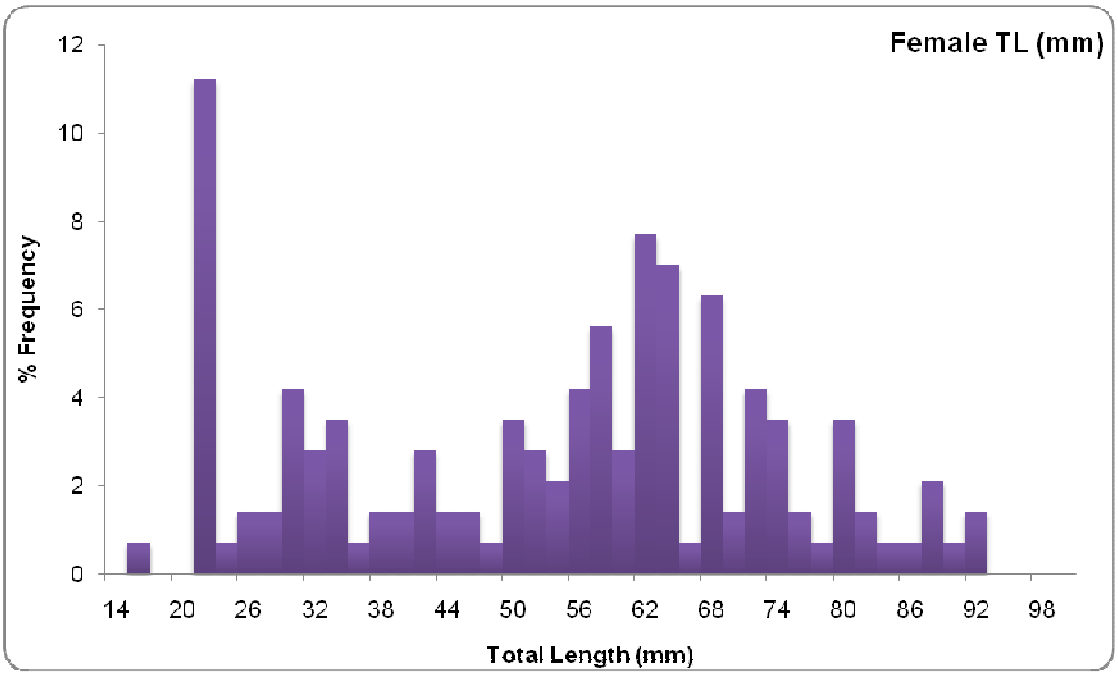

Figure 9 Total length (mm) percentage frequency distribution for all female crayfish (n=145) identified during the 2007 survey.

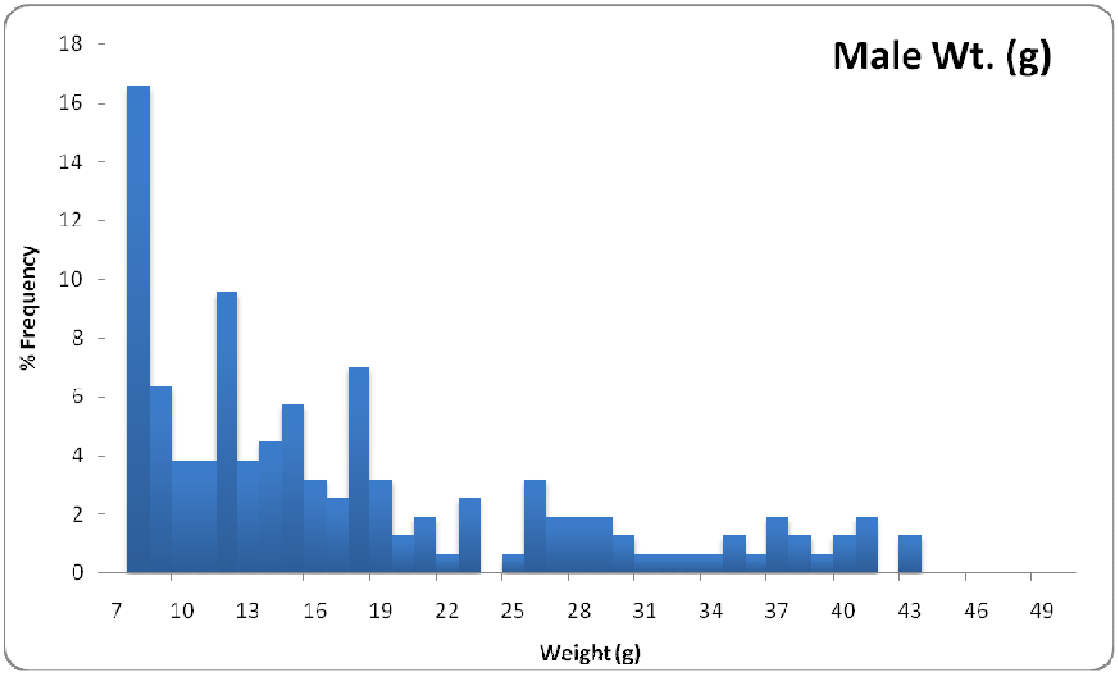

Figure 10 Weight (g) percentage frequency distribution for all male crayfish (n=163) identified during the 2007 survey.

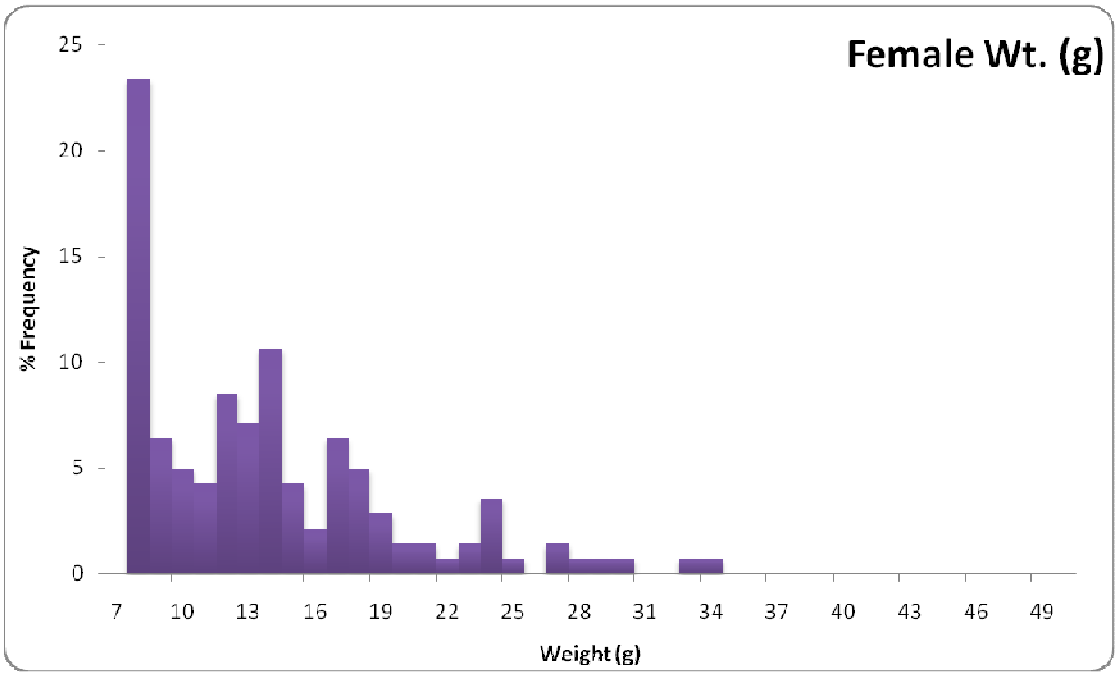

Figure 11 Weight (g) percentage frequency distribution for all female crayfish (n=145) identified during the 2007 survey.

