SIGNAL CRAYFISH IN SCOTLAND

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ABSTRACT

The spread of the non-indigenous North American signal crayfish (*Pacifastacus leniusculus*) in Scottish freshwater ecosystems is of major concern due to the threats that this species poses to biodiversity. In 2007, the Scottish Government listed signal crayfish under the Species Action Framework (SAF), a five-year strategy for species management in Scotland**.** One of its foremost objectives is to determine the distribution of signal crayfish in Scotland, thereby allowing control or containment efforts to be targeted appropriately. This paper outlines the recent work undertaken to fulfil this objective. Existing records of crayfish distribution were collated and validated prior to extensive field surveys. A standard crayfish detection protocol involving kick sampling, electrofishing and baited-traps was applied at all sites. Signal crayfish are now known to occupy at least 58 km of river length in Scotland. They are also present in a small number of standing waters, ranging in size from small ponds to large lochs. Field surveys confirmed and refined crayfish distribution records and identified sites where eradication of localised populations might be possible. At some sites the protocol failed to detect crayfish despite previous records. This lack of detection may be attributed to the completion of fieldwork at a time of year when crayfish activity is low and also the difficulty of detecting crayfish at low densities. Future surveys should take account of these limitations and where appropriate, modify the survey timings or methodologies to maximise the likelihood of crayfish detection.

Keywords: crayfish, distribution, Scotland, survey

INTRODUCTION

Unlike the rest of the British Isles, no crayfish species occur naturally in Scotland (Maitland 1996, Holdich et al. this volume). There are, however, two known introduced species. The white-clawed crayfish, *Austropotamobius pallipes* (Lereboullet), inhabits Loch Croispol, Sutherland (Thomas 1992) and Whitemoss Reservoir, Renfrewshire (Maitland et al. 2001). The Loch Croispol population is thought to have originated from the introduction of crayfish to a feeder stream in 1945 (Thomas 1992). Local information suggests that the population at Whitemoss Reservoir has also been present for many decades (Maitland et al. 2001). The other crayfish species in Scotland, the North American signal crayfish, *Pacifastacus leniusculus* (Dana), was first recorded in the wild in Galloway in 1995 (Maitland 1996) and has become established in at least eight localities across the country (Bean et al. 2006).

White-clawed crayfish are protected under Schedule 5 of the Wildlife & Countryside Act 1981, Appendix III of the Bern Convention, Annexes IIa and Va of the EC Habitats Directive and The Nature Conservation (Scotland) Act 2004. Given the plight of white-clawed crayfish in the rest of Britain

resulting from signal crayfish introductions and the subsequent spread of crayfish plague, these Scottish populations are likely to represent valuable refuge stocks for conservation in the future. Recent survey work has assessed and confirmed the suitability of Loch Croispol as an ark site for white-clawed crayfish, which is sufficiently isolated from the threat of invading signal crayfish and supports a healthy, recruiting population (the author 2009, pers. obs.). Future surveys will assess the status of the white-clawed crayfish population at Whitemoss Reservoir.

To date, there is no obvious evidence to suggest that white-clawed crayfish populations have negatively impacted native biota or have dispersed or been translocated from their sites of introduction. By contrast, the introduction and continued spread of signal crayfish has been highlighted as cause for concern in Scotland and is likely to have a significant impact on freshwater ecosystems. Previous research Scotland has highlighted the potential for signal crayfish to impact Atlantic salmon stocks (Giffiths et al. 2004) and significantly alter the structure of invertebrate communities (Crawford et al. 2006). In 2007, the Scottish Government listed signal crayfish under the Species Action Framework (SAF) as an invasive species posing a significant threat to native freshwater biodiversity. This framework, developed and implemented by Scottish Natural Heritage (SNH) and partners, sets out a five-year long strategy for species management in Scotland (SNH, 2007). One of the foremost objectives of the SAF Signal Crayfish Implementation Plan is to assess the distribution and status of signal crayfish in Scotland, which will allow control and containment programmes or other mitigation measures to be targeted appropriately.

The purpose of this paper is to outline the most recent efforts made by SNH and the Rivers and Fisheries Trusts of Scotland (RAFTS) to determine the fine-scale distribution of signal crayfish in Scotland. The merits and problems associated with this programme of work and implications for future projects are discussed.

MATERIALS AND METHODS

Collating Records

Prior to field surveys, existing records of signal crayfish distribution were collected from published and unpublished literature. Additionally, Fisheries Trusts and District Salmon Fishery Boards (DSFBs) were contacted by letter to appeal for up-to-date information. In December 2008, a workshop was held to allow verification of crayfish records by delegates from the Rivers and Fisheries Trusts of Scotland (RAFTS), the United Clyde Angling Protective Association Ltd (UCAPA), SNH and seven different Fisheries Trusts. Marine Scotland (formerly the Fisheries Research Services, FRS) and the Scottish Environment Protection Agency (SEPA) were also asked to provide access to any data held by them.

