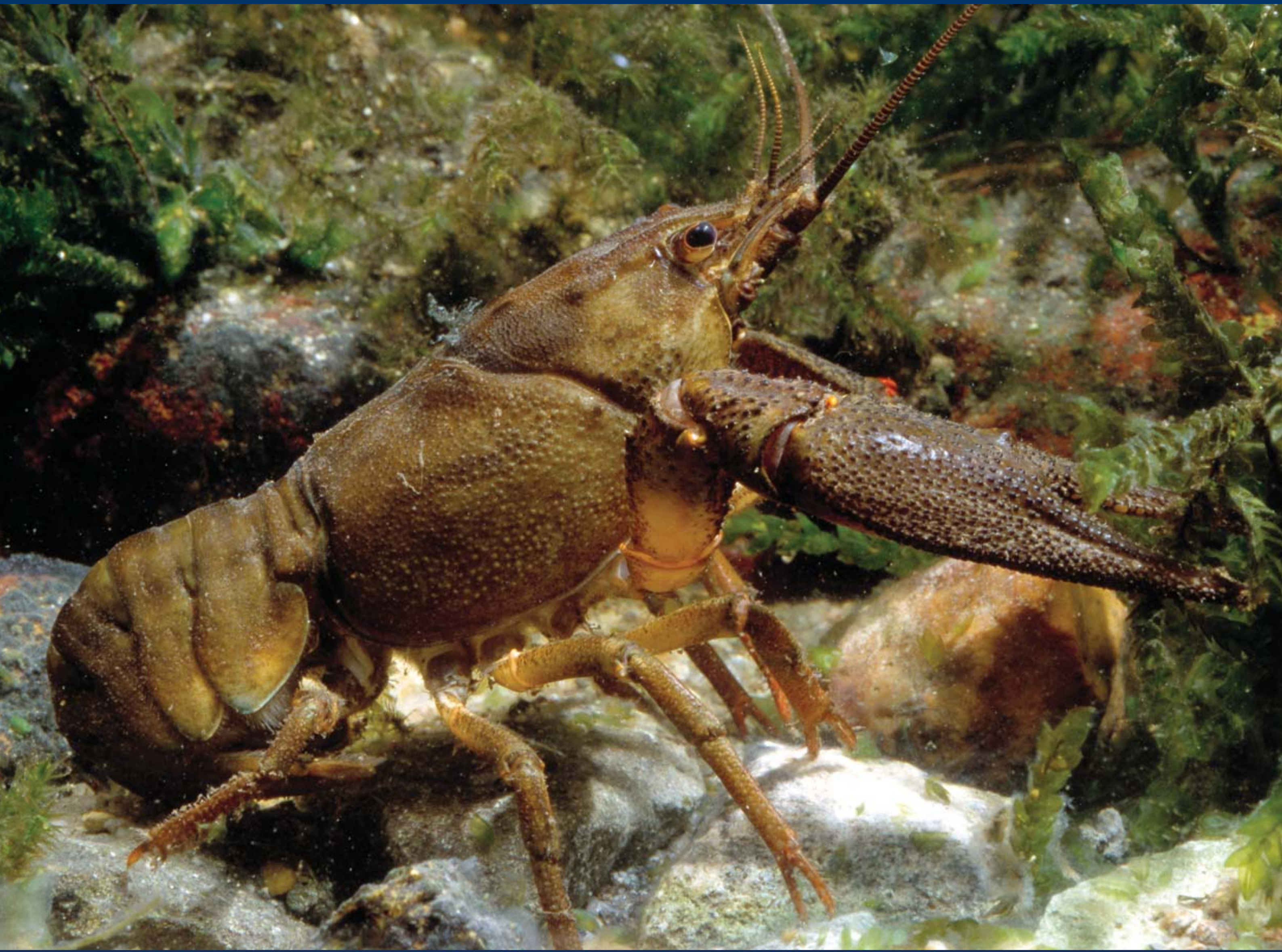
Reintroducing the White-clawed Crayfish

Austropotamobius pallipes



Conserving Natura 2000 Rivers

Conservation Techniques Series No. 1

Reintroducing the White-clawed Crayfish

Austropotamobius pallipes

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Conserving Natura 2000 Rivers

This account of methods to reintroduce the white-clawed crayfish (*Austropotamobius pallipes*) to rivers where it has become rare or extinct has been produced as part of **Life in UK Rivers** – a project to develop methods for conserving the wildlife and habitats of rivers within the Natura 2000 network of protected European sites. The project's focus has been the conservation of rivers identified as Special Areas of Conservation (SACs) and of relevant habitats and species listed in annexes I and II of the European Union Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (the Habitats Directive).

One of the main products is a set of reports collating the best available information on the ecological requirements of each species and habitat, while a complementary series contains advice on monitoring and assessment techniques. Each report has been compiled by ecologists who are studying these species and habitats in the UK, and has been subject to peer review, including scrutiny by a Technical Advisory Group established by the project partners. In the case of the monitoring techniques, further refinement has been accomplished by field-testing and by workshops involving experts and conservation practitioners.

Life in UK Rivers is very much a demonstration project, and although the reports have no official status in the implementation of the directive, they are intended as a helpful source of information for organisations trying to set 'conservation objectives' and to monitor for 'favourable conservation status' for these habitats and species. They can also be used to help assess plans and projects affecting Natura 2000 sites, as required by Article 6.3 of the directive.

As part of the project, conservation strategies have been produced for seven different SAC rivers in the UK. In these, you can see how the statutory conservation and environment agencies have developed objectives for the conservation of the habitats and species, and drawn up action plans with their local partners for achieving 'favourable conservation status'.

The project has also developed new conservation techniques for practical management of key species, including this reintroduction protocol.

For each of the 13 riverine species and for the *Ranunculus* habitat, the project has also published tables setting out what can be considered as 'favourable condition' for attributes such as water quality and nutrient levels, flow conditions, river channel and riparian habitat, substrate, access for migratory fish, and level of disturbance. 'Favourable condition' is taken to be the status required of Annex I habitats and Annex II species on each Natura 2000 site to contribute adequately to 'favourable conservation status' across their natural range.

Titles in the Conserving Natura 2000 Rivers ecology and monitoring series are listed inside the back cover of this report, and copies of these, together with other project publications, are available via the project website: www.riverlife.org.uk.

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1 Introduction

Reintroduction of a threatened species to suitable sites within its natural range can play an important role in its conservation. As increasing numbers of species decline and are lost from within their historic range, it seems likely the drive for reintroductions will become increasingly common. The role of reintroduction in species recovery programmes in Britain is the subject of a great deal of debate.

Guidelines published by the International Union for the Conservation of Nature (IUCN) in 1995 advise that species reintroductions are likely to be acceptable only when:

- The principle aim of reintroduction is to establish a viable, free-ranging population in the wild of a species, subspecies or race that has become globally or locally extinct, or has been extirpated from the wild.
- The species is to be introduced within its former natural range and into suitable habitat.
- The introduced population will require minimal long-term management.

The viability and acceptability of proposed reintroduction programmes are assessed on species and site-specific basis. In Britain, the white-clawed crayfish (*Austropotamobius pallipes*) has been lost from many watercourses. In some instances it may be possible to reintroduce white-clawed crayfish to areas from which they have been lost, provided the reason for their absence no longer applies. **Life in UK Rivers** commissioned the development of this protocol to provide direct, practical assistance to those planning, approving or wishing to carry out white-clawed crayfish reintroductions in the UK and Europe.

2 Potential for reintroduction of white-clawed crayfish to British watercourses

The white-clawed crayfish is the only native freshwater crayfish in Britain. It also occurs in France, Spain, Switzerland, Italy and further east, to parts of the former Yugoslavia. It is under threat and declining throughout its European range.

The white-clawed crayfish is a cold-water species that tends to be confined to smaller upland, and clean lowland, base-rich watercourses. In England and Wales it also occurs in some base-poor waters including larger rivers, canals and stillwaters. The species does not occur naturally in Scotland and has not been recorded from catchments in the far southwest of England and parts of west Wales. Detailed information on the ecological requirements of the species can be found on the **Life in UK Rivers** website, www.riverlife.org.uk.

The decline of the white-clawed crayfish is attributable to a variety of factors that, both independently and in combination, pose very real threats to the continued survival of the species. These include:

- Infection with crayfish plague, caused by the fungus *Aphanomyces astaci* (Alderman 1993).
- Competition for resources from invasive alien crayfish species, particularly the signal crayfish (*Pacifastacus leniusculus*) (Holdich *et al.* 1995).
- Loss of suitable habitat due to factors such as land drainage and river engineering, and other changes in watercourses such as increase in suspended solids (Jay & Holdich 1981).
- Changes in water and/or substrate chemistry, including nutrient enrichment from fertiliser runoff or pollution incidents, including sheep dip pollution.

In some catchments of British rivers white-clawed crayfish occur in headwater streams, but are either not found, or are only patchily distributed, in the middle or lower reaches where there have historically been areas of poor water quality. The converse may also apply where pollution, for example from sheep dip, has eliminated populations in headwater streams. As water quality continues to improve there is the potential for crayfish to survive more extensively in these catchments. Given the slow rate of re-colonisation, the process would be aided by targeted reintroductions at suitable sites.

3 Legal and policy requirements for crayfish reintroduction

3.1 Designations

The white-clawed crayfish is a protected species under Schedule 5 of the Wildlife and Countryside Act 1981. This makes it an offence to take it from the wild or sell it without a licence. In addition, it is listed in annexes II and IV of the European Habitats Directive, implemented in the UK by the Conservation (Natural Habitats &c.) Regulations 1994. This requires that Special Areas of Conservation (SACs) are designated to maintain and enhance the conservation status of important populations of this species. The white-clawed crayfish is also included on the IUCN Red Data List for endangered and threatened species and the Bern Convention, Appendix III. The latter requires that signatories take appropriate and necessary legislative and administrative measures to ensure the protection of the species

3.2 National and international guidelines for species reintroductions

Two main bodies of work guide the policies and processes of species translocation in the UK. The IUCN Guidelines For Reintroduction (1995), drafted by the reintroduction Specialist Group of the IUCN Species Survival Commission, is a generic document advising on reintroduction programs for both flora and fauna. The document is for international reference and covers both wild and captive bred species.

