

# A toolkit for developing catchment-scale conservation strategy for White-clawed crayfish



# A toolkit for developing catchment-scale conservation strategy for White-clawed crayfish

**Version 2 October 2011**

Reference this document as:

Peay S., Kindemba V., Attwood F. and Christmas M. (2011). A toolkit for developing catchment-scale conservation strategy for White-clawed crayfish. Version 1 October 2011  
Buglife – The Invertebrate Conservation Trust, Peterborough.

ISBN 978-1-908657-00-8

Available to download from the crayfish website [www.crayfish.org.uk](http://www.crayfish.org.uk)

## Document history

Consultation draft issued January 2011

Final Version 1 issued October 2011



White-clawed crayfish



Signal crayfish

## Acknowledgements:

This guidance has been produced with funding from the Environment Agency. The project has been developed following a crayfish conservation workshop held by the Environment Agency in July 2009 at Malham Tarn Field Centre, North Yorkshire.

Assistance with graphics in the guidance was provided by Paul Bryden. Photographs are by Stephanie Peay.

Thanks go to all those who have kindly provided comments on earlier drafts, including Margaret Palmer and Suzannah Dangerfield, Buglife; Pete Sibley, Environment Agency; Julia Stansfield, Environment Agency; Mike Howe, Countryside Council for Wales, David Heaver, Natural England, Joanne Backshall, Eden Rivers Trust; Abigail Stancliffe-Vaughn, University of East Anglia, Paul Bradley, PBA Applied Ecology.

## Contents

1. Introduction	
1.1 How to use this guidance on conservation strategy for White-clawed crayfish.....	1
2. Considerations before starting a catchment strategy	
2.1 Policy and regulations in the countries of the UK .....	3
2.2 Status of crayfish in the River Basin Districts .....	4
2.3 Policy and planning at country to catchment scale .....	5
2.4 Combine work and resources with others .....	7
3. Collating information to underpin a conservation strategy and action plans	
3.1 Coordinating data management .....	8
3.2 Priorities for surveys and monitoring.....	9
4. Identifying actions and formulating a strategy	
4.1 Tools for action plans at catchment scale .....	11
4.2 Crayfish risk assessment and developing an action plan at catchment scale.....	12
4.3 Additional notes on the Flowcharts on developing crayfish strategy .....	21
4.4 Additional notes on ark site strategy and contingency planning .....	28
4.5 Protection and management – combining the actions in a catchment.....	32
4.6 Developing strategy - from catchments to River Basin Districts .....	38
5. Developing knowledge and communications	
5.1 Research – information for future best practice guidance.....	39
5.2 Involving people in crayfish conservation .....	40
References	
Appendix 1 How conservation strategy for White-clawed crayfish has developed in the UK	45
A1.1 The development of White-clawed crayfish conservation.....	45
A1.2 England White-clawed crayfish strategy 2010 to 2015.....	46
Appendix 2: England Biodiversity Strategy 2010 to 2015 Atlantic Stream or White-Clawed Crayfish – <i>Austropotamobius pallipes</i>	
Appendix 3: Summary	
Appendix 4: Time-scale of development of a new population of White-clawed crayfish	

Table 1: Measures related to conservation of White-clawed crayfish at a range of geographic scales	2
Box 1 Summary of differences in regulations for crayfish in the countries of the UK .....	3
Table 2: Status of crayfish in River Basin Districts (2010 approximate summary).....	5
Table 3 Priority of response to a new alert about non-native crayfish in a catchment.....	11
Box 2 Conservation Action Plan for White-clawed crayfish – ten questions to answer .....	12
Box 3 Instructions for using the flowcharts.....	13
Figure 4.1 Schematic of contingency planning for biosecurity of White-clawed crayfish .....	31
Table 4: Developing strategy on crayfish based on status of crayfish in the catchment – summary recommendations.....	33
Appendix Figure 1 Keeping of Live Fish (England and Wales) Act 1996 areas where keeping of crayfish is exempt from the requirement for a licence, shown in green.....	46
Appendix table 4.1: Potential year classes of White-clawed crayfish after introduction to an ark site .....	52