Field Surveys

The locations of sites to be surveyed for crayfish were finalised based on the validity of previous records and the expert opinions of participating Fishery Trust and DSFB biologists. A list of sites surveyed during the exercise is provided in Table 1. In March 2009, a standard protocol for detecting signal crayfish (Gladman et al., in prep.) was applied at all survey sites. This active-search protocol was based upon the results of previous field experiments on the River Clyde and involved the sequential application of kick sampling, up to three runs of electro-fishing and baited-trap setting to determine crayfish presence. Sample timings and equipment including nets, traps, baits and field-recording sheets were standardised. Before and after use, equipment was thoroughly disinfected. All crayfish captured during the survey work were counted and killed on-site, prior to storage in 100% (Analar grade) alcohol.

Location	River Catchment	Fishery Trust Undertaking the Survey
Upper Clyde	Clyde	Clyde River Foundation
River North Esk (ponds); Lugar Burn/main stem	North Esk	Esks DSFBs
Pow Burn	South Esk	Esks DSFBs
Rankeillour Burn (Fife)	Eden	Forth Fisheries Trust
River Teith (pond and ditches)	Forth	Forth Fisheries Trust
River Tyne (stillwater fishery, East Lothian)	East Lothian Tyne	Forth Fisheries Trust
Tiel Burn (Fife)	Tiel	Forth Fisheries Trust
Murray Burn	Water of Leith	Forth Fisheries Trust
Kirkcudbrightshire	Dee	Galloway Fisheries Trust
Skyre Burn	Fleet	Galloway Fisheries Trust
River Nairn	Nairn	Ness and Beauly Fisheries Trust
Dighty Water (Dundee)	Dighty	Tay DSFB
River Earn	Earn	Tay DSFB
River Ardle (pond and small stream)	Ericht	Tay DSFB
Shee Water (pond and small stream)	Ericht	Tay DSFB
Rivers Ettrick and Till	Tweed	Tweed Foundation
Kirkbank (Teviot Water)	Tweed	Tweed Foundation

Table 1: Locations of sites surveyed for signal crayfish in Scotland during 2008/9.

RESULTS AND DISCUSSION

Fine-scale maps showing the distribution of signal crayfish in Scotland, based on the current surveys, are provided in Sinclair (2009). The main findings are summarised below:

Signal crayfish are now known to occupy at least 58 km of river length in Scotland. This figure represents a minimum estimate of crayfish distribution and does not include populations in large still waters such as Loch Ken in Galloway. Loch Ken is thought to contain the largest population of signal crayfish in Scotland and the Scottish Government has recently provided funding to undertake a major trapping research programme, which will include an assessment of crayfish distribution, population size and overall density. The present project has successfully confirmed and delimited signal crayfish distribution at a number of sites. It has also provided some indication of the relative density of crayfish within and between catchments and, in the case of the Clyde, helped determine the approximate upstream and downstream limit of crayfish distribution on the main stem and associated tributaries. New records of crayfish presence have been verified by surveys on the Arvie Burn in the Kirkcudbrightshire Dee catchment and on the Tiel Burn and its tributaries in Fife.

Based on the results, potential sites for eradication of localised populations on the Forth, Fleet, Tweed and Nairn catchments have been identified. By contrast, surveys have demonstrated that the cost-effective eradication of crayfish populations in some areas, such as the Clyde and Kirkcudbrightshire Dee, is now impossible. The upstream spread from the main stem to adjoining burns in these well-established populations appears to be relatively slow. The reasons for this are unknown and require investigation. On the Clyde there is a pressing need to apply targeted control of the crayfish currently occupying headwaters and take preventative measures to avoid cross-catchment spread to the nearby River Annan.

The sequential use of kick sampling, electrofishing and trapping as part of the crayfish detection protocol has proven effective, with electrofishing generally detecting crayfish in sites where kick sampling failed (but requiring greater effort in terms of the time taken to obtain the positive result), thus providing information on the relative density of crayfish within catchments. Very few crayfish were caught in traps, supporting the decision to favour active search methods over passive ones, such as trapping. Kick sampling and electrofishing were also shown to be adaptable for use in still water, detecting crayfish in ponds on the Forth catchment. Electrofishing was unsuitable, however, for use in deep, turbid water or areas with very strong currents. Practitioners regarded the protocol as cost and time-effective: kick sampling does not require expensive or specialist equipment (i.e. only pond nets and trays), nor does it require specialist training for surveyors to implement; electrofishing is already an integral part of fishery surveys that are carried out by Fisheries Trusts throughout Scotland and so equipment and trained staff were readily available; traps were easily assembled and deployed. For a team of two or three people, the estimated time to apply all three methods at one site was one hour.

Despite its practicalities, the protocol failed to detect signal crayfish on several occasions. In two catchments, the Esk and the Tweed, no crayfish were found during surveys despite previous records. The Esk Rivers and Fisheries Trust reported the capture of a single crayfish during juvenile fish surveys in the Pow Burn in 2008; crayfish were also found at Drumtochty pond in the same year. No crayfish were found at either location during the present study which involved taking six replicate kick samples at each site and setting five traps which were checked daily for eight days (Pow Burn) and seven days (Drumtochty). Similarly, surveys failed to confirm previous records of crayfish presence in areas within the Tweed, Tay and Kirkcudbrightshire Dee catchments. Ponds on the Tay and Esk, which were previously subject to chemical control trials (Peay et al. 2006), did not yield crayfish during the current surveys (Peay 2009 pers. comm.).