The principles set out in the IUCN document are supported and adopted by the UK Joint Nature Conservation Committee (JNCC) (JNCC 2001). The aim of *Biological Translocations: a Conservation Policy for Britain* (JNCC 2001) is to provide a policy framework and appropriate procedures to manage the activities relating to translocations in the UK. Elements for inclusion in national policy are discussed, along with issues associated with translocation of non-native species, potential legislative improvements, and the process for evaluating and undertaking translocation for conservation purposes. Options are also considered for obtaining better information on species translocations and the role of lead partners in the reintroduction process.

Annex 1 of JNCC (2001) provides a process by which a potential translocation can be assessed, prepared, undertaken and monitored. As with IUCN (1995), this process is generic and aimed at both flora and fauna. *Reintroducing the White-clawed Crayfish* has been designed to adopt the principles and address the requirements of JNCC (2001) for *Austropotamobius pallipes*.

3.3 Duties of key organisations to further the conservation of *A. pallipes*

The white-clawed crayfish is identified as a priority species in the UK Biodiversity Action Plan (UKBAP), which identifies the UK Environment Agency as the lead partner in the conservation of the species. The Species Action Plan (SAP) (Palmer 1994) also details specific actions to be undertaken by a number of organisations to help achieve the targets set for this species. This includes a requirement for statutory nature conservation authorities (such as English Nature and the Countryside Council for Wales) to instigate and support reintroduction programmes to selected sites if feasible. A full copy of the white-clawed crayfish SAP, including actions required and organisations responsible for their implementation can be found on the website www.ukbap.org.uk.

In addition to responsibilities conferred by the UKBAP, key organisations involved in river works have general legal obligations to further the conservation of flora and fauna. The principal bodies are the Environment Agency, water companies, the Department for the Environment, Food and Rural Affairs (DEFRA), local authorities, British Waterways and internal drainage boards. These obligations confer a responsibility to take the needs of species of high conservation priority into account.

4 Approach

Reintroductions of crayfish populations may be proposed for a number of reasons, for example:

- To replace a previously existing population that has been lost due to infection with crayfish plague or pollution.
- To establish a 'safe', isolated population of white-clawed crayfish in a catchment where their future is threatened from competition with alien crayfish species.
- To relocate a donor population that is under imminent threat from competition from alien crayfish or engineering works at its current site.

The reintroduction process can be broken down into four key stages:

- Feasibility
- Preparation
- Implementation
- Post-release activities.

5 Feasibility

The first stage in planning and carrying out a reintroduction project is to assess whether reintroduction is appropriate to the specific situation. Although the detailed approach to reintroductions will vary from project to project, broadly speaking reintroduction should only be undertaken when:

- The reintroduction of crayfish to the proposed receptor site is judged likely to result in the establishment and survival of a new population of white-clawed crayfish, within their historic range.
- Suitable donor stock are available within the catchment (or region if crayfish are absent from the catchment).
- All phases of the project can be carried out without unacceptable levels of risk to human health and safety.
- Resources are available to carry out the work, including follow-up monitoring.

An overview of the components of the feasibility study is given in Figure 1.

5.1 Is the proposed receptor site suitable?

Many factors may influence the suitability of the proposed receptor site as a location for reintroducing white-clawed crayfish. If the reintroduction is to result in the establishment of a stable, self-sustaining population, then all these variables should be in favourable condition at the receptor site.

The key questions to be addressed are:

- Does the receptor site fall within the natural range of white-clawed crayfish?
- Are white-clawed crayfish populations in this location likely to be threatened by alien crayfish?
- Are any crayfish already present at or near to the site, and has an appropriate recent survey been undertaken to assess this?
- If crayfish are not present, why not? Are the reasons for absence likely to affect the success of the reintroduction?
- Are the ecological requirements of white-clawed crayfish met at the site, including both physical and chemical habitat requirements?

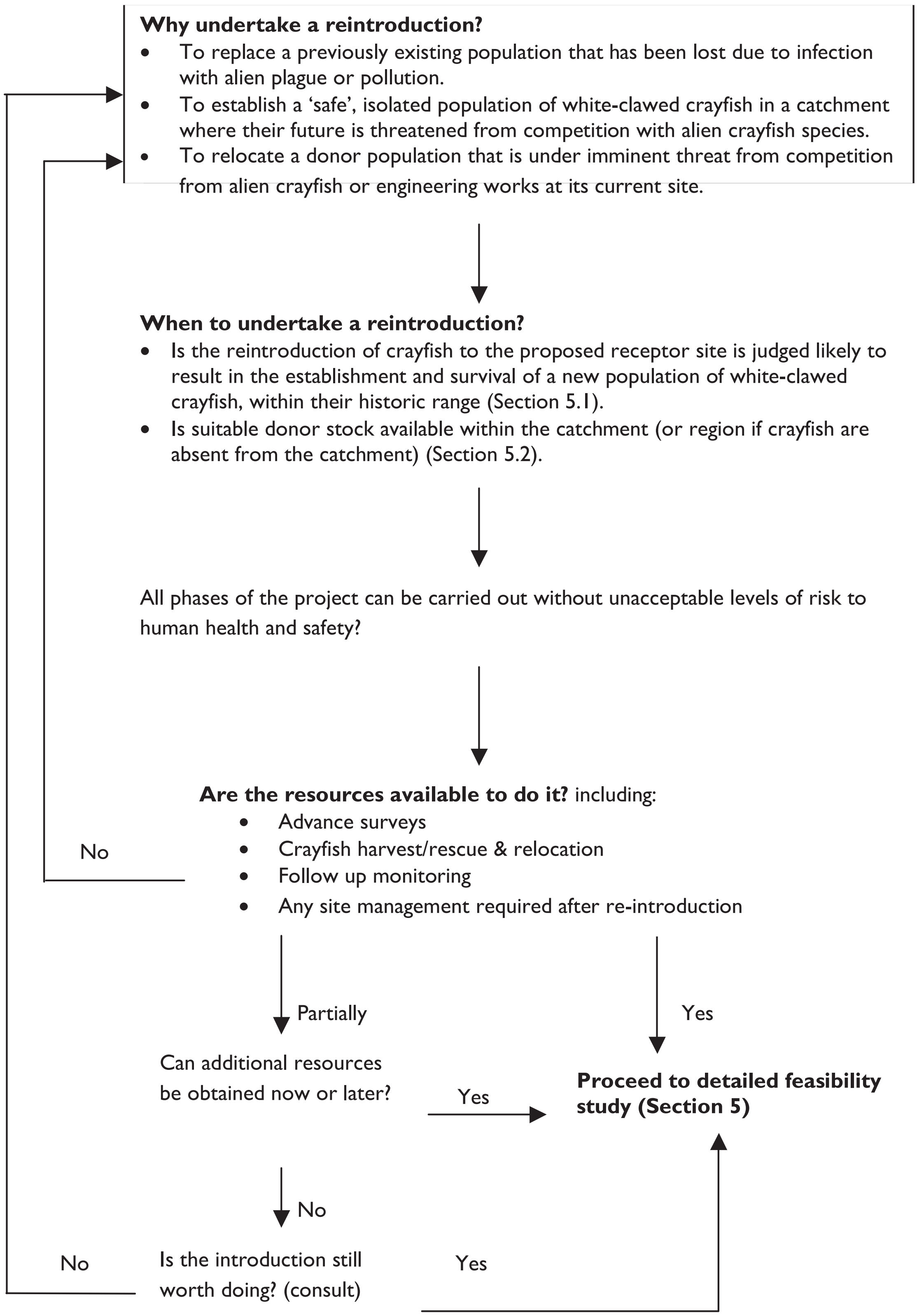

Figure 1. Planning a crayfish reintroduction: Overview of feasibility study

- Will the existing flora and fauna at the receptor site be significantly adversely affected by the reintroduction?

Information to help answer these questions is provided below and summarised in Figure 2.

5.1.1 Is the receptor site within the natural range of white-clawed crayfish?

White-clawed crayfish reintroductions will only be acceptable within their natural range. This is defined as catchments where crayfish already occur or are known to have occurred in the past.

Where recent or historic records of white-clawed crayfish exist from part of a river catchment, it is reasonable to assume that, historically, they will have occurred in suitable habitat throughout the catchment, except where a barrier existed to their movement, or natural water chemistry made watercourses unsuitable. Therefore, although reintroductions should preferentially be undertaken at sites where white-clawed crayfish have previously been recorded, in catchments where they occur, or have occurred in the past, it may be acceptable to carry out introductions to alternative sites, from which no specific records exist.

There are some enclosed waterbodies that support nationally important populations of crayfish. Where these are man-made, the crayfish must have been introduced in the past. Given that the invasion of alien crayfish is such a major threat to the white-clawed crayfish, isolated waterbodies may offer the chance of retaining native crayfish within a catchment where riverine populations are being lost. Therefore reintroductions should not necessarily be restricted to running water or only sites with historic population records.

5.1.2 Have alien crayfish species been recorded in the catchment?

Alien crayfish species, in particular the North American signal crayfish (*Pacifastacus leniusculus*), are larger and more aggressive than white-clawed crayfish, and inevitably outcompete the native species where they occur together (Holdich & Domaniewski 1995).

Signal crayfish can rapidly spread both downstream and upstream. Peay & Rogers (1999) estimated a rate of 1.2 km per year in one direction, though the rate of spread is not certain, as populations may be present at low abundance without being detected.