Table 6 Summary statistics for carapace length (mm) for crayfish captured during the 2007 survey.

Lake	N	Mean	Minimum	Maximum	St. Dev.
Doon	8	24.72	8.27	31.28	7.48
Glenade	4	29.75	27.04	33.03	2.65
Gowna	26	21.35	13.00	46.90	9.63
Kill	15	18.91	11.60	37.00	8.62
Kilrooskey	85	29.35	9.00	47.60	14.38
Labe	68	28.04	7.48	47.69	7.32
Major	15	19.85	11.79	33.65	7.28
Nageage	6	28.27	11.29	47.58	11.53
Owel	50	29.66	12.19	43.68	9.24
Poulaphuca	13	29.33	18.68	42.72	6.21
Talt	47	21.14	11.20	34.50	6.41
Veenagreane	20	23.40	12.12	34.14	5.76
White	2	34.89	32.65	37.12	3.16

Table 7 Summary statistics for total length (mm) for crayfish captured during the 2007 survey.

Lake	N	Mean	Minimum	Maximum	St. Dev.
Doon	8	51.36	18.23	67.17	15.39
Glenade	4	61.81	58.02	66.79	4.28
Gowna	26	45.76	28.50	97.20	19.90
Kill	15	41.75	29.50	79.10	17.78
Kilrooskey	85	60.85	21.70	96.50	29.00
Labe	68	58.64	15.17	93.69	14.63
Major	15	41.66	24.80	70.80	15.29
Nageage	6	58.61	24.18	97.20	23.27
Owel	50	61.98	26.22	90.34	18.80
Poulaphuca	13	61.92	39.86	86.14	11.66
Talt	43	45.71	23.50	75.00	13.85
Veenagreane	20	49.33	23.93	72.04	12.09
White	2	73.32	67.88	78.76	7.69

Table 8 Summary statistics for weight (g) for crayfish captured during the 2007 survey.

Lake	N	Mean	Minimum	Maximum	St. Dev.
Doon	7	5.70	2.40	9.70	2.46
Glenade	4	8.23	6.50	11.50	2.29
Gowna	25	4.12	0.60	22.30	5.61
Kill	15	4.03	0.70	16.80	5.38
Kilrooskey	84	12.55	0.30	33.70	11.44
Labe	67	8.09	0.30	35.10	6.14
Major	15	3.08	0.40	10.30	3.04
Nageage	6	10.20	0.50	35.60	12.69
Owel	50	10.06	0.50	25.69	7.41
Poulaphuca	13	7.97	1.50	21.30	5.28
Talt	41	3.97	0.30	16.40	3.64
Veenagreane	20	4.06	0.40	10.60	2.80
White	2	13.50	10.40	16.60	4.38

Table 9 Summary statistics for carapace length (mm) for male, female and unidentified crayfish captured during the 2007 survey.

Sex	N	Mean	Minimum	Maximum	St. Dev.
U	51	23.24	11.20	42.55	9.62
F	145	24.67	7.48	44.00	9.35
M	163	28.57	8.27	47.69	11.06

U = unidentified, F = female, M = male.

Table 10 Summary statistics for total length (mm) for male, female and unidentified crayfish captured during the 2007 survey.

Sex	N	Mean	Minimum	Maximum	St. Dev.
U	51	48.50	23.50	88.07	19.84
F	143	52.79	15.17	91.24	19.66
M	161	59.57	18.23	97.20	21.77

U = unidentified, F = female, M = male.

Table 11 Summary statistics for weight (g) for male, female and unidentified crayfish captured during the 2007 survey.

Sex	N	Mean	Minimum	Maximum	St. Dev.
U	51	5.77	0.30	23.69	7.07
F	141	6.44	0.30	26.10	5.82
M	157	10.29	0.30	35.60	9.67

U = unidentified, F = female, M = male.

Table 12 Summary statistics for carapace length (mm) for crayfish captured during the 2007 survey, by sex and month surveyed.

Lake	Site	Month surveyed	Sex*	N	Mean	Min	Max	St. Dev.
Doon	1	August	F	4	26.15	20.97	31.28	4.22
			M	4	23.28	8.27	30.74	10.36
Glenade	1	August	F	1	30.64	30.64	30.64	
			M	3	29.45	27.04	33.03	3.16
Gowna	1	August	F	2	30.62	19.35	41.88	15.93
			M	1	25.91	25.91	25.91	
	1	October	F	10	17.41	13.10	28.70	5.72
			M	13	22.61	13.00	46.90	10.80
Kill	2	October	F	7	19.67	12.90	37.00	9.93
			M	8	18.25	11.60	31.00	7.93
Kilrooskey	1	August	M	4	41.30	38.37	45.09	2.87
	2	October	F	39	22.39	10.30	44.00	12.66
			M	42	34.67	9.00	47.60	13.61
Labe	1	August	F	11	23.88	7.48	35.34	8.62
			M	10	31.91	17.32	47.69	9.35
	1	September	F	22	27.32	15.80	35.40	5.00
			M	25	28.96	11.52	41.07	6.95
Major	2	October	F	5	25.46	13.36	33.65	7.59
			M	10	17.05	11.79	25.51	5.53
Nageage	1	October	F	2	19.21	11.29	27.13	11.20
			M	4	32.80	26.79	47.58	9.88
Owel	1	June	U	28	26.98	12.19	42.55	10.78
			F	9	34.54	26.20	43.68	5.86
			M	13	32.05	25.19	41.54	4.86
Poulaphuca	1	August	F	8	26.54	18.68	31.37	4.03
			M	5	33.79	23.79	42.72	6.85
Talt	1	August	U	23	18.69	11.20	29.10	5.31
			F	6	30.58	27.40	34.50	3.34
	2	August	F	7	21.06	14.25	30.00	6.15
			M	11	21.16	13.53	29.25	5.57
Veenagreane	1	August	F	8	24.23	16.88	34.14	6.89
			M	3	21.10	15.68	25.90	5.14
	1	October	F	3	27.34	22.05	30.05	4.58
			M	6	21.48	12.12	24.29	4.73
White	2	August	F	1	37.12	37.12	37.12	
			M	1	32.65	32.65	32.65	

*U = unidentified, F = female, M = male.

Table 13 Summary statistics for total length (mm) for crayfish captured during the 2007 survey, by sex and month surveyed.