## 1. Introduction

The White-clawed crayfish (*Austropotamobius pallipes*) is the only native species of freshwater crayfish in the British Isles. It is under threat and decreasing in range. The White-clawed crayfish is a European protected species under the Habitats Directive and threatened throughout its range. It was classified as Endangered in the IUCN Red List of Threatened Species (Füreder et al., [2010](#)). In England and Wales the main threats are the invasion of catchments by populations of non-native crayfish, mainly the Signal crayfish (*Pacifastacus leniusculus*) and crayfish plague (*Aphanomyces astaci*), a disease which is lethal to White-clawed crayfish and is carried by most populations of Signal crayfish and other species of North American crayfish. Pollution and other reductions of habitat quality are also threats in many areas, causing reductions in abundance and extent of White-clawed crayfish. Without action for conservation, White-clawed crayfish will continue to be lost from sites and whole catchments.

Regulation and conservation strategy has been developed previously at national scale (see [Appendix 1](#) for further information on the historic development of strategy and regulation). This document gives guidance on developing conservation strategy for White-clawed crayfish at a catchment scale. Many of the issues raised will also be relevant in areas that are dealing with the risks and impacts of invasive non-native crayfish. Indeed, non-native crayfish are now so widespread that it is not possible to consider White-clawed crayfish conservation without also addressing the issues of non-native crayfish and crayfish plague, and the regulations, policies and plans associated with them.

### 1.1 How to use this guidance on conservation strategy for White-clawed crayfish

Conservation strategy for White-clawed crayfish was first set out in the UK Biodiversity Action Plan for White-clawed Crayfish (see [Appendix 1](#)) and has recently been developed further in the England Biodiversity Strategy 2010-2015 for White-clawed crayfish, produced by the Environment Agency ([Appendix 2](#)) (the England strategy). This guidance provides supplementary information to that given in the England strategy, to help those involved in managing freshwater environments to link the national objectives into local action. This guidance and other supporting documents can be obtained from the UK crayfish website ([www.crayfish.org.uk](http://www.crayfish.org.uk)). It has been developed principally for England, but much of the approach would be applicable in the other countries of the UK and possibly in other European countries too.

The guidance is for use mainly at catchment scale, but includes some issues that may need to be considered in a region or River Basin District; these could include the issue of wild harvest of crayfish, the coordination of the work of different agencies and possibly some aspects of public awareness-raising. In this case 'catchment' is taken to extend from the watershed to the tidal limits. It may be convenient to subdivide large catchments into smaller units for detailed action plans, but any action plans for individual sub-catchments or administrative areas should always consider the potential for invasion of non-native crayfish or spread of crayfish plague from other parts of the catchment and should not, in any case, be considered in isolation. The guidance does not set out specific actions for individual catchments, but gives general recommendations on issues to consider and how priorities for action could be determined. [Table 1](#) gives examples of the regulation, policy

and guidance relating to crayfish at different geographic scale and gives examples of actions at each scale to show how this guidance fits in the context of crayfish regulation and strategy in the UK.