Signal crayfish are becoming increasingly widespread in Britain, particularly in southern and central England, where they are present in almost all river catchments (Sibley *et al.* 2002). Recent R&D work undertaken for the Environment Agency found no known way of eradicating or controlling the spread of signal crayfish (Scott Wilson 2001). This species can be expected to spread to all parts of a catchment in which it occurs over a period of years to a few decades, depending on the size of the catchment. Consequently, Sites of Special Scientific Interest (SSSIs) designated for white-clawed crayfish are automatically considered to be in unfavourable condition if a signal crayfish population occurs within 20 km of the site by watercourse (Peay 2003b). Where a signal crayfish population occurs in the same catchment within 20–50km of a site by water the population is considered to be threatened.

Reintroduction will not be successful if white-clawed crayfish are re-introduced to a site where alien crayfish have been recorded within 50 km in a connecting watercourse.

Reintroductions are most likely to be appropriate in catchments containing no records of signal crayfish. Information on the known locations of signal crayfish populations is available from the Environment Agency. If the proposed receptor site is effectively isolated (see below) from signal crayfish populations then reintroduction may be possible. Broadly speaking, reintroduction will only be appropriate when:

- No records of alien crayfish species exist within 50 km by water of the proposed receptor site.
- The receptor site is effectively isolated from signal crayfish populations within the catchment.

Examples of isolated sites may include:

- Ponds or lakes with no inflow or outflow, even in extreme weather.

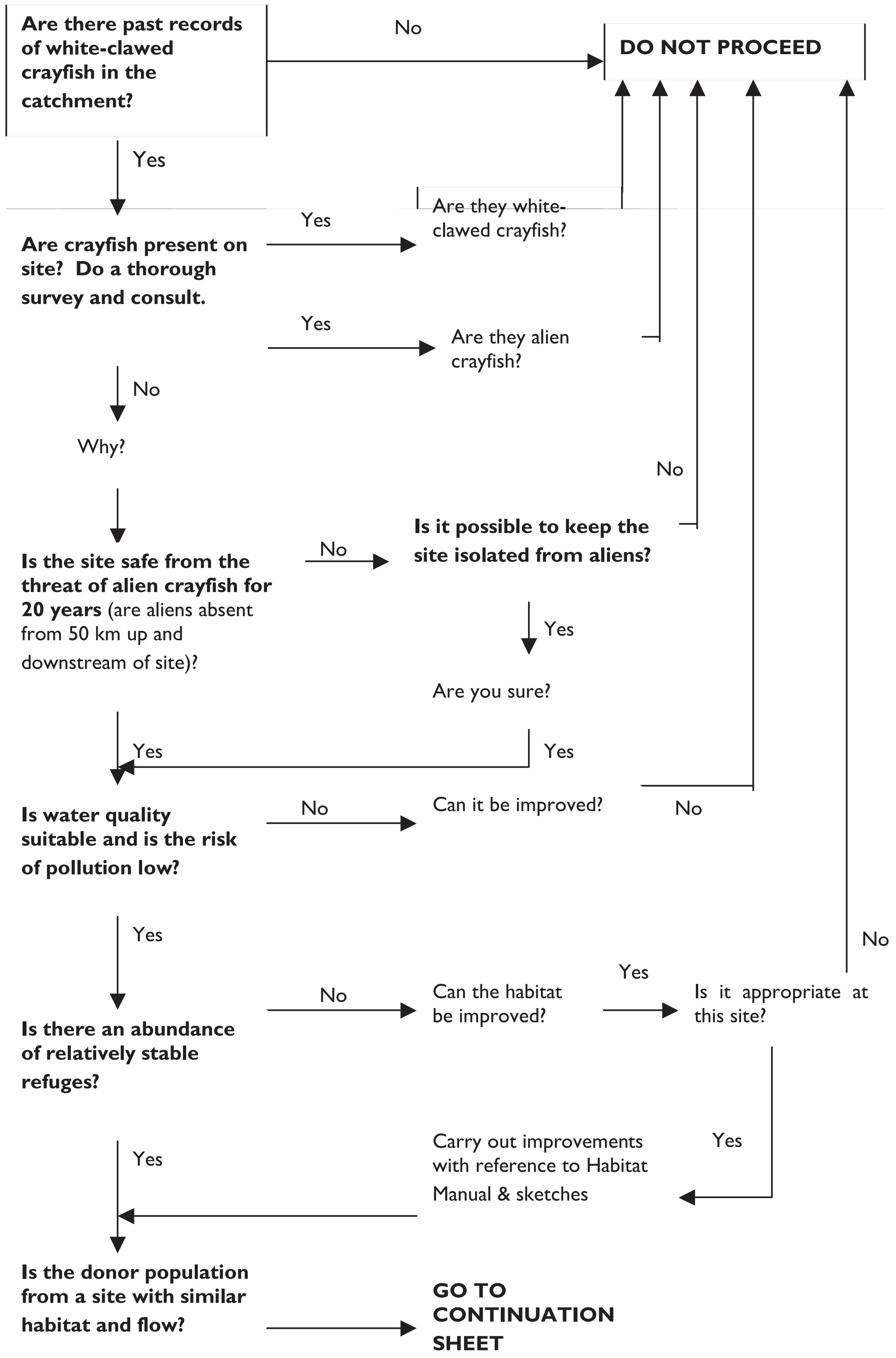

Figure 2. Planning a re-introduction of white-clawed crayfish: Is the receptor site suitable?

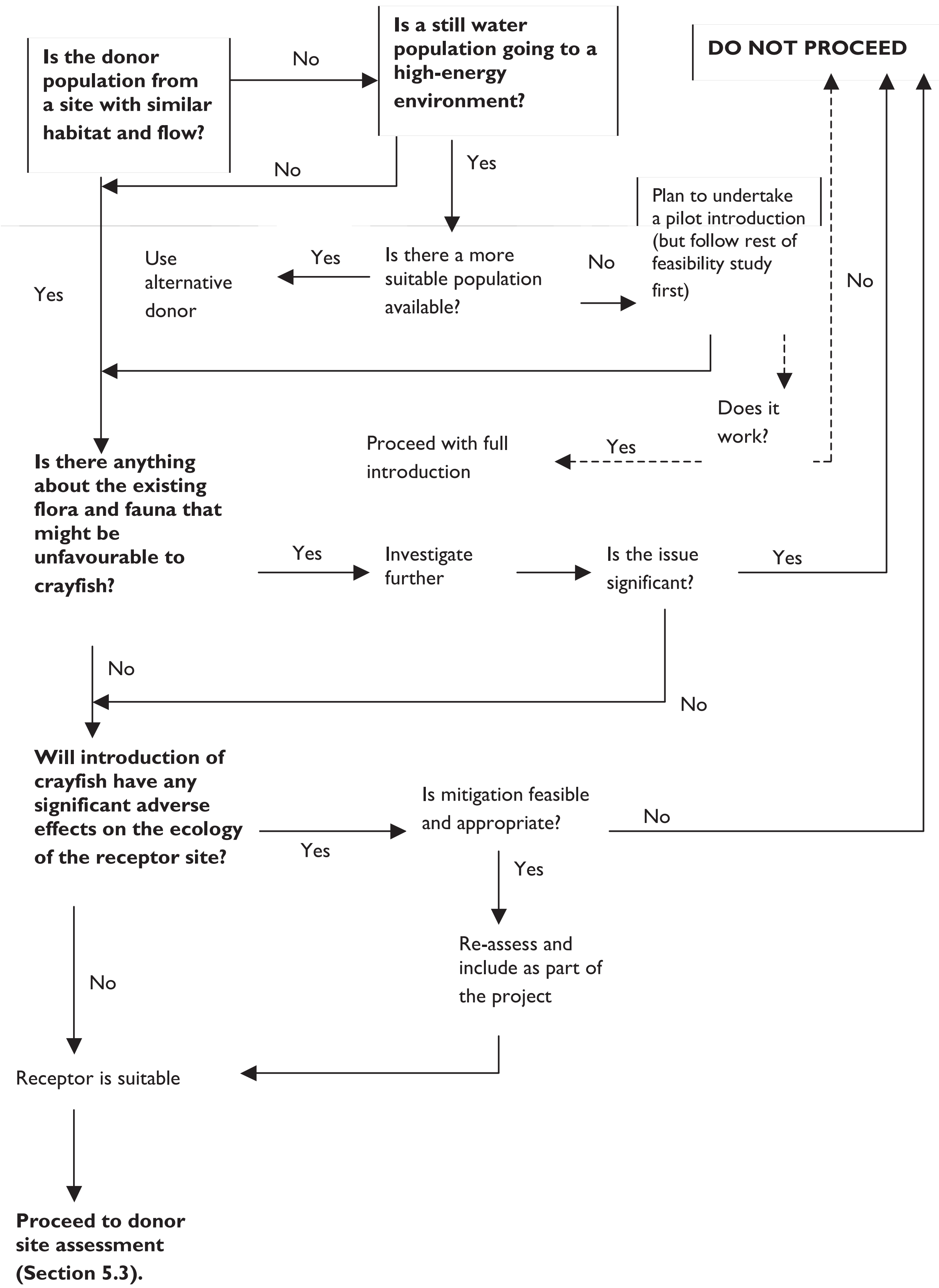

Figure 2a. Planning a re-introduction of white-clawed crayfish: Is the receptor site suitable? Continuation sheet.

- Stretches of river where an effective barrier exists to prevent signal crayfish colonisation, for example where poor water quality downstream prohibits upstream crayfish movement. Weirs and waterfalls less than 2 m high are not considered suitable barriers to signal crayfish (Scott Wilson 2001).

5.1.3 Are crayfish already present at the site, and if not why not?

If white-clawed crayfish are already present at a site, then reintroduction is not necessary. Likewise, if an existing population elsewhere in the catchment can be expected to re-colonise the site naturally, reintroduction will not be required.