Lake	Site	Month surveyed	Sex	N	Mean	Min	Max	St Dev
Doon	1	August	F	4	54.60	42.95	67.17	10.33
			M	4	48.12	18.23	63.17	20.44
Glenade	1	August	F	1	63.96	63.96	63.96	
			M	3	61.10	58.02	66.79	4.94
Gowna	1	August	F	2	66.43	41.61	91.24	35.09
			M	1	53.40	53.40	53.40	
	1	October	F	10	38.04	29.20	60.30	11.84
			M	13	47.94	28.50	97.20	22.05
Kill	2	October	F	7	42.99	29.50	79.10	21.09
			M	8	40.66	29.60	66.00	15.76
Kilrooskey	1	August	M	4	84.74	80.37	93.60	6.00
	2	October	F	39	47.36	21.70	90.00	26.78
			M	42	71.10	21.70	96.50	26.83
Labe	1	August	F	11	50.76	15.17	75.63	18.22
			M	10	65.57	36.57	93.69	18.16
	1	September	F	22	58.25	33.48	72.10	10.61
			M	25	59.69	24.59	84.00	13.68
Major	2	October	F	5	53.50	27.68	70.80	16.14
			M	10	35.75	24.80	53.28	11.47
Nageage	1	October	F	2	40.85	24.18	57.52	23.57
			M	4	67.49	53.31	97.20	20.04
Owel	1	June	U	28	56.50	26.22	88.07	21.94
			F	9	71.93	55.04	90.34	11.83
			M	13	66.89	53.00	86.04	9.84
Poulaphuca	1	August	F	8	57.37	39.86	69.08	9.08
			M	5	69.20	51.91	86.14	12.48
Talt	1	August	U	23	38.77	23.50	63.90	11.11
			F	6	66.03	59.40	75.00	6.46
	2	August	F	5	50.07	33.26	63.62	11.77
			M	9	47.47	32.53	61.97	10.42
Veenagreane	1	August	F	8	51.16	35.46	72.04	14.52
			M	3	44.88	34.94	54.41	9.74
	1	October	F	3	58.38	50.27	63.52	7.11
			M	6	44.58	23.93	51.20	10.41
White	2	August	F	1	78.76	78.76	78.76	
			M	1	67.88	67.88	67.88	

*U = unidentified, F = female, M = male.

Table 14 Summary statistics for weight (g) for crayfish captured during the 2007 survey, by sex and month surveyed.

Lake	Site	Month surveyed	Sex	N	Mean	Min	Max	St Dev
Doon	1	August	F	4	5.40	2.40	9.70	3.10
			M	3	6.10	4.00	7.20	1.82
Glenade	1	August	F	1	8.10	8.10	8.10	
			M	3	8.27	6.50	11.50	2.80
Gowna	1	August	F	2	12.25	2.20	22.30	14.21
			M	1	4.40	4.40	4.40	
	1	October	F	10	2.24	0.60	7.90	2.52
			M	12	4.32	0.70	19.30	5.45
Kill	2	October	F	7	4.60	0.70	16.80	6.50
			M	8	3.54	0.90	11.70	4.60
Kilrooskey	1	August	M	4	21.08	15.10	29.70	6.18
	2	October	F	39	6.51	0.30	26.10	7.58
			M	41	17.47	0.30	33.70	12.10
Labe	1	August	F	10	5.71	0.90	11.90	4.03
			M	10	13.23	1.40	35.10	10.75
	1	September	F	22	6.32	1.00	12.40	3.10
			M	25	8.54	0.30	22.80	5.41
Major	2	October	F	5	5.60	0.70	10.30	3.52
			M	10	1.82	0.40	4.90	1.90
Nageage	1	October	F	2	2.90	0.50	5.30	3.39
			M	4	13.85	5.20	35.60	14.53
Owel	1	June	U	28	8.74	0.50	23.69	8.32
			F	9	13.48	5.30	25.69	6.88
			M	13	10.56	4.70	21.99	4.91
Poulaphuca	1	August	F	8	5.49	1.50	9.50	2.44
			M	5	11.94	3.80	21.30	6.42
Talt	1	August	U	23	2.15	0.30	7.10	1.97
			F	6	10.17	6.90	16.40	3.89
	2	August	F	4	4.78	2.90	7.40	2.06
			M	8	4.14	1.30	8.30	2.57
Veenagreane	1	August	F	8	4.68	1.30	10.60	3.76
			M	3	2.97	1.10	5.30	2.14
	1	October	F	3	5.40	2.60	7.40	2.50
			M	6	3.12	0.40	4.50	1.49
White	2	August	F	1	16.60	16.60	16.60	
			M	1	10.40	10.40	10.40	

*U = unidentified, F = female, M = male.

Table 15 Summary statistics for carapace length (mm) for crayfish captured by hand-searching, sweep-netting and trapping during the 2007 survey.

Method	N	Mean	Minimum	Maximum	St. Dev.
HS	275	25.47	7.48	47.69	8.82
SN	35	13.89	9.00	31.10	6.91
T	49	39.38	24.74	47.60	6.13

HS = hand search, SN = sweep net, T = trap.

Table 16 Summary statistics for total length (mm) for crayfish captured by hand-searching, sweep-netting and trapping during the 2007 survey.

Method	N	Mean	Minimum	Maximum	St. Dev.
HS	271	53.84	15.17	96.50	17.89
SN	35	29.61	21.70	64.40	14.24
T	49	81.35	52.20	97.20	11.55

HS = hand search, SN = sweep net, T = trap.

Table 17 Summary statistics for weight (g) for crayfish captured by hand-searching, sweep-netting and trapping during the 2007 survey.

Method	N	Mean	Minimum	Maximum	St. Dev.
HS	267	6.96	0.30	35.10	6.67
SN	35	1.53	0.30	8.30	2.39
T	47	19.28	4.10	35.60	8.72

HS = hand search, SN = sweep net, T = trap.

Table 18 Indicative conservation assessment for the 26 lakes surveyed during 2007.

Lakes	No. of Sites	Sampling Methods	Crayfish detected	Population	Area of suitable habitat	Future Prospects	Overall	Pressures noted
Lough Labe	1*	HS, T	✓	G	A	A	A	
Lough Glaslough	1	HS, SN		R	R	R	R	Encroachment, Horse riding
White Lake	1	HS	✓	A	G	A	A	Predation Boating, angling
Lough Aclaureen	2	HS, SN		U	A	A	A	
Lough Carra	1	HS, SN		U	G	U	U	
Lough Corrib	2	HS, SN		U	G	U	U	
Lough Mask	1	HS, SN		U	G	U	U	
Lough Carrickaport	1	HS, SN		U	G	R	R	Pollution Zebra mussel
Lough Gowna	1*	HS, T, SN, EF	✓	A	G	G	A	
Lough Kill	2	HS, SN	✓	A	A	A	A	Pollution
Lough Kilrooskey	2	HS, T, NS	✓	G	G	G	G	
Lough Major	2	HS, SN	✓	A	A	A	A	Pollution
Lough Nageage	1*	HS, SN	✓	A	A	A	A	Forestry
Lough Tullaghan	1	HS, SN		U	A	U	U	
Lough Veenagreane	1*	HS, SN	✓	A	G	A	A	
Lough Doon	1	HS	✓	A	G	G	A	
Lough Gill	2	HS, SN		U	A	A	A	Zebra mussel
Lough Glenade	1	HS, SN	✓	A	G	A	A	
Poulaphuca Reservoir	1	HS	✓	A	G	A	A	Regulation
Lough Talt	1	HS, SN, EF	✓	G	G	G	G	
Lough Carrickacladdy	1	HS, SN		U	A	U	A	Pollution
Lough Derg	2	HS, SN		U	A	U	A	Pollution Zebra mussel
Lough Ennell	2	HS, SN		ABSENT				Pollution
Lough Owel	1	HS, SN, EF	✓	G	G	G	G	Boating, angling
Lough Ree	2	HS,SN		U	G	U	U	Zebra mussel Regulation
Loughaunwillian	1	HS, SN		ABSENT				