Reasons for the lack of positive records at sites where signal crayfish were previously found are likely to relate primarily to the time of year in which sampling was undertaken and also the difficulty of detecting crayfish low densities. Due to external pressures, this programme of fieldwork was completed in Quarter 1 of 2008, during a time of year that is suboptimal to crayfish detection. At Knocknairling Burn in the Kirkcudbrightshire Dee catchment, for example, a local landowner reported crayfish as being easily visible during low summer flows two years ago but no crayfish were detected during the present surveys in March. The efficacy of surveying is likely to increase, therefore, during the summer months when water temperatures and subsequent crayfish activity are higher. Detecting crayfish at low densities, particularly in larger water bodies is difficult, as observed on the Tweed. Variation in weather conditions and habitat type between catchments may also have impacted the efficiency of crayfish detection. During surveys on the Tay catchment, for example, sampling conditions were poor due to snowmelt and at some sites electrofishing was not possible due to high water. At two sites on the Nairn, kick sampling was not possible due to excessive depth within the sampling area or the presence of deep silts within the main river channel.

It is hoped that this project marks the beginning of a long-term monitoring plan for signal crayfish in Scotland. Data collected this year using the standardised method will serve as a baseline against which future changes in crayfish distribution can be assessed. Such work will provide a useful body of knowledge for use by SNH, SEPA and others involved in the monitoring and management of invasive non-native species in Scotland and other parts of the UK. Feedback from practitioners will aid improvements in the design of the signal crayfish detection protocol, which may already require modification to take account of variation in water body or habitat type, weather conditions and crayfish density between catchments. Increasing the number of kick sample and electrofishing replicates might help improve the reliability of the protocol as a detection method. The feasibility of incorporating crayfish surveying into routine fishery monitoring work during the summer, when crayfish activity is highest and most detectable, should be considered. Data relating to the distribution of this species must be kept up to date to ensure that an early warning of new populations is obtained whilst the opportunity

still exists to initiate a rapid management or eradication programme. Developing and implementing the best strategy for such programmes has been the focus of previous research (Ribbens and Graham 2004, Reeve 2002) and is currently under review (Freeman et al. 2009); this will form the next step in fulfilling the aims of the SAF Signal Crayfish Implementation Plan.

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REFERENCES

Bean CW, Maitland PS and Collen P (2006). Crayfish in Scotland: A Review of Current Status and Legislative Control. *Freshwater Crayfish* 15: 220-228.

Crawford L, Yeomans WE and Adams CE (2006). The impact of introduced signal crayfish *Pacifastacus leniusculus* on stream invertebrate communities. *Aquatic Conservation: Marine and Freshwater Ecosystems* 16: 611-621.

Griffiths SW, Collen P and Armstrong JD (2004). Competition for shelter among over-wintering signal crayfish and juvenile Atlantic salmon. *Journal of Fish Biology* 65: 436-447.

Freeman MA, Turnbull JF, Yeomans WE and Bean CE (2009). Prospects for the control of crayfish in Scotland. *Aquatic Conservation: Marine and Freshwater Ecosystems* (in press).

Maitland PS (1996). The North American signal crayfish, *Pacifastacus leniusculus* (Dana), established in the wild in Scotland. *Aquatic Conservation*: *Marine and Freshwater Ecosystems* 6(2): 107-110.

Maitland PS, Sinclair C and Doughty CR (2001). The status of freshwater crayfish in Scotland in the year 2000. *Glasgow Naturalist* 23:26-32.

Peay S (2009). Scott Wilson Ltd/University of Leeds, England. *Personal communication*.

Peay S, Hiley PD, Collen and Martin I (2006). Biocide treatment of ponds in Scotland to eradicate signal crayfish. *Bulletin Français de la Pêche et de la Pisciculture* 380-381: 1363-1379.

Reeve ID (2002). The removal of the North American signal crayfish (*Pacifastacus leniusculus*) from the River Clyde. Scottish Natural Heritage Commissioned Report No. 020 (ROAME No. F) LI12).

Ribbens JCH and Graham JL (2004). Strategy for the conservation and possible eradication of the American signal crayfish (*Pacifastacus leniusculus*) in the River Dee catchment and Skyre Burn catchment, Dumfries and Galloway. Scottish Natural Heritage Commissioned Report No. 014. (ROAME No. FO2lk05).

Scottish Natural Heritage, (2007). A Five Year Species Action Framework: Making a Difference for Scotland's Species.

Sinclair CA (2009). Fine scale mapping of signal crayfish distribution in Scotland. Scottish Natural Heritage Commissioned Report, Project 26686.

Thomas WJ (1992). A note on the Crayfish of Loch Croispol. *Glasgow Naturalist* 22:102-109.