If historic records of white-clawed crayfish are available at or within 10 km of a site, or signal crayfish have previously been recorded in the catchment, preliminary survey of the reach will be particularly important to determine whether any crayfish are present. Crayfish populations can theoretically survive at very low abundance (Scott Wilson 2001) and commonly used survey techniques often only detect populations at much higher densities. Consequently, even if crayfish have never previously been recorded at the site, advance survey will be required.

For the purposes of reintroduction it is important that the most appropriate survey method is used to maximise the chance of detecting low-abundance crayfish populations that may be present. It should be noted no known survey method is capable of definitively proving populations are absent. Condition-specific survey methods are summarised in Table 1.

If white-clawed crayfish have previously been recorded at the proposed receptor site but can no longer be detected, the reason the population became extinct should be determined if possible. If the reason for the loss of the original population is still present it may act on introduced crayfish and cause failure of the reintroduction.

If a population has been lost due to direct competition from alien crayfish species, reintroduction of white-clawed crayfish will not be successful. Other factors that may cause the loss of white-clawed crayfish include:

- Infection with crayfish plague.
- Chronic deterioration in physical or chemical habitat quality, such as siltation or eutrophication.
- Sporadic pollution incidents (for example, sheep dip spills).

In many cases no definite cause for loss of the population can be confirmed. If previous infection with crayfish plague is known or suspected, it is recommended that a pilot reintroduction be carried out as part of the site preparation (see Section 6.3) to confirm absence of plague spores.

5.1.4 Are the ecological requirements for white-clawed crayfish met at the site?

The ecological requirements of white-clawed crayfish have been well researched (Holdich 2003; Holdich & Rogers 2000; Smith *et al.* 1996; Foster 1993; Naura & Robinson 1997). Details of these requirements (Holdich 2003) can be downloaded from www.riverlife.org.uk. A summary of the ecological requirements of white-clawed crayfish is given in Table 2 (derived from Holdich & Rogers 2000; Peay 2003b).

Although some white-clawed crayfish populations have been recorded at sites where one or more of these variables is unfavourable, for the purposes of reintroduction most, if not all, of these criteria should be met at the receptor site.

The standard survey methodology (Peay 2003a) incorporates recording of favourable habitat patches. For the purposes of assessing the feasibility of reintroduction, both favourable and unfavourable habitat features should be mapped on a plan. This will also help to identify suitable areas for release of crayfish should the reintroduction be undertaken (Section 7.3).

The habitat appraisal should extend for at least 5 km either side of the proposed receptor site to ensure that enough suitable habitat is available to enable a crayfish population to expand over time.

Table 1. Selecting appropriate survey techniques.

Site conditions	Survey technique	Survey method	Application
Shallow water, bed visible, moveable in-channel refuges, e.g. cobbles.	Standard crayfish survey as developed for monitoring crayfish (Peay 2003a).	Manual search of a 100/200 m site from a 500 m stretch of river. The five best patches of habitat are selected and 10 potential refuges searched within each patch. Average number of crayfish per 10 refuges recorded to give indication of abundance.	Appropriate where bed is clearly visible and habitat can be searched/accessed safely. In searching for low-density populations the number of favourable patches searched can be increased.
Shallow water, bed visible, predominantly fixed or bank refuges.	Standard survey supplemented with night-viewing (Peay 1999).	The survey is undertaken by wading the channel and viewing the bed in front of the surveyor with a torch. Numbers and approximate size class of crayfish are recorded.	Good method for searching areas with fixed refuges, e.g. where crayfish are using bankside burrows. Due to health and safety considerations requires a minimum of two surveyors and strict risk assessment/control measures. Only appropriate where water is clear and shallow enough to wade . Only records active crayfish so not successful during winter months when crayfish are inactive. Mostly records adult crayfish
Deep and/or turbid water.	Drawdown	The site is dewatered to encourage crayfish in bankside refuges to emerge. Crayfish emerge within half an hour of being exposed (Nick Birkinshaw & Erica Kemp pers. obs.). Potential refuges on the bed can also be examined more easily.	Appropriate on small, contained waterbodies or canals where water levels can be controlled, also occasionally in streams, where part or all of a length of stream is temporarily diverted for engineering works. Only likely to be feasible where drawdown is required anyway.
	Trapping with baited traps	Baited traps set at high density around identified 'habitat patches' (Peay 2002). Trapping for a minimum of three consecutive nights in summer or early autumn, may detect largest and most active crayfish if present.	Very poor for detecting low-density populations, as only a small proportion of individuals are susceptible to trapping. Only to be used where no other survey method can be undertaken.

Table 2: Summary of ecological requirements for white-clawed crayfish.

Factor	Suitable	Unsuitable
Water Quality	Clean UK Environment Agency (GQA class A or B), well-oxygenated, mesotrophic water	Polluted (GQA Class C or D), eutrophic waters liable to de-oxygenation
	Calcium levels above 5 mgl^{-1}	Calcium levels below 5 mgl^{-1}
	pH levels in the range 6.5–9	pH levels outside this range
	Low risk of pollution events, such as permethrin-based sheep dip pollution. No local effluents likely to lead to high biological oxygen demand(BOD), e.g. farm or fish farm effluents.	History of pollution with toxic substances, e.g. sheep dip or ammonia from slurry. Local effluents likely to lead to high BOD.
Water quantity/ flow regime	Water present throughout the year	Seasonal watercourses or waterbodies
	Stable flow regime with pools and glides	Tendency for extreme flood events (severe enough to dislodge boulders)
Physical habitat, shelter and food	A variety of refuges present in the channel or banks, e.g. cobbles interspersed with boulders, submerged tree roots, unpointed masonry or soft banks for burrowing.	Few refuges present in channel and/or banks, e.g. unfissured bedrock, sheet piling and smooth concrete banks.
	Stands of submerged vegetation such as *Fontinalis* moss and water crowfoot to provide food and cover. Abundant invertebrate fauna as a source of food and calcium.	Little or no submerged vegetation. Sparse invertebrate fauna.
	Habitat not dominated by algae such as blanket weed.	Habitat dominated by algae.
Channel structure and management	Areas of undercut, vertical bank. Banks well vegetated with overhanging vegetation to provide shelter and food.	Eroding, unvegetated banks, poaching by cattle.
	No factors likely to lead to decline of submerged plant communities present.	Changes to channel structure or deposition of sediments anticipated to occur.
	No works likely to lead to destruction of refuges and banks anticipated.	Dredging or channelisation works planned.
	No substantial local inputs of fine or anoxic sediments that may clog gills.	Poaching by cattle leading to increased inputs of sediment. Mining works or pond construction and maintenance.

To ensure that water quality is suitable for supporting crayfish, a review of water quality data over the previous five to 10 years should be carried out to investigate long-term trends. If the site is prone to sporadic pollution incidents, these may not be evident in the chemical data. Biological water quality data from the habitat appraisal area should be analysed to confirm the absence of any indication of sporadic or toxic pollutants.

If physical or chemical habitat features are unsuitable for supporting white-clawed crayfish, the reintroduction should not be progressed unless these problems can be resolved. If feasible, this work will form part of the site preparation (Section 6.3). In the event that several features are unfavourable, or if improving the habitat would require substantial resources, consideration should be given to locating an alternative site where favourable conditions already exist.

5.1.5 Are there likely to be any significant adverse effects to the receptor site?

The introduction of a species to a site will inevitably have some effect on the local ecosystem. Crayfish feed on a wide range of animal species, such as insect larvae, worms, water snails and freshwater shrimp, and may alter the invertebrate communities of a site following reintroduction (Matthews *et al.* 1993). They may also alter the site's macrophyte communities by grazing the root systems and shoots of plants such as pondweeds, watercress and *Fontinalis* moss. In addition, some white-clawed crayfish populations have been found to burrow extensively, and may undermine bank stability.

Potential impacts on existing freshwater ecosystems are only likely to be of concern where the proposed recipient site is already of significant nature conservation importance for its freshwater macrophyte, fish or invertebrate communities. In such cases an assessment of the likely impacts on the recipient community should be carried out. This should assume that the white-clawed crayfish population will increase in range and density following reintroduction.

5.2 Has the most suitable donor population been selected?

The feasibility of a reintroduction programme is unlikely to be limited by the lack of a suitable donor population, as white-clawed crayfish populations are **currently** far more abundant than suitable reintroduction sites. In assessing the suitability of a population as a 'donor' the following factors should be considered:

- Status of the population at the potential donor site.
- Location of donor site relative to receptor site.
- Abundance and accessibility of population.
- Health of population, in particular the incidence of porcelain disease.

The extent to which other issues affect the suitability of the population as a 'donor' is dependent on the status of the population. A process for evaluating and ranking the suitability of potential donor sites is shown in Figure 3.

5.2.1 Status of candidate donor population

For any single receptor site it is likely that a number of potential donor populations will be available. The status of white-clawed crayfish at these sites will play a key role in determining the preferred donor site. In order of preference the donor stock should be taken from:

- A population that is to undergo scheduled rescue and relocation works.
- A crayfish population that is under threat at its existing location, for example due to competition from invading alien crayfish species.
- A 'safe' population in either a catchment with no records of alien crayfish or an 'isolated site'.

5.2.2 Location of donor site relative to receptor site

The IUCN Guidelines for Reintroduction advocate the use of local donor stock to ensure that any genetic traits specific to the area are maintained. Using local stock also helps to safeguard individual animals during the reintroduction process by minimising the requirement for storage and transportation of crayfish.

Genetic analysis of crayfish populations in Britain and Europe indicates that the species has evolved little since its arrival in this country (Grandjean *et al.* 1997), and all populations may originate from the same genetic stock. Nonetheless, in selecting suitable crayfish for reintroduction the order of preference is:

- The same catchment as the recipient site.
- The same region as the recipient site.
- Adjacent regions.