*site visited twice G = favourable (GREEN), A = unfavourable inadequate (AMBER), R = unfavourable bad (RED), U=unknown

5. DISCUSSION AND CONCLUSIONS

Initially, difficulties were encountered with identifying the location of many of the lakes selected for the project, particularly the historical/anecdotal records. In several cases, the names of lakes on the list supplied varied from those shown on OS maps. In other cases, the OSI grid references, catchments and/or counties were incorrectly listed. For example, 'Lough Sheehan', Co. Cavan, on the Boyne catchment, could not be found. It is clear that many of the existing records for crayfish need to be reviewed and updated, with correct names, locations etc. added. An evaluation of the accuracy of some of the existing historical/anecdotal records should also be undertaken. It was surprising that crayfish were present in only 50% of the lakes surveyed and only nominal populations were indicated in many of the lakes, which had crayfish present. It may be necessary to extend the list of lakes selected for the current project, in order to have a sufficient number of confirmed lakes containing crayfish for conservation status monitoring.

An extremely wet summer was experienced in Ireland in 2007 and this caused difficulties for the current investigation. The resulting high water levels and associated turbidity caused access difficulties and poor visibility in many lakes during June, July and August. However, supplementary work was carried out in September and early October, when water levels had dropped back to normal levels. However, the results of the current survey must be considered in the context of the environmental difficulties encountered, particularly in relation to lakes not resurveyed in the autumn. The absence of hatchlings along the shores of many of the lakes surveyed may have been due to the high water levels at the time of the assessment.

Lakes resurveyed in September/October were Gowna, Kill, Nageage, Veenagreane, Kilrooskey, Major and Labe. In Lough Kill, Lough Kilrooskey and Lough Major, the stretch surveyed in the September/October survey was located in a different area of the lake from that initially surveyed. This is because once the lake levels had gone down, new shoreline areas, containing more suitable potential crayfish habitat, could be accessed. Of the resurveyed lakes in which the same stretch was surveyed in both summer and autumn, only Lough Veenagreane yielded similar results. Significantly, different results were obtained from Lough Labe and Lough Gowna. In Lough Labe 21 crayfish were caught from 100 refuges in the summer survey, while 39 crayfish were caught in the autumn survey at the same site, but under more favourable environmental conditions. These trends were repeated in Lough Gowna, with three crayfish caught during the summer, versus 23 in the autumn survey at the same site. Lough Gowna in Co. Cavan was surveyed for the first time in August and was reported by local anglers to be "*at least two feet above normal water levels*". Underwater visibility was also poor during the summer survey. These results give an indication of the influence of lake levels/water clarity on catch efficiency and the difficulties presented by the prevailing conditions during the 2007 survey, highlighting the importance of undertaking such surveys under suitable environmental conditions.

A total of 26 lakes were surveyed and crayfish were recorded in 13 of these (50%). A total of 359 crayfish were captured, measured, sexed and weighed during the survey. While in some cases different surveying techniques were applied to different lakes, it was concluded that Loughs Kilrooskey, Labe, Gowna, Owel and Talt were the most important lakes for crayfish, of those surveyed.

Hand searching using snorkel gear was found to be the most successful method overall and is recommended as the monitoring method of choice for many of the lakes assessed during 2007. While the survey technique remains the same as that outlined in Reynolds (2006), the main advantages of the use of snorkel gear was the comfort of surveying and the increased visibility. The fact that the surveyor is submerged also means that he/she is nearer to the crayfish with the advantage of better visibility and efficiency of catch. Manoeuvrability and careful displacement of potential refuges is also

made easier. This method allowed deeper or more inaccessible areas to be searched, as the surveyor is often swimming over the area being surveyed, as opposed to standing in it. Moreover, the use of snorkel gear helps reduce the amount of soft debris disturbed from the lake bed.

Sweep-netting was carried out in soft or vegetated areas, but this method proved unsuccessful for many lakes. This was especially found to be the case in stretches of shore containing rocky areas. However, in Lough Kilrooskey sweep-net sampling was found to be a highly effective method of surveying soft and vegetated areas. As mentioned above, it is likely that the high lake levels, which persisted during the summer of 2007, affected the efficiency of this method. Trapping was successfully undertaken at four lakes and was confirmed to be a useful method, although not always consistently effective. The 'Trapy' August traps, which were recommended in Reynolds (2006) and used in the current survey, were not found to be ideal for trapping crayfish. However, the modification of these traps with the addition of 10mm plastic mesh was found to be beneficial.

Plate 35 Snorkelling hand search method.

Night searching was found to be useful in some instances, but may often not be practical, particularly due to safety considerations. However, night searching may be used as a means of assessing the presence/absence of crayfish in lakes. The importance of general visual observations was highlighted during the current survey. The presence/absence of crayfish along a stretch of lake can often be ascertained by looking for otter spraints with crayfish remains, or other signs of crayfish presence. As part of this study, some electrical fishing was carried out at a number of lakes on an experimental basis. However, the results from these assessments were very variable and catch efficiency was found to be determined by lake conductivity. It was concluded that this technique is not useful in a low conductivity lake, such as Lough Talt, but may be used to quickly indicate the presence of crayfish in high conductivity lakes (e.g. Lough Owel).

The efficiencies of the various survey methods employed were found to vary greatly between habitats. For example, in Lough Kilrooskey, with its heavily vegetated margins and soft substrate, only seven crayfish were caught during a hand-search (100 refuges); in contrast to 35 crayfish caught by sweep-netting (20 sweeps) and 39 by trapping (20 traps). Conversely, on the generally stony substrate of Lough Labe, 39 crayfish were caught by hand-searching (100 refuges), eight were caught by trapping (10 traps) and only one was caught by sweep-netting (20 sweeps).

The current survey was carried out at a time of year that is considered optimal for crayfish surveying. In June and July, crayfish had already hatched and all crayfish were fully active. By early October, when the survey ceased, crayfish had just begun to mate and two females were noted to have a spermatophore attached to their underside, but egg laying had yet to begin. No berried females were encountered during the current survey.

During this survey, a disproportionately small number of hatchling crayfish were recorded. Crayfish are known to hatch in June or July and so hatchlings were expected to have been caught in significant numbers during the current survey. The low numbers of hatchlings captured may have been due to high water levels on some lakes. The largest crayfish caught during the current survey was recorded from a trap set in Lough Nageage in early October, having a total length of 97.2mm and weighing 35.6g. The size range and characteristics of crayfish recorded during the current survey was similar to that report from previous studies of Irish lakes.