**Table 1: Measures related to conservation of White-clawed crayfish at a range of geographic scales**

Scale	Regulation, policy, guidance	Examples of Action (current and <i>potential</i> measures)
International	European Union: Habitats Directive; proposed Invasive Species Directive; EU trade regulations.	EIFAC working party on crayfish, advising on regulation and exploitation of crayfish in Europe. EU funding for research and management of crayfish in Europe. IUCN Red List.
UK	Habitats Regulations, Wildlife and Countryside Act, Water Framework Directive, Regulations on keeping non-native crayfish. UK BAP, GB Non-native Species Strategy.	JNCC monitoring status of crayfish in UK. SAC and SSSIs. National Biodiversity Network for crayfish records. Import controls on non-native crayfish. Defra research funding. Crayfish website and other sources information.
country	Strategies: SNH Species Action Framework, Environment Agency England Biodiversity strategy for White-clawed crayfish, all Ireland crayfish strategy. Regulations on keeping non-native crayfish.	Licences and consents records. <i>Resources for rapid contingency responses e.g. in key areas for White-clawed crayfish.</i> Coordination between statutory agencies on conservation of crayfish.
River Basin District/ region	Water Framework Directive and associated targets. Fisheries consents. This guidance.	<i>Priorities for crayfish conservation and funding at regional scale.</i> Coordinating data management on crayfish and crayfish plague.
catchment	This guidance and other information on the crayfish website ( <a href="http://www.crayfish.org.uk">www.crayfish.org.uk</a> )	Catchment risk assessment. Action planning with stakeholder groups. Crayfish surveillance, monitoring. Catchment management measures to maintain or improve habitat quality.
sub-catchment	This guidance and other information on the crayfish website ( <a href="http://www.crayfish.org.uk">www.crayfish.org.uk</a> ).	Individual ark sites. Volunteers helping with crayfish surveys and conservation. Alerts about illegal trapping, crayfish sightings, pollution incidents. Working with local angling clubs and other water users to minimise risks of introductions and crayfish plague. Events to engage people with native crayfish. Local papers for news items on crayfish.

## 2. Considerations before starting a catchment strategy

### 2.1 Policy and regulations in the countries of the UK

There are differences in the regulation and policy regarding crayfish in the four countries of the UK, which need to be taken into account when developing a regional strategy (summarised in [Box 1](#)).

These differences in regulation of non-native crayfish between countries are not necessarily well understood by the public. There is a risk that live crayfish may be taken from areas where they can be legally caught or sold for food to Ireland or Scotland, where keeping or sale is completely banned, or to areas of England and Wales that are currently free from non-native crayfish.

#### Box 1 Summary of differences in regulations for crayfish in the countries of the UK

##### Box 1

In **Northern Ireland** White-clawed crayfish are protected and there are no known populations of non-native crayfish. All species of non-native crayfish are banned from sale. It is an offence to introduce any non-native crayfish species into the wild in Northern Ireland, however this does not cover introduction for food or private collections. Once non-native crayfish are present, it is an offence to prevent further spread of certain non-native species.

In **Scotland** there are only two populations of White-clawed crayfish, which were introduced historically. Although these are outside the original geographic range of White-clawed crayfish, they have been accepted as part of the Scottish fauna by Scottish Natural Heritage and can be considered as two existing ark sites. There is a complete ban on keeping or sale of crayfish of any species in Scotland. There is a ban on selling live crayfish for human consumption and on keeping any species of crayfish in aquaria including the Redclaw crayfish (*Cherax quadricarinatus*). Trapping and/or keeping of crayfish is not allowed. The only exceptions are authorised surveys or research. There is no consented wild harvesting of crayfish. It is illegal to release non-native crayfish into the wild or allow them to escape.

In **England** White-clawed crayfish are protected. It is illegal to release non-native crayfish into the wild or allow them to escape, but Signal crayfish can be kept in much of southern England. There are exemptions for keeping and selling live crayfish directly for human consumption and for keeping Redclaw crayfish in aquaria. Trapping of Signal crayfish or any other species can only be done where there is consent from the Environment Agency, but the policy on granting consents varies between regions. Wild harvesting is currently permitted in much of southern England, where there are many populations of non-native crayfish and relatively few populations of White-clawed crayfish. In some other areas where wild harvesting is not allowed, consents for trapping have been granted for purpose of fisheries management. Licences for research, measures to protect White-clawed crayfish (mitigation) and surveys for White-clawed crayfish are issued by Natural England.

In **Wales** White-clawed crayfish are protected, with the Countryside Council for Wales being the statutory agency that gives consent for 'taking' including surveys. Regulations regarding non-native crayfish are the same as those in England. Trapping and keeping consents are dealt with by the Environment Agency.