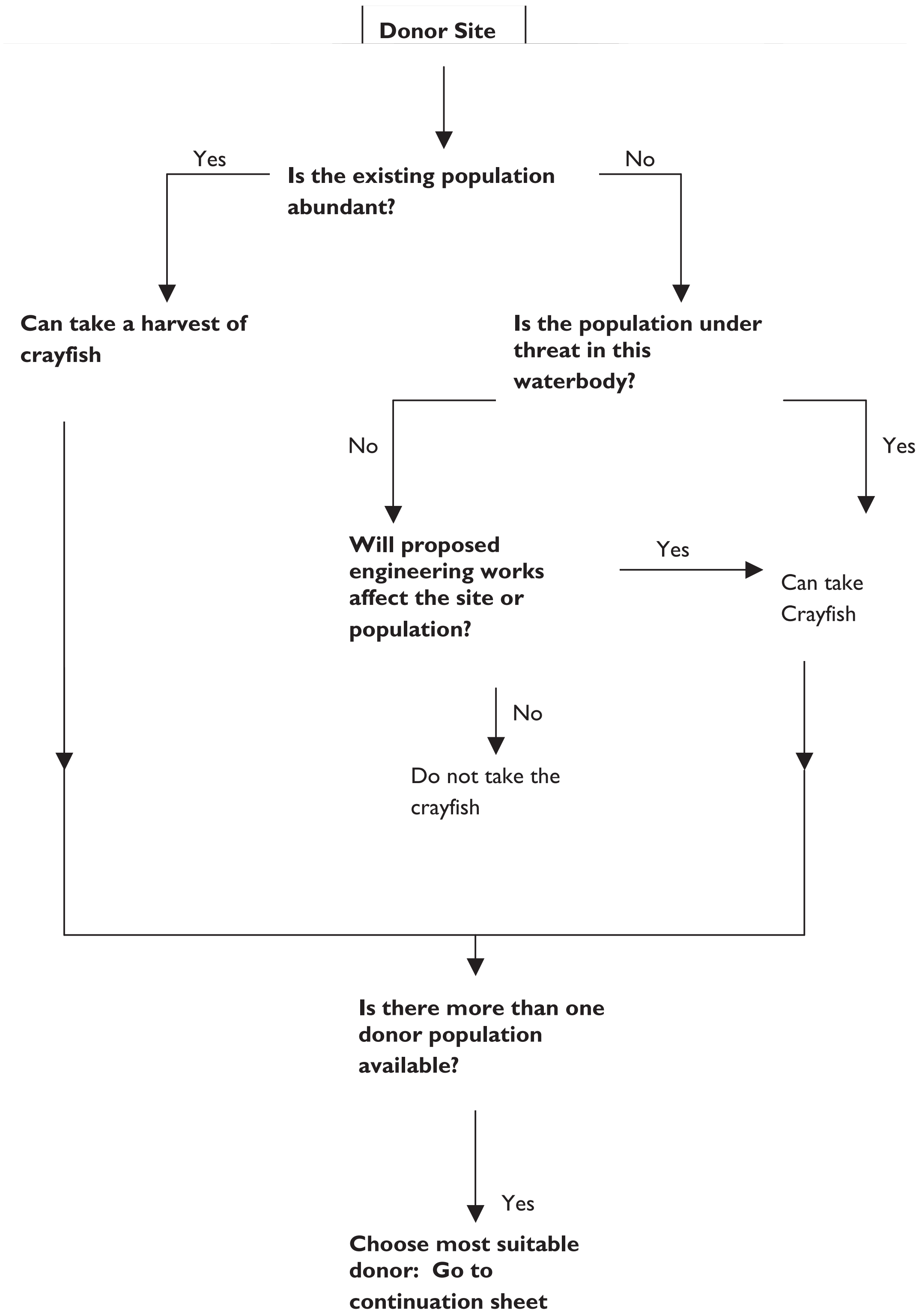

Figure 3. Planning a re-introduction of white-clawed crayfish: choosing a donor population.

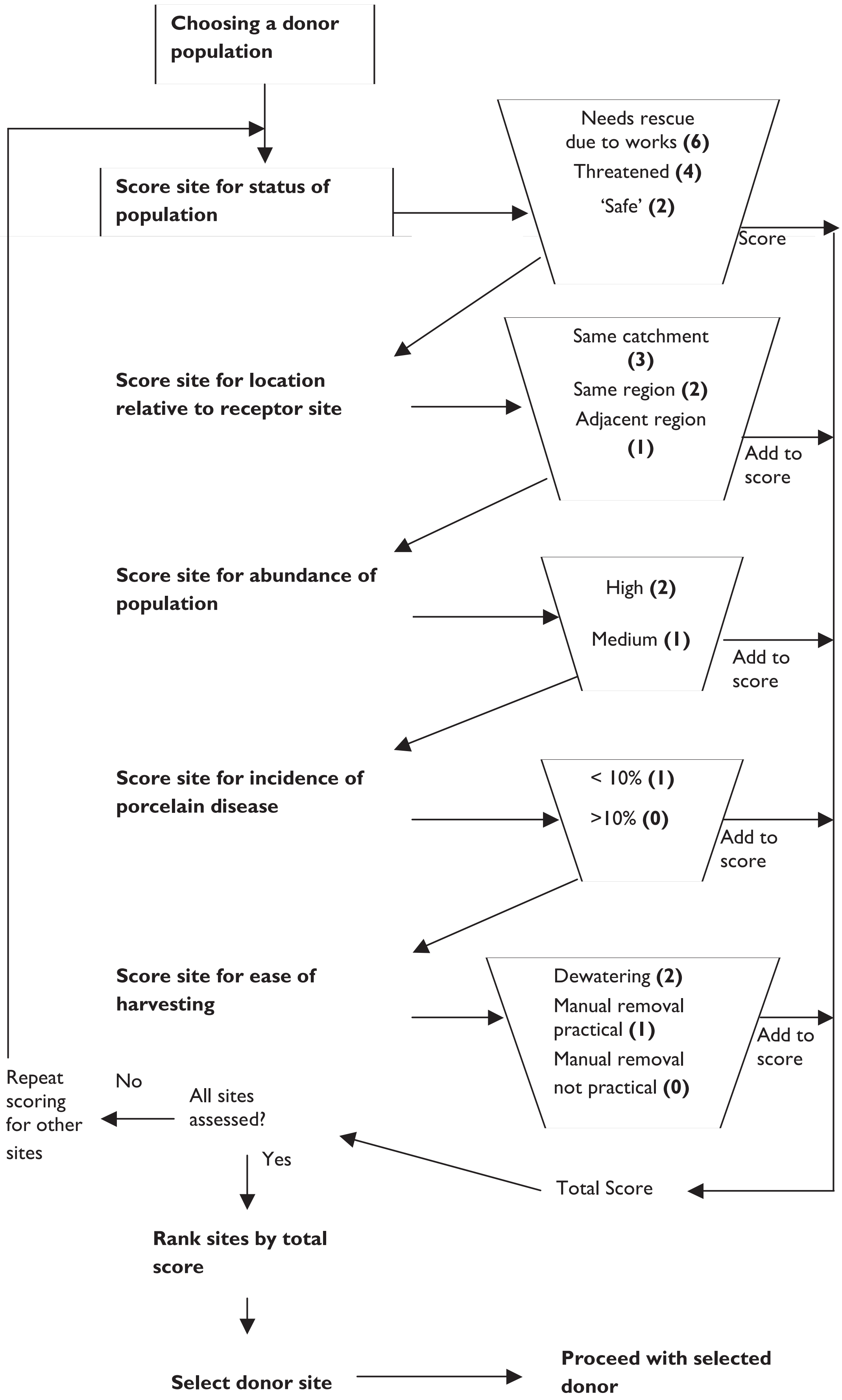

Figure 3a. Planning a crayfish re-introduction: choosing a donor population – continuation sheet.

5.2.3 Abundance of donor population

Crayfish populations can survive at low abundances. Therefore, it is unlikely that the viability of any population will be affected by the loss of the small proportion of the total that is removed for reintroduction elsewhere. However, the abundance of the donor population may limit the ease and efficiency with which suitable stock can be obtained.

When a 'safe' population is proposed as a donor, a precautionary approach should be adopted. In this case the donor population should be at 'high' abundance (>3 crayfish per 10 refuges) or more (Peay 2003b).

Where a 'threatened' population is being considered, the long-term survival prospects for crayfish at that site are already compromised and a 'moderate' density population of at least 1 crayfish per 10 refuges (Peay 2003b) is likely to be sufficiently abundant to 'harvest' suitable stock (Section 7.1).

If crayfish at the donor site will be subject to rescue and relocation as part of engineering works the abundance of the population is unlikely to constitute a limiting factor to the suitability of the population.

5.2.4 Health of the donor population

The donor population should be free from crayfish plague. This disease is caused by the fungus *Aphanomyces astaci* and causes virtually 100% mortality in infected white-clawed crayfish populations. The main method of transmission is via signal crayfish, which may carry this disease without becoming ill (Svärdson *et al.* 1991).

Crayfish incubating plague may take several weeks to express symptoms, particularly at low temperature (Oidtmann 2000). Therefore, unless the complete donor stock is kept in captivity for a protracted 'quarantine' period, it will not be possible to guarantee that the population is free from crayfish plague. However, keeping crayfish in captivity is difficult to achieve. Workers on the River Lathkill, Derbyshire, where a reintroduction was attempted, found it difficult to keep donor stock alive before the reintroduction (David Holdich, pers. comm.).

It is suggested that the donor population be monitored prior to reintroduction as a precautionary measure. If the donor population shows no signs of plague, the reintroduction can proceed. As reintroductions will not be undertaken to sites where white-clawed crayfish are present (Section 5.1.3) or likely to re-colonise the site naturally, no impacts to other populations should occur in the event that the introduced specimens express plague following release. In the event that the re-introduced population is lost due to plague, the receptor site should not be considered for future reintroductions until it has been demonstrated that plague spores are no longer present (Section 6.3).