Plate 36 Specimen from Lough Kilrooskey

Of the 308 crayfish which were sexed conclusively, 163 were males and 145 were females. A total of 19 crayfish were found to have recently moulted. In lakes such as Loughs Labe and Talt, recent recruitment was detected and these lakes were found to contain a particularly good range of sizes, thus indicating a healthy population. However, most of the lakes where good catches were realised, had a good range of crayfish sizes present.

In the lakes where they were found, the average crayfish catch was 16 per 100 refuges. The greatest density of crayfish caught was 50 from a hand-search of 100 refuges in Lough Owel. The least dense crayfish population was indicated from White Lake where only two crayfish per 100 refuges were recorded. The most crayfish caught from any one lake was 85 individuals, at Lough Kilrooskey, Co. Monaghan. Hand-searching, trapping and night-searching were all carried out on this lake. A total of 68 crayfish were caught at Lough Labe, Co. Sligo. These were found to be smaller than those in Kilrooskey and there were general size variations between the populations from different lakes. However, some lakes showed surprisingly similar results in the size data recorded. For example, a total of 47 crayfish were caught in Lough Talt and the respective mean carapace length and weights of these individuals were 21.1mm and 4g. In Lough Gowna, a total 26 crayfish were caught with the average carapace length and weight being 21.4mm and 4.1g respectively.

In line with previous studies, the current investigation concluded that crayfish appear reasonably tolerant of at least moderately polluted conditions. For example, a significant crayfish population was recorded in Lough Gowna, where the water quality is rated as 'highly eutrophic'. However, it is again acknowledged that the water quality requirements of crayfish are not well understood at this time and they should be considered to be vulnerable to changes in water quality. Crayfish numbers may be affected by the presence of predators, such as perch, pike and eels. The presence of eels has been suggested as a reason for the absence of crayfish from many of our larger lakes (Reynolds, 1998). The apparent recent introduction of perch into White Lake may have affected the recovering stocks in this lake. At some lakes, crayfish appeared to be important in the diet of otters. This was especially the

case in Lough Labe where numerous otter spraints appeared to be composed entirely of crayfish remains. At this lake, crayfish remains were also found on a rock used by otters.

Modifications carried out on many Irish lakes are likely to have had an effect on the habitat quality of the littoral zone of these lakes. Drainage schemes have undoubtedly had an impact on littoral crayfish habitats, due to lowering of water levels and the loss of refuges (i.e. Lough Owel, Lough Ennel). Some lakes are also likely to have had large littoral rocks removed for wall building purposes etc. in the past. In order to offset these impacts and to provide crayfish with suitable refuges, enhancement measures, such the creation of artificial reefs in lakes where crayfish are already present, would probably be beneficial in some areas (i.e. White lake, Lough Owel). Creation of such artificial reefs would also provide an opportunity for controlled conservation monitoring.

No non-native crayfish were recorded during the current survey. Moreover, no evidence of crayfish plague or other diseases was detected during the current survey. It is clear that more effort needs to be made to prevent the transport of signal crayfish, crayfish plague and non-native aquatic species into or around the island of Ireland. The re-introduction of crayfish into lakes where they are known to have occurred, or into isolated lakes with suitable habitat, should continue to be considered, despite the apparent decline in White Lake. A re-introduction project targeting isolated lakes, which are not used for angling, would be especially useful. Isolated populations of crayfish would act as a safeguarded stock of white-clawed crayfish, in the event of a spread of crayfish plague or alien crayfish species in Ireland.

The results of the current survey confirm that some Irish lakes still contain excellent stocks of crayfish. White-clawed crayfish remain widely distributed in the Irish midlands where they are locally abundant. The lakes that were found to be important for crayfish varied widely in terms of size, available refuges, substrates present, vegetation cover and water quality. However, the conservation status of crayfish in Ireland may be threatened by the introduction of non-native species, diseases and other factors such as the spread of the zebra mussel.

REFERENCES

Bowman, J.J. (1998) The Shannon. In: *Studies of Irish Rivers and Lakes* (Ed. C. Moriarty). Essays on the occasion of the XXVII Congress of Societas Internationalis Limnologiae (SIL), Dublin 1998. Marine Institute.

CFB (2007) Office of Public Works (OPW) funded investigations on Lamprey and Crayfish. Part II: Crayfish. CFB Website www.cfb.ie.

Clabby, K.J., Kirwan, D. & Browne, P. (2005). *Water Quality in Ireland 2001-2003*. Statistical Compendium of River Quality Data. Environmental Protection Agency, Wexford.

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

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.

Gargan, P.G., O'Grady, M.F., Delanty, K,. Igoe, F. & Byrne, C. (2002). The effectiveness of habitat enhancement on salmon and trout stocks in streams in the Corrib Catchment. In O'Grady, M.F. (ed): *Proceedings of the 13th International Salmonid Riverine Enhancement Workshop, Westport, Ireland, September, 2002*.

Holdich, D. (2003). Ecology of the White-clawed Crayfish. *Conserving Natura 2000 Rivers Ecology*. Series No. 1. English Nature, Peterborough.

Holdich, D.M., Rogers, W.D., Reader, J.P. & Harlioglu, M.M. (1995). Interactions between three species of freshwater crayfish (*Austropotamobius pallipes, Astacus leptodactylus* and *Pacifastacus leniusculus*). *Freshwater Crayfish* 10, 46–56.

McGarrigle, M.L. (1998) The Moy. In: *Studies of Irish Rivers and Lakes* (Ed; C. Moriarty). Essays on the occasion of the XXVII Congress of Societas Internationalis Limnologiae (SIL), Dublin 1998. Marine Institute.

McGinnity, P., Gargan, P., Roche W., Mills, P., & McGarrigle, M. (2003) Quantification of the freshwater salmon habitat asset in Ireland using data interpreted in a GIS platform. *Irish Freshwater Fisheries Ecology and Management Series*, Central Fisheries Board, Dublin, 3. 131 pp.

Moriarty, C. (1998) The Liffey. In: *Studies of Irish Rivers and Lakes* (Ed; C. Moriarty). Essays on the occasion of the XXVII Congress of Societas Internationalis Limnologiae (SIL), Dublin 1998. Marine Institute.

O'Connor, W. & McDonnell, D. (2008) 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 Office of Public Works*, November 2008.

O'Grady, M. (1998) The Boyne. In: *Studies of Irish Rivers and Lakes* (Ed; C. Moriarty). Essays on the occasion of the XXVII Congress of Societas Internationalis Limnologiae (SIL), Dublin 1998. Marine Institute.

O'Keeffe, C. (1986) *The ecology of two populations of the freshwater crayfish* Austropotamobius pallipes *(Lereboullet) in Ireland*. PhD. Thesis, University of Dublin.

O'Reilly, Peter. (1998*). Lakes of Ireland, A Flyfishers Guide*. Merlin Unwin Books: Shropshire.

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, *Austrpotamobius pallipes* Part 1. *Irish Wildlife Manuals* No. 1. Dúchas the Heritage Service, Dublin. Ireland.

Reynolds, J.D. (2006). *Manual for monitoring Irish lake stocks of white-clawed crayfish*, Austropotamobius pallipes. Unpublished report to NPWS. Dublin. Ireland.