The incidence of porcelain disease in the donor population should be less than 10% (Holdich 2001). Porcelain disease is the result of infection by the sporocyst protozoan *Thelohania contejani*, and is only easily recognisable in the advanced stages, when the abdominal muscle, translucent in healthy individuals, becomes white and opaque. Porcelain disease frequently occurs at low levels (up to 10%) in crayfish populations without appearing to affect their viability (Alderman & Polglase 1988). However, problems may occur at higher infection rates (Holdich 2003). The incidence of porcelain disease can be established from a sample of a minimum of 50 crayfish, with no more than five individuals (less than 10%) showing signs of infection.

Several other bacterial, fungal and parasitic infections are known to infect crayfish. At present, the incidence of these infections in wild populations, and the level of threat they represent to crayfish, is largely unknown (Oidtmann 2000). A sample of crayfish can be taken at the time of baseline survey and tested for known crayfish pathogens, if desired. On the basis of current knowledge it is considered that unless a number of obviously sick or deformed individuals are discovered it should be assumed that the donor population is viable.

5.2.5 Health and safety considerations

Appropriate health and safety risk assessments should be undertaken prior to surveys and reintroduction works, and precautions taken to minimise potential risks. Site-specific risk assessments be required before any survey work. If the scheme is progressed, risk assessment of crayfish harvest and reintroduction works will also be required. Risks commonly associated with working on or near waterbodies and examples of potential control measures are shown in Table 3.

If the risk assessment process identifies high levels of risk that cannot be reasonably avoided, the project should not be undertaken.

Table 3. Examples of risks associated with working near waterbodies.

Risk	Control measures
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 where appropriate – including self-inflating lifejacket.
Leptospirosis	Wash hands as soon as possible after working around watercourses and always before touching food. Protect cuts & grazes by dressing/gloves.
Cuts, biological and chemical pathogens	Avoid physical contact with areas where sharp items/contaminants may exist.

5.3 Are resources available to carry out the reintroduction?

A white-clawed crayfish reintroduction programme is a long-term project that requires continued commitment from all parties involved. Sufficient resources must therefore be available to complete all phases of the project. This includes resources to cover:

- Staffing
- Volunteer input
- Habitat improvements
- Monitoring commitment
- On-going management.

Following the initial introduction exercise, long-term monitoring of crayfish status at both the donor and recipient sites will be required, and funding must be available to enable this to be undertaken at an appropriate level.

The involvement of the local community and the support of local interest groups is often pivotal in attracting funding to establish and run on-going translocation/monitoring projects. Any involvement should be planned in consultation with statutory nature conservation agencies at the project planning stage.

6 Preparation

6.1 Consultation

The reintroduction of a species requires a multidisciplinary approach involving a team of people drawn from a variety of backgrounds. Consultation should therefore be undertaken and agreement obtained with the following groups:

- Environment Agency
- English Nature (or Countryside Council for Wales)
- Landowners and other stakeholders.

6.1.1 Environment Agency
Under the Water Resources Act 1991, any works within 8 m of a main riverbank or flood-bank require formal consent from the Environment Agency. The Environment Agency is also a lead partner for the conservation of white-clawed crayfish in Britain, and should be consulted during the initial planning stage of the project. Consent from Environment Agency takes a minimum of four weeks. In addition, the Environment Agency is often able to assist with provision of valuable water quality and River Corridor Survey data.

6.1.2 English Nature/Countryside Council for Wales
Actions involving the 'taking' of white-clawed crayfish will require a licence from English Nature's licensing service, or the Counrtyside Council for Wales. Relevant activities are: a) surveying and b) removing individuals from a site (i.e. removal from a donor population for subsequent release to the recipient site). Licences are only granted to an appropriately qualified and experienced ecologist.

If either the donor or recipient sites occur within SSSI, SAC, SPA or RAMSAR sites, written permission is required from the relevant English Nature local team, who may require a specific method statement containing the following information:

- Rationale for the project.
- Details of the donor population including reason for selection, type and number of crayfish required.
- Details of the receptor site, including habitat, water quality and distance to the nearest alien and native crayfish populations.
- Methods of obtaining crayfish including staffing and timing of works.
- Method of holding and transporting crayfish, including duration.
- Method of reintroduction.
- Monitoring programme.

A licence can take up to six weeks to obtain following submission of appropriate applications and method statements. A licensed crayfish worker must be present during all works affecting this species, although others can carry out work under the supervision of a licence-holder.

6.1.3 Others
Where someone other than the landowner proposes a reintroduction, the landowner must be consulted and permission obtained to pursue the project. Local user groups such as anglers may also be consulted, as the long-term survival of crayfish at the site may be influenced by the attitudes of these groups.

6.2 Publicity

The need for publicity may be influenced by the particular circumstances of the reintroduction project or programme. Public awareness of the plight of the native crayfish is not high, and support for conservation of the species would benefit from news about successful introductions. However, publicising the fact that a watercourse is suitable for crayfish may encourage illegal introductions of signal crayfish for commercial purposes, which would defeat the purpose. Such considerations may influence decisions about the degree to which local people are informed.

Decisions regarding the appropriateness of publicity should be made in consultation with the project partners, including the relevant conservation authorities.

6.3 Site preparation

Once all permissions and access have been agreed and appropriate licences obtained, advanced works identified by the feasibility study can be undertaken. The Habitat Manual suggests techniques for such habitat improvements if required (Peay 2003b). These works should be carried out in sufficient time for the effects of any disturbance to subside before reintroduction takes place.

If a pilot study is to be undertaken to detect the presence of crayfish plague spores at the receptor site, this should be phased for this period of the project. Ten cages, each containing one adult crayfish, should be established within the recipient site. These should be monitored on site for at least six months prior to reintroduction. If these individuals die from plague during this period a new reintroduction site should be selected. Rather than permanently disregard the site affected by plague for future reintroductions, it should be re-assessed in five years time.

The survival of the caged crayfish will confirm suitable water quality conditions and freedom from disease. These individuals can be maintained thereafter if desired, to provide long-term monitoring data on conditions within the site.

7 Implementation

7.1 Harvesting suitable stock for reintroduction

Relatively little quantitative information exists on the structure and dynamics of crayfish populations. However, it is considered that re-introducing a cross-section of the population is likely to aid establishment following reintroduction. On the basis of current knowledge it is suggested that the reintroduction population should be structured as follows:

- Equal ratio of male to female crayfish.
- A range of size classes, with a high proportion of the smaller sizes, to reflect natural structure (see Table 4).
- If berried females are recovered these should be translocated, as the eggs will hatch the following year and help ensure continuity of age classes.

Juvenile white-clawed and signal crayfish can be easily confused. In order to avoid accidental introduction of signal crayfish, animals below 15 mm carapace length (CL) should not be harvested. Juvenile crayfish have naturally higher mortality rates (Brewis 1978), which is likely to make them less effective as reintroduction stock.

In natural populations the larger size-classes are relatively low in abundance. However, they are easier to locate during harvesting, and as a result are often over-represented in the sample. Considering the relatively small proportion of individuals above 40 mm CL, the tendency to aggressive behaviour of large males (Woodcock & Reynolds 1988), and the overall vitality and future lifespan of animals in this size-class, it is recommended that crayfish over 40 mm are not collected. The exception to this would be where large populations, consisting of hundreds of individuals, are being recovered as part of engineering works. In this instance recovery of all animals except the <15 mm size-class is desirable.

The size-class distribution of the harvested population, and in particular the extent to which juvenile crayfish are represented in the population, will depend on the method used to obtain the donor stock. Crayfish harvest undertaken using the ‘habitat patch’ approach can be expected to yield populations comprising around 40% juvenile crayfish. Dewatering and rescue tends to yield a higher proportion of smaller crayfish, with juveniles typically comprising 50–60 % of the total catch. When rescue is undertaken by skilled crayfish workers, this figure can rise to above 70% (Erica Kemp, Nick Birkinshaw, pers. obs.). The suggested target ratio of sizes in the harvested population is given in Table 4.

Actual numbers of crayfish re-introduced will be dependent on the abundance of the donor population and the method of harvest. Previous projects have been successful in establishing stable and self-sustaining white-clawed crayfish populations with reintroduction numbers of between 50 and 100 individuals (Spink & Frayling 2000; Geoff Keenlyside, Kirklees Environment Unit, pers. comm.).

Table 4. Target size-class distribution for crayfish reintroductions.

Carapace length (mm)	Suggested target ratio
<15	0
15–25	3
26–35	2
36–39	1
40+	0

Where the intention is to take a sustainable harvest it is important to ensure that the viability of the donor population is not compromised. This is achieved by removing no more than 10% of the estimated stock available for sampling at the donor site. This provides an additional safeguard because the actual stock may be several times larger than the proportion of the population detected in surveys.

To minimise impacts to the donor population during the harvesting operation, manual search and subsequent removal should be undertaken in no more than 10% of favourable habitat patches by area. All crayfish discovered within these areas can be removed. This minimises disturbance to the remaining population, which should rapidly recolonise the harvested patches from the home ranges of individuals in adjacent unharvested areas. In all cases it should be ensured that stones and other key habitat features are replaced and that trampling is minimised.

No crayfish showing symptoms of disease, including visible signs of porcelain disease, should be used for reintroduction. Confirmation is essential that all the animals are healthy and, more importantly, of the correct species. This must be carried out by the licence holder, or agents skilled in identification, during the harvesting process and before the crayfish are placed in the storage containers.