Reynolds, J.D. (2007). Conservation status assessment report (1092) of the white-clawed crayfish (*Austropotamobius pallipes*) (Lereboullet, 1858) in Ireland. National Parks and Wildlife Service.

Reynolds, J.D., O'Connor, W., O'Keeffe, C., & Lynn, D. (in prep.) A technical manual for monitoring of the 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.

Reynolds, J.D., and O'Keeffe, C. (2005) Dietary patters in stream and lake dwelling populations of *Austropotambius pallipes. Bull. Fr. Peche Piscic.* 376-377: 715-730.

Reynolds, J.D., Souty-Grosset, C., Gouin, N., Devaney, S. & Grandjean, F. (2000). Experimental restocking of native crayfish in White Lake, Co. Westmeath, Ireland. Pp. 123-130 in: Rogers, D., Brickland, J. (eds) *Crayfish Conference Leeds, April 26-27 2000*. Environmental Agency.

Sockal, R.R., & Rohlf, F.J. (1995) *Biometry – The Principles and Practice of Statistics in Biological Research*. Third Edition. Freeman and Company. New York.

Toner, P., Bowman, K., Clabby, K., Lucey, J., McGarrigle, M., Concannon, C., Clenaghan, C., Cunningham, P., Delaney, J., O'Boyle, S., MaCartaigh, M., Craig, M. & Quinn, R. (2005). *Water Quality in Ireland 2001-2003*. Environmental Protection Agency, Waterford.

ACKNOWLEDGEMENTS

It is again highlighted that the current project has drawn heavily on the previous studies undertaken by Dr Julian Reynolds. The contribution of Paul Murphy during the planning of the fieldwork is acknowledged, as is the assistance of the following Ecofact staff during the fieldwork and compilation of this report: Thomas O'Donnell, Daireann McDonnell and Eamonn Delaney.

APPENDIX 1 Standard field forms.

NPWS WHITE-CLAWED CRAYFISH SURVEY 2007
FIELD RECORD SHEETS

Site Code:		**Date Surveyed:**		
Catchment:		**Method:**		
Lake:		**Surveyors:**		
Location:		**Lake Levels:**		
Grid Reference:		**Water Temperature:**		
Photograph Number:		**DO(%):**		
Weather Conditions:		**DO (ppm):**		
		Conductivity:		

	Patch/Site									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Location										
Surveyor										
Patch / Site Area (m^2)										
Distance from shore (m)										
Shoreline type										
Shore gradient (^{o})										
Mean depth (cm)										
Maximum depth (m)										
Substrate										
Rock (%)										
Cobble (%)										
Gravel (%)										
Sand (%)										
Clay (%)										
Silt (%)										
Vegetation Cover (%)										
Shade (%)										
Refuges Present										
Small Cobble (6.5-15cm)										
Large Cobble (15-25.6cm)										
Rock (25.6-40cm)										
Boulder (>40cm)										
Other (state)										
Woody Debris										
Urban Debris										
Tree Roots										
Moss										
Filamentous Algae										
Chara										
Other Vegetation										
Emergent Vegetation										
Search Time (mins)										
Total Number of Crayfish (n)										
Total Adult Males (n)										
Total Adult Females (n)										
Total Juveniles (n)										
Other Fish										
Crayfish Habitat Evaluation										
Notes:										

Figure A1.1 Field form for recording results during the lake crayfish survey.

NPWS WHITE-CLAWED CRAYFISH SURVEY 2007 – Individual Records Field Sheet

Reference:

Record	Site	Sex	CL (mm)	TL (mm)	Weight (g)	Condition	Breeding	Moult	Catch Method	Notes
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

Figure 1.2 Field form for recording results during the lake crayfish survey.

APPENDIX 2 Monitoring prescriptions for each lake.

A summary of crayfish survey methods is provided in Table A2.1. All of these methods are based on the '*Manual for monitoring white-clawed crayfish, Austropotamobius pallipes (Lereboullet)*' by Reynolds (2006) which has also been updated on the request of NPWS and is published separately (Reynolds *et al*. in prep).

A monitoring prescription for each of the lakes surveyed during the current project is provided in Table A2.2. It is hoped that the status of the Irish population will be better understood by future surveying and monitoring. For sustained lake monitoring, the survey methods proposed should be repeated periodically at the same sites and under similar conditions, to ensure accurate monitoring of Irish lake crayfish stocks. The locations (NOS grid references) for certain sites are given below in Table A2.2. In this prescription, at least two methods of surveying are recommended for each lake. A manual for crayfish monitoring in lakes is published separately on the NPWS website (Reynolds *et al*. in prep).

Table A2.1 Summary of methods available for crayfish monitoring.

Method	Equipment Required	Lake characteristics where the method is suitable	Advantages	Limitations / Disadvantages
Snorkelling Hand Search (SHS)	Wet suit or dry suit, snorkelling mask, small fish net (those used for aquarium fish are ideal), snorkelling boots, bucket, towel, disinfectant. Snorkelling hood and gloves provide extra insulation.	Deeper stretches, easily disturbed substrate, lakes that shelve off abruptly, lakes with marshy/unstable margins, stony shores	Closer to the target species, increased buoyancy in deeper water, ability to survey deeper (up to 1 metre), can use both hands, crayfish easily seen/wide field of view therefore fewer escapees, less disturbance of the substrate, zero glare, wind and rain doesn't significantly impair ability to survey.	Time consuming changing into snorkelling gear, need clear water, drying out time/disinfecting of equipment prior to entering a different waterbody, can be difficult in very shallow water, overcast conditions can reduce visibility somewhat.
Hand Search (HS)	Flat-bottomed transparent tray or Aquascope viewer, chest waders, lifejacket, bucket, disinfectant.	Stony shores to 60cm deep.	Standard equipment required. Ideal in very shallow water.	Field of view limited to the size of the tray, reach restricted to arms length, possibility of falling into water, one hand engaged in holding tray, disturbance of sediment by feet, clear water essential, rain can impair effectiveness by blurring the tray, wind can adversely affect ability to survey, overcast conditions can reduce visibility.
Sweep Netting (SN)	Sweep net, waders, lifejacket, disinfectant.	Vegetated lakes, lakes with a substratum of silt, sand or gravel.	Fast, little equipment needed, smaller crayfish (hatchlings, juveniles) are easily caught, water clarity not an issue. Can survey to depths according to the length of the net handle and waterproof gear. Easy to disinfect the equipment used.	Method not suited for shores of larger substrate size (cobbles, rocks, boulders).
Trapping (T)	Crayfish traps, bait, rope, buoys, disinfectant, life jacket.	Deep lakes, lakes with lots of vegetation and limited visibility.	Weather independent, water clarity not an issue, can be deployed any time of year to any depth (may require a boat).	Have to return to lake to retrieve traps, smaller crayfish can escape from traps especially if not modified, traps could be interfered with by public, time consuming.
Night Search (NS)	LED security torch with a narrow beam, spare batteries, waders, lifejacket.	All lake types with easy access.	Least labour intensive method, as crayfish are only counted, quick way to assess the presence of crayfish in a waterbody	Survey area needs to be visited during daylight hours prior to night searching, calm conditions required for observation of crayfish, crayfish characteristics not recorded. Smaller crayfish can be easily missed. Dependent on good water clarity.