7.2 Transport and temporary storage

To avoid unnecessary stress or damage to the harvested stock, storage and transport of crayfish should be carried out sensitively. The key requirements are:

- **Keep crayfish cool** and ensure they have enough oxygen available. The ideal temperature range during transportation is between 8 and 12°C with a maximum of 15°C and minimum of 4°C.
- **Minimise aggression** by sorting crayfish into size groups, preventing overcrowding and ensuring that plenty of refuges are available throughout the storage/transportation period. Keeping the temperature low will further reduce activity and therefore aggression.
- **Transport berried females separately** – keep them apart from other crayfish.
- **Drive carefully to minimise jolting**. Containers with shallow water and low surface area are less likely to lose water due to turbulence. The addition of moss or hessian sacking will further reduce this and also provide refuges for transported crayfish.

The transportation period should be kept to the minimum required to undertake the transfer. Assuming the above measures are taken, the crayfish should be able to survive without harm for up to 18 hours. Taylor & Wheatly (1980) detected no lasting impact on white-clawed crayfish exposed for up to 48 hours in humid conditions. The animals should be regularly monitored during this period to ensure that favourable storage conditions are being maintained.

It is recommended that storage and transfer vessels are no more than 1 m^2 in size. Tough plastic storage crates with securely fitting lids (available from DIY stores) are ideal, as are large cool boxes. The reasons for this are:

- Small size reduces water turbulence during transport.

- Temperatures can be easily kept low with ice packs on the outside of the containers, or suspended securely above the water level.
- Crayfish can be transported by hand from donor to receptor site with minimum handling.
- Light weight allows for easier transit.

Maintaining cool conditions during storage will ensure that crayfish are relatively inactive. This will increase the densities at which they can be stored, as they are less likely to display aggressive behaviour or sustain injury by moving around. For transport periods of less than four hours, crayfish can be kept at 50% cover of surface area of each vessel, with less than 1% suffering damage, providing an abundance of refuges are available (Nick Birkinshaw and Erica Kemp, pers. obs.). For periods longer than four hours, the storage density should not exceed 25% cover of crayfish per vessel. Oxygen levels in the storage vessel must be maintained using aquarium air pumps. These figures are meant for guidance only and should be agreed in advance with relevant project and statutory consultees.

In the event that transfer between sites is likely to take more than 18 hours, interim storage facilities should be made available. Similar principles apply when retaining crayfish for long periods of time, but this option should only be used where immediate transfer is not possible.

- **Maintain sufficient depth of water** to ensure stable conditions within the storage area. Temperature levels should reflect the habitat from which the crayfish have been harvested.
- **Maintain oxygen concentration** at levels that ensure no discomfort to the animals. This may require the use of aquarium or pond oxygenation pumps.
- **Minimise aggressive behaviour** by:

  Providing adequate refuges/shelters

  Splitting crayfish into similar size-classes

  Providing and evenly distributing sufficient food.
- **Storage areas must be kept clean** with regular water changes. Water supply should ideally be from the same water body from which the animals were harvested, or of similar chemistry.

The conditions required are known from commercial farming of alien crayfish (Holdich 1993b), and from a few cases where keeping and rearing of the native species has been carried out. Other projects have stored native crayfish at one per litre, 5% occupancy of stacked plug trays, for two weeks at 10°C with less than 1% mortality (Peter Hiley, Scott Wilson, pers.comm.). The details are beyond the scope of this document. This should only be undertaken with the approval of the Environment Agency and English Nature and where other options are not available.

7.3 Methods for introducing crayfish to a site

Crayfish should be introduced to stable refuges in favourable habitat patches.

It is proposed that crayfish be introduced at a population density of around 1 per square metre in favourable habitat patches. These should have abundant refuges to ensure each individual has ample choice of shelter. This will maximise the chances of being able to detect crayfish in selected parts of the recipient site within one year of introduction. Observations of selected refuges may also provide clues as to the success of the establishment.

If stable refuges cannot be safely accessed, crayfish can be provided with temporary refuges, but these should be secured sufficiently to resist high flows. These may take the form of bankside or in-channel refuges and examples of possible refuge designs are shown in figures 4 and 5.

If the resources are available to do it, there may be benefits in micro-tagging some or all of the crayfish before they are released. A micro-tag can be inserted carefully into the body cavity, just behind the legs. Indications are that crayfish can survive and undergo normal moulting without adverse effects (Damien Bubb, Durham University, pers. comm.).

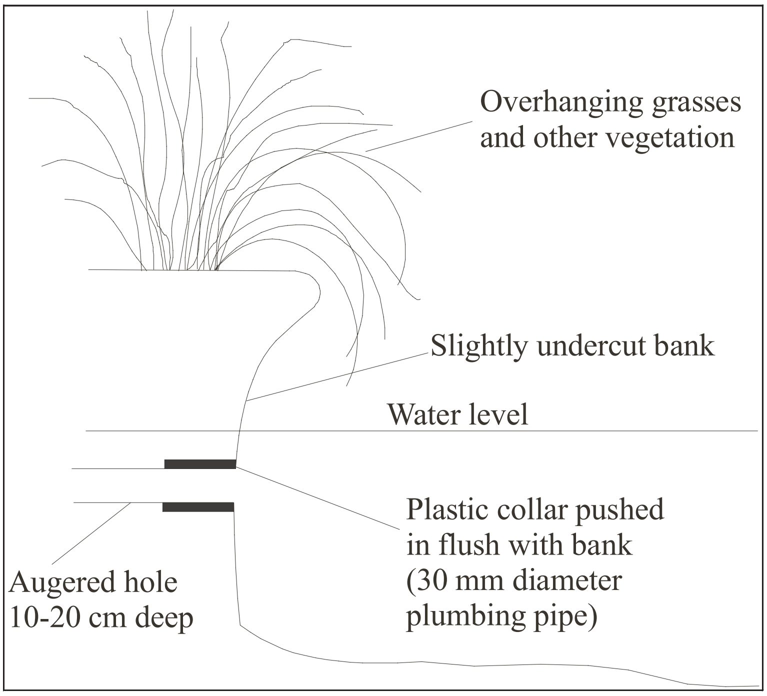

Figure 4. Example of man-made bankside refuge.

After tagging, a scanning device can be used to detect crayfish. The range of detection is a limiting factor with this method – crayfish in refuges in banks or under large boulders will not be detected during the day, although they can be detected if they are out at night. Likewise, crayfish caught during manual surveys can be scanned to see if they are from the original introduction. The purpose of this is to follow the movement and survival of individual crayfish that are introduced to an area. It can be used for mark-recapture studies to help provide estimates of the increasing population. Micro-tagging is not essential for reintroduction programmes, but can be a useful tool in monitoring the introduction (see Section 8.1).

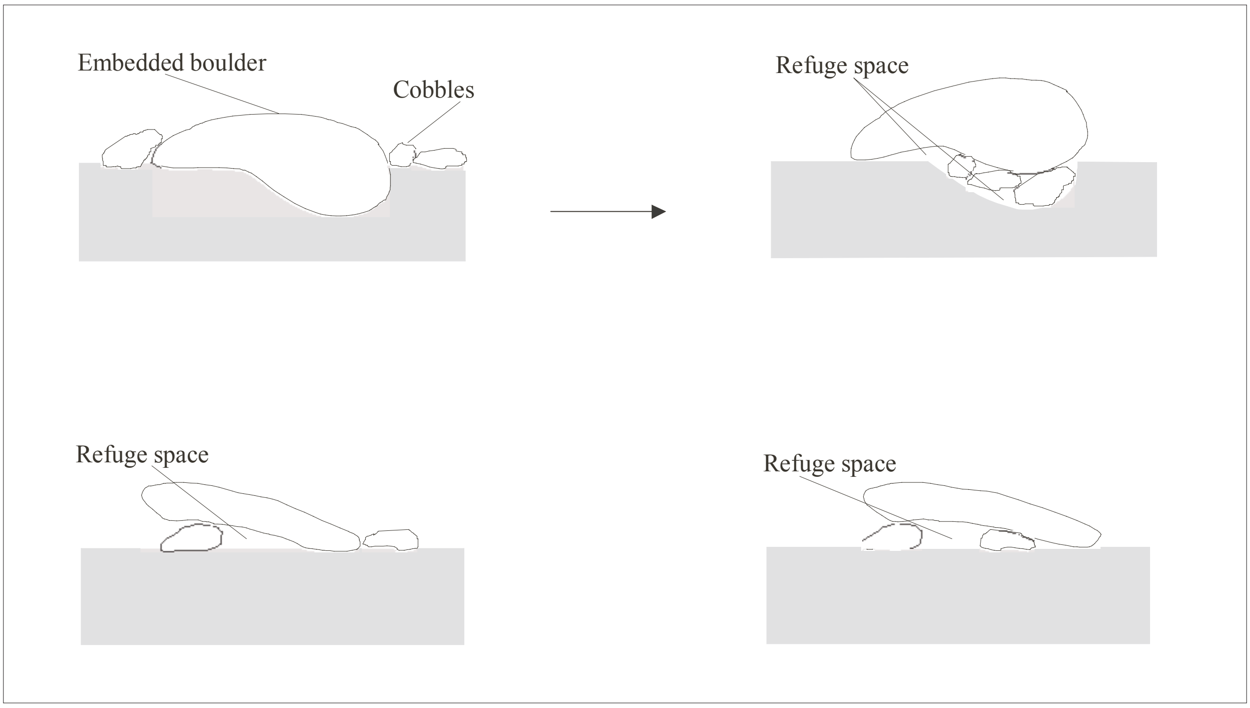

Figure 5. Examples of in-channel refuges created by placement of stones.

7.4 Timing and phasing of reintroduction

Sufficient time should be allowed in the project plan for the following:

- Advance survey and assessment of the receptor and donor sites.
- Consultation with Environment Agency and English Nature.
- Carrying out crayfish removal from the donor site.

- Transporting crayfish to the receptor site.
- Introducing crayfish to the receptor site.
- Monitoring.