Table A1.2 Recommended monitoring approach of the 26 lakes investigated during 2007.

Lakes	Hand Searching	Sweep Netting	Trapping	Night Searching	Monitoring prescription
Lough Labe	Suitable: hand searching with snorkelling gear preferable so as not to disturb the substrate. Without snorkelling gear, searching limited to the margins of the lake.	Suitable habitat for this method present along vegetated parts, and patches of finer substrate at the north-eastern shore.	Ease of access and ability to place traps along shore would make trapping a feasible option.	Could be easily and safely searched during the dark along the shallows of the lake margin.	Monitoring recommended. Access from the west by a steeply sloping roadway that ends at the lake (G 72654 12489) – roadway not shown on OS map 25 but evident at location. Hand search from this point for 100 metres in the direction of a pump house (south) along the shallows of the lakeshore.
Lough Glaslough	Generally not suited to this method.	Northern shore should be sweep netted. Restricted access limits suitability.	Suitable - a boat would be required for access.	Access and depth reduce suitability of this method for most of the shoreline	Further surveying recommended. The presence of crayfish has not been confirmed during the current survey. It is recommended that a trapping survey be undertaken due to the lack of suitable refuges for crayfish in the shallower parts of this lake. Use of a boat would be the best way of deploying the traps. Marginal crayfish habitat occurs along the northern shore (H 72626 41852) and could be hand searched (100 metre stretch) or sweep netted (20 sweeps). Alternatively, this stretch could be searched at night by walking slowly along the shore. The northern part of the lake can be accessed via the grounds of the castle demesne. The western shore of the lake should be avoided for hand and sweep surveying as it is largely inaccessible, deep, and very difficult to survey.
White Lake	Middle reaches of the western shore are best hand searched with snorkelling gear. General scarcity of larger substrate limits suitability.	Ideal sweep netting habitat present	Suitable.	Appropriate for most of the shoreline and ideal for the western shore.	Monitoring recommended. Access from the south via a small road off the R195 Oldcastle to Castlepollard road. Hand search 100 metres of the middle section of the western shore (N 50979 73080). Parts of the southern shore offer good sweep netting opportunities around the vegetation and should be hand searched (100m) also if no crayfish are found along the western shore. Tyres along the docking area of the southern shore should be searched, as these are favoured crayfish refuges. The sweep netting survey should

Lakes	Hand Searching	Sweep Netting	Trapping	Night Searching	Monitoring prescription
					consist of 20 individual sweeps.
Lough Aclaureen	Not suitable - hand searching limited to a narrow strip along the edge of the reeds.	Not ideal due to soft lake margins and dense reeds.	Trapping recommended However, no access to bring boat into this lake.	Difficult to access and safety considerations. Not recommended.	Further surveying recommended. Due to the marshy nature of the lake edge, trapping is recommended at sites located at M 38621 57863 and M 38851 57697. Sweep netting should also be carried out at these sites. This lake is best accessed from the north by the old railway line.
Lough Carra	Can be hand searched using snorkelling gear. However, difficult lake due to shallow water and soft marl substrate.	Restricted to vegetated parts of lake.	Suitable.	Ideal - crayfish would stand out against the white substrate. Good access.	Further surveying recommended. Night searching 100 metre stretches with a narrow beam torch. Trapping should also be considered.
Lough Corrib	Suitable - clarity of water ideal for hand searching with clear bottomed tray / snorkelling gear.	Suitable locations for sweep netting are present around the lake.	Ideal method and easy access for boats.	Appropriate for most of the shoreline - sheltered bays more suitable for this method.	Further surveying recommended. Survey at sites by hand searching, trapping or night searching. Hand searching of 100 metre stretches would be the most convenient method due to the rocky substrate and the numerous accessible locations. Night searches would also be a useful method in establishing the presence or absence of crayfish in this lake.
Lough Mask	Suitable - snorkelling hand search much more effective due to varying substrate depths.	Suitable locations for sweep netting are present around the lake.	Ideal method and easy access for boats.	Appropriate for most of the shoreline - sheltered bays more suitable for this method.	Survey at sites by hand searching, trapping or night searching. Hand searching of 100 metre stretches would be the most convenient method due to the rocky substrate and the numerous accessible locations. Night searches would also be a useful method in establishing the presence or absence of crayfish in this lake.
Lough Carrickaport	Hand search with snorkelling gear suitable as substrate is very easily disturbed by wading.	Ideal.	Suitable	Not ideal as survey would require some wading.	Further surveying recommended. The presence/absence of crayfish in this lake needs to be determined by additional surveying. Access this lake from the R210 Carrick on Shannon to Ballinamore road to survey the south-eastern part of the lake. The northern part of the lake should be investigated from the R208 Drumshanbo road. Hand-searching with snorkelling gear and sweep-

Lakes	Hand Searching	Sweep Netting	Trapping	Night Searching	Monitoring prescription
					netting recommended.
Lough Gowna	Suitable - during normal water levels, hand search with a transparent-bottomed tray, otherwise with snorkelling gear.	Marginal suitability.	Suitable, easy access.	Appropriate under calm conditions.	Monitoring recommended. The site in the northern part of the lake known locally as "Paddy Brady's" should be surveyed using hand-searching with snorkelling gear (N 29348 92611). There are numerous other potential sites on this lake and some general survey work is recommended. Night-searching is also recommended for this lake.
Lough Kill	Suitable method at a number of locations around the lake. Use snorkelling gear.	Marginal suitability.	Suitable – though access would be difficult with traps.	Suitable along the shallower parts of the shore.	Monitoring recommended. Access to this lake is via any one of three small roads that end within 200 metres of the lake. The monitoring site should be located on the eastern side of the lake at N 42317 91307. The hand-searching method is ideal for this location. Sweep netting should also be undertaken here.
Lough Kilrooskey	Unsuitable	Ideal method for this lake.	Ideal for trapping.	Survey from fishing stands, and along more stable parts of the shore.	Monitoring recommended. Sweep-netting (20 sweeps per site) should be carried out at two sites on this lake, accessed from fishing stands. Suitable locations are at H 49382 27300 and H 49221 27451. Traps should also be set at these sites.
Lough Major	Suitable - hand searching using transparent bottomed tray sufficient around most of shore.	Limited to the verge of vegetation due to vegetation density.	Suitable.	Suitable.	Monitoring recommended The southern shore of this lake can be accessed by a small roadway linking the R162 and the R183. The site located at H 72497 20191 should be surveyed by hand searching and sweep netting.
Lough Nageage	Suitable - hand searching sufficient with a transparent bottomed tray along western shore.	Limited suitability - sub-optimal habitat available.	Suitable.	Suitable in shallower parts of the western shore.	Monitoring recommended The western shore can be reached by a minor road. The adjacent shore should be surveyed by hand searching. Survey to the north from the location M 16862 73743. Sweep netting should also be undertaken at this site (working to the south of the grid reference provided).
Lough Veenagreane	Suitable - hand searching	Suitable – limited to patches of small	Suitable.	Suitable, but difficult access to	Monitoring recommended