Guidance on appropriate timing and phasing of crayfish survey and removal from a watercourse is provided in Peay (2000). The easiest time to remove crayfish is likely to be from August to October, as this is when the animals are most active, and accessing the channel tends to be easier during periods of low flow. Harvesting from a donor population that is not under threat should always be carried out in the summer period after females have released young.

Removal of crayfish should not be undertaken between May and July as females will be carrying eggs that are about to hatch, or have attached young. The timing of hatching and subsequent release of young varies with water temperature, and may extend to the end of July in more northerly catchments (Peay 2003b).

When crayfish removal is being undertaken by dewatering, for example due engineering works, it may be necessary to take the crayfish in the winter months. This will enable the collection of berried females for reintroduction. Previous rescues from dewatered sites have indicated that berried females are as quick to emerge from dewatered refuges as other crayfish, and can be easily retrieved from the bed.

7.5 Avoiding the transfer of disease

Crayfish plague spores can be carried on wet nets, boots and other gear. Minimise the risks of transferring plague between by taking the following precautions:

- After working on any site that has alien crayfish, ensure all equipment and vehicles that have been in water are cleaned of mud.
- After working on any watercourse with alien crayfish disinfect with hypochlorite bleach, an iodophor (at least 100 ppm available iodine for at least five minutes) or the DEFRA-approved 'STERIL TAB' as used by the Environment Agency. If this cannot be done, ensure all machinery and other equipment is thoroughly cleaned and allowed to dry completely.
- If stocking with aquatic plants during habitat restoration, do not use material from stockists or watercourses that have alien crayfish.
- **If you find any alien crayfish at a site where the species is not already known to the Environment Agency, report it immediately.**

7.6 Record keeping

Detailed records should be kept of all works undertaken during the project. These should include:

- Distribution maps of any known white-clawed or alien crayfish populations within the catchment.
- River corridor survey/crayfish habitat maps of both the donor and receptor sites. These should extend a minimum of 1 km upstream and downstream of the sites and ideally 5 km each way. Any habitat improvements made should be detailed on separate maps.
- Records of all the crayfish caught. Parameters to be recorded include sex, carapace length, any sign of damage or disease, and whether breeding. Any dead crayfish should also be recorded (including the cause of death, if this is evident). This recording is usually a condition of the licence held by a crayfish surveyor. The standard crayfish record form included in Peay (2003a) should be used for recording information.
- Notes on where and how the animals were captured, such as size of capture area, habitat and methods of capture used. Environmental conditions at the time of sampling – for example,

weather, flow conditions and water temperature – should also be recorded on the standard crayfish survey and habitat record sheet (Peay 2003a).

- Records of all crayfish released, location and methods of release.

8 Post-reintroduction requirements

8.1 Post-release monitoring

Regular monitoring of the reintroduced population is essential to provide useful feedback for future projects. However, monitoring of newly established crayfish populations is difficult due to the insensitivity of current survey techniques. As no known survey method is capable of reliably detecting very low-density populations, a time-lag of several surveys/years may pass before it is possible to detect whether or not the introduction has succeeded.

Standard crayfish surveys (Peay 2003a) should be carried out annually for the first three years after introduction. These may be supplemented with night-viewing and/or fixed-area sampling where appropriate. Subsequent surveys should be undertaken five, seven and 10 years after reintroduction (based on establishing time for signal crayfish populations, Holdich *et al.* 1995).

If crayfish have been micro-tagged (Section 7.3) it will be possible to distinguish between introduced animals and others that have bred on the site. There is no other method of permanently marking crayfish.

8.2 Post-release management

If reintroduction is successful, little future management is likely to be required. However, if monitoring identifies deterioration in the suitability of the site, habitat management (water quality improvements or the control of siltation might also be necessary) may be required to restore it. Such works are outside the scope of this document, but guidance on appropriate habitat management techniques is provided in Peay (2003b).

8.3 Reporting on works undertaken

All works undertaken and records held should be reported to the relevant statutory agencies. This includes the results of post-release monitoring and details of any management undertaken.

In England, English Nature and the Environment Agency will generally have a close involvement in any reintroduction project.

9 Summary

9.1 Feasibility

Establish whether receptor site is suitable:

- Site is within natural range of white-clawed crayfish, with no current crayfish populations. Natural re-colonisation is not feasible, or is expected to take more than 10 years to occur.
- No alien crayfish populations recorded in adjoining watercourses within 50 km of the site.
- Site meets ecological requirements for white-clawed crayfish, including physical habitat and water quality. No known risk of sporadic pollution incidents.
- Sufficient suitable habitat is available at the site to enable future expansion of population.
- No significant negative environmental impacts are anticipated from crayfish reintroduction.

Choose the most appropriate donor population:

- In order of preference donor population to be sourced from: a scheduled rescue, a threatened population or a 'safe' population.
- In order of preference, donor population to be sourced from: same catchment, same region or an adjacent region.
- 'Safe' populations should be at 'high' abundance of >3 individuals per 10 refuges (Peay 2003a).
- Threatened donor populations must be sufficiently abundant to enable harvested (at least 1 individual per 10 refuges).
- Population must be free from crayfish plague. Incidence of porcelain disease should be no more than 10%.

Undertake health and safety risk assessments to ensure no unacceptable risks to human health and safety are associated with the project.

Ensure that sufficient resources are available to complete all stages of the reintroduction, including funding and staffing.

9.2 Preparation

Consult, and obtain agreement with, relevant partners/conservation agencies. Consider whether to publicise the project in consultation with nature conservation agencies. Obtain necessary licenses and appropriate permissions. Carry out any necessary site preparation works – for example, habitat enhancement or a pilot study – to confirm absence of plague.

9.3 Implementation

Obtain suitable stock for reintroduction.

- Aim for an equal ratio of male to female crayfish.
- Don't take very small (<15 CL) or very large (>40 CL) crayfish.
- Take a range of size classes, with a high proportion of smaller individuals to emulate natural population structure.
- Numbers harvested will vary, but between 50 and 100 individuals are likely to be sufficient to enable a population to become established. Take more if reasonably available.
- Don't take crayfish showing signs of disease.
- Don't harvest crayfish from more than 10% of favourable habitat patches at the donor site.

Transport and storage:

- Keep storage to a minimum, and provide interim storage facilities if storage exceeds 18 hours.

- Minimise aggression by keeping crayfish cool, separating crayfish into size-classes and providing abundant cover.
- Transport berried females separately.

Release:

- Introduce to stable refuges in favourable habitat patches at a density of 1 individual per m^2 of favourable habitat patch.
- If stable refuges are not easily accessible then create some.
- Ensure appropriate and correct phasing and timing of each project element.
- Take appropriate measures to avoid accidental spread of crayfish plague.
- Keep accurate records of reintroduction process, whether or not it went according to plan.

Post reintroduction requirements:

- Monitor the reintroduced population annually for the first three years following reintroduction, then at five, seven and 10 years from the reintroduction date.
- Be prepared to carry out management works in future if conditions at the receptor site deteriorate.
- Report all works undertaken, and copy all records held to the relevant statutory agencies.
- Be prepared to carry out management works in future if conditions at the receptor site deteriorate.
- Report all works undertaken, and copy all records held to the relevant statutory agencies.

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Conserving Natura 2000 Rivers

Ecology Series

1 Ecology of the White-clawed Crayfish, *Austropotamobius pallipes*
2 Ecology of the Freshwater Pearl Mussel, *Margaritifera margaritifera*
3 Ecology of the Allis and Twaite Shad, *Alosa alosa* and *A. fallax*
4 Ecology of the Bullhead, *Cottus gobio*
5 Ecology of the River, Brook and Sea Lamprey, *Lampetra fluviatilis*, *L. planeri* and *Petromyzon marinus*
6 Ecology of Desmoulin's Whorl Snail, *Vertigo moulinsiana*
7 Ecology of the Atlantic Salmon, *Salmo salar*
8 Ecology of the Southern Damselfly, *Coenagrion mercuriale*
9 Ecology of the Floating Water-plantain, *Luronium natans*
10 Ecology of the European Otter, *Lutra lutra*
11 Ecology of Watercourses Characterised by *Ranunculion fluitantis* and *Callitricho-Batrachion* Vegetation

Monitoring Series

1 A Monitoring Protocol for the White-clawed Crayfish, *Austropotamobius pallipes*
2 A Monitoring Protocol for the Freshwater Pearl Mussel, *Margaritifera margaritifera*
3 A Monitoring Protocol for the Allis and Twaite Shad, *Alosa alosa* and *A. fallax*
4 A Monitoring Protocol for the Bullhead, *Cottus gobio*
5 A Monitoring Protocol for the River, Brook and Sea Lamprey, *Lampetra fluviatilis*, *L. planeri* and *Petromyzon marinus*
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These publications can be obtained from:

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They can also be downloaded from the project website: www.riverlife.org.uk

The Life in UK Rivers project was established to develop methods for conserving the wildlife and habitats of rivers within the Natura 2000 network of protected European sites.

Set up by the UK statutory conservation bodies and the European Commission's LIFE Nature programme, the project has sought to identify the ecological requirements of key plants and animals supported by river Special Areas of Conservation.

In addition, monitoring techniques and conservation strategies have been developed as practical tools for assessing and maintaining these internationally important species and habitats.

The white-clawed crayfish is the only native freshwater crayfish in Britain, and is under threat and declining throughout its European range.

The white-clawed crayfish has disappeared from many watercourses because of loss of habitat due to land drainage and river engineering, nutrient enrichment or pollution, infection with crayfish plague, or competition for resources from introduced species.

The aim of this protocol is to provide guidance and practical assistance to those planning or approving white-clawed crayfish reintroductions in the UK and Europe.

Information on Conserving Natura 2000 Rivers and the Life in UK Rivers project can be found at **www.riverlife.org.uk**

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