Lakes	Hand Searching	Sweep Netting	Trapping	Night Searching	Monitoring prescription
	sufficient with a transparent bottomed tray along the southern shore.	cobbles and sparse vegetation.		lake at night.	Monitoring a 100 metre stretch of the southern shore of this lake (site H 17970 73991) by hand-searching would suffice in future surveys. One site is sufficient in this small upland lake. The western shore is similar in nature to the southern shore and should be surveyed should no crayfish be found in the first 100 metre surveyed. Sweep-netting should also be undertaken at this site.
Lough Tullaghan	Unsuitable	Only marginally suitable due to dense vegetation.	Suitable.	Not suitable. Access is difficult and soft lake margin could give way under weight.	Monitoring recommended This minor lake (H 61135 34212) can be reached via a small farm road from the west. The use of traps is advised for this lake. The traps should be baited with catfood and placed all around the lake from the vegetated soft lake margin. Caution should be exercised as the reeds shelve off abruptly and are unstable in certain areas. Parts of the shore could also be sweep-netted, best carried out while in a wetsuit due to the unstable and soft margin.
Lough Doon	Suitable - snorkelling hand search recommended due to varying depth of lake around margins.	Suitable in vegetated areas and substrates of finer grade.	Suitable.	Suitable - good access along the shore from road.	Monitoring recommended Hand searching of a 100 metre stretch with the aid of snorkelling gear should be carried out along the southern shore in future surveys. The recommended site is at G 79471 36232 at the south-western shore alongside the road. One site is deemed sufficient in this small lake but should one site not produce any crayfish, another stretch to the east should be investigated. A night search of this lake would be suitable given the ease of access and the easily negotiated terrain along the lake shore. Sweep netting) is also recommended.
Lough Gill	Suitable - with transparent bottomed tray or with snorkelling gear.	Limited suitability – some patches of vegetation and substrate of smaller grade.	Suitable	Suitable - good access along the shore from road.	Further surveying required. Hand searching should be carried out in at least 5 sites well distributed around this lake. In particular, the region of the lake around the River Bonet inflow should be examined (south-eastern corner of lake). A site at Annagh Bay (G 72336 34614) on the western shore is easily accessed and attention should be given to the tyres here. Another significant watercourse enters the lake at Bunowen Bay on the southern shore next to the R287 road and should be examined. Night searching should also be undertaken in an effort to determine if crayfish are still present in this lake.

Lakes	Hand Searching	Sweep Netting	Trapping	Night Searching	Monitoring prescription
Lough Glenade	Suitable - sufficient with a transparent bottomed tray.	Limited suitability – some patches of vegetation and substrate of smaller grade.	Suitable	Suitable	Monitoring recommended. This lake is close to the R280 Manorhamilton to Bundoran road. For future monitoring, two sites should be investigated by hand searching 100 metre lengths of shoreline; one site at the southern end of the lake at the small quay (G 83157 45694) and another at the northern end. The site at the quay is near the lake outflow can be easily accessed from the small road that crosses the Bonet River. This road runs along the eastern shore of the lake and continues as far to the north of the lake. A night search could easily be carried out in the southern part of this lake also due to the ease of accessibility and the shallow shores.
Poulaphuca Reservoir	Suitable – method dependent on depth of substrate.	Limited suitability – some patches of vegetation and substrate of smaller grade.	Suitable	Suitable in calm conditions, sheltered shores offer good locations for this type of survey.	Monitoring recommended. This lake is readily accessed from the roads that surround the lake. One such location is at the southern bridge on the Blessington Valleymount road (N 98015 08179). Hand searching and night searching is recommended and should be undertaken during low water levels.
Lough Talt	Ideal lake for this method.	Method was successful during the current study.	Suitable – easily accessed from nearby road.	Suitable – ideal shoreline and access.	Monitoring recommended. The Tobercurry to Ballina R294 road skirts the eastern side of this lake and is easily accessed from here, see OS map 24. Two hand search sites, each of length 100 metres should be surveyed, one at each end of the lake (north and south). An ideal site at the southern end of the lake (G 39933 14479) can be accessed from a minor road alongside the lake. Sweep netting should be carried out in shallow vegetated areas.
Lough Carrickacladdy	Suitable - hand search with snorkelling gear recommended, peaty water.	Suitable	Suitable - though access is fairly difficult.	Possible in shallower parts of shoreline where light can penetrate.	The status of crayfish in this lake needs further assessment. Access to this lake is gained from the minor road from the south (approx. 200 metres from lake). Sweep netting is the best option for this lake. No fewer than 2 sites (20 sweeps per site) along the south-eastern shore should be carried out. The lake gets deep at the northern end, where large rocks can be seen to form part of the bank and should be avoided. This part of the lake should be hand searched with snorkelling gear.
Lough Derg	Suitable – hand search with	Suitable – well vegetated shores	Suitable – should be	Suitable.	Further surveying required.

Lakes	Hand Searching	Sweep Netting	Trapping	Night Searching	Monitoring prescription
	snorkelling gear recommended, silted substrate very easily disturbed.	around lake.	carried out with modified traps to increase efficiency.		The western shore of this lake should be focused on around the mouths of afferent rivers and streams. A large number of presence / absence surveys should be undertaken first to establish crayfish status. Sweep-netting would also be useful in this respect.
Lough Ennell	Suitable – hand search with snorkelling gear recommended due shore gradient.	Suitable - vegetation and substrate of smaller grade frequent around shore.	Suitable - should be carried out with modified traps to increase efficiency.	Marginally suitable – luxuriant growth could hinder visibility.	Probably no crayfish present in this lake due to water quality problems. No further surveying recommended.
Lough Owel	Suitable - with transparent bottomed tray or with snorkelling gear (dependent on characteristics of chosen site).	Suitable - vegetation and substrate of smaller grade frequent around shore.	Suitable – as well as surveying the shore by this method, boats could be used to set traps in deep water.	Suitable	Monitoring recommended. Hand-searching is the most effective method on this lake though sweep-netting is useful around vegetated areas. There is an ideal site for hand-searching near the Shannon Regional Fisheries Board facility, at the southern end of the lake (N 41335 36238). Hand-searches should involve the searching of 100 metre lengths of shoreline, in various depths of water. Sweep net areas with vegetation and loose substrate. Other sites on the western shore, the northern part of the lake around the River Brosna, and the eastern shore near the N4 should be examined.
Lough Ree	Suitable - hand searching sufficient with a transparent bottomed tray.	Marginal suitability –vegetation present but sparse and substrate difficult to disturb.	Suitable – easily accessed from nearby roads.	Suitable – easily accessed from nearby roads.	Further surveying required. A large number of presence / absence surveys should be undertaken using hand-searching and sweep-netting. This surveying should concentrate on areas adjacent to inflowing watercourses throughout the lake. Access to Hodson's Bay is easy and has suitable substrate for hand searching (N 01399 45390, N 01399 45390). However, no crayfish were found here during the current assessment.
Loughaunwillian	Suitable - snorkelling hand search recommended due to varying depth of lake around margins.	Unsuitable	Suitable – easily accessed from nearby roads.	Suitable – easily accessed from nearby roads.	No further crayfish surveying is recommended – crayfish are thought to be absent from this lake.