## 2.2 Status of crayfish in the River Basin Districts

Historically, White-clawed crayfish were widespread in all the regions of England, but they were not found in the western end of the South West England, western parts of Wales, nor in Scotland. The White-clawed crayfish is considered to be native ([Holdich et al., 2009](#)), in at least southern and eastern England, although its range was extended north and west by human introductions in the post-glacial to late medieval period.

Introductions of non-native crayfish for aquaculture in the 1970s and 1980s were concentrated in the southern half of England, although there were scattered introductions of non-native crayfish elsewhere in England and Wales and in Scotland from the 1990s. Illegal and accidental introductions of non-native crayfish continued through the 1990s and 2000s, together with expansion of the range of the established populations. There is no doubt that populations of Signal crayfish and other non-native crayfish species will continue to spread in the catchments where they have already established.

[Table 2](#) gives a broad indication of current status of crayfish in the various River Basin Districts/regions in Great Britain in 2010. This status is indicative and will need review and revision regionally. Available records on distribution of crayfish, past records of crayfish plague and recorded stocking with signal crayfish will be a useful starting point for catchment-scale plans. The status of White-clawed crayfish in Ireland is described in [Reynolds \(2009\)](#).

Reviewing populations of non-native crayfish is an essential process in developing a strategy. There are conservation implications of non-native crayfish being found in catchments where they have not yet been recorded, either from additional introductions (accidental or deliberate) or from future surveys detecting populations that are currently established but not recorded. Except in Northern Ireland, most River Basin Districts within the UK already have one or more known populations of non-native crayfish.

Northern Ireland and the Republic of Ireland together are of very high importance for the conservation of White-clawed crayfish at a European scale. This is because the whole of Ireland is currently free from non-native crayfish and, being an island, it is safe from natural colonisation from other regions. This is unlike many of the countries in Europe, where large river systems and extensive waterway networks provide easy routes for trans-boundary spread of non-native crayfish. Whilst Ireland as a whole represents a major ark site, this status is wholly dependent on the prevention of non-native crayfish colonising the watercourses.



**Table 2: Status of crayfish in River Basin Districts (2010 approximate summary)**

River Basin District	White-clawed crayfish	Signal crayfish	Status other non-native crayfish species
Scotland	No, not present, except two introduced populations	Yes, present in several major catchments	No
Solway Tweed	Yes, present in 'White-clawed only' catchment (River Eden SAC Cumbria), absent from catchments in Scotland	Yes, present in several catchments in southwest Scotland and in Tweed. Some catchments have no crayfish	No
Northumbria	Yes, has a 'White-clawed only' catchment, and other populations of White-claws present	Yes, present in several catchments	Yes, Turkish
Northwest	Yes, extensive White-clawed populations, including 'White-clawed only' catchments	Yes (North) very few populations; (South) present in some catchments	No
Humber	Yes, still many White-clawed populations, some extensive but declining	Yes, present in all the main catchments, widespread in some	Yes, <i>Orconectes</i> sp.
Dee (Wales/England)	No, not present	No?	No
West Wales	No, except for a few introduced populations	Yes, several populations	No
Severn	Yes, still widely distributed but declining	Yes, widespread in major catchments	Yes, Turkish, Spiny-cheek
Anglian	Yes, several populations but isolated or under threat	Yes, present, or widespread in several/most catchments	Yes, Turkish, Spiny-cheek
Thames	Yes, a few populations, isolated or under threat	Yes, very widespread in most/all catchments	Yes, Turkish, Spiny-cheek, Virile, Red swamp
South West	Yes, a few populations, isolated or under threat	Yes, present or widespread in most catchments	Yes, Turkish, Noble
South East	Yes, a few populations, isolated or under threat	Yes, present or widespread in most catchments	Yes, Turkish, Spiny-cheek

### 2.3 Policy and planning at country to catchment scale

The England strategy for the conservation of White-clawed crayfish sets aims in the following categories: combine work and resources with others; effectively manage data and information; protect and improve habitats and populations, and invest in knowledge and communication. A similar approach is used here, with some modifications relevant to catchment-scale.

Policy and planning is needed at regional scale to coordinate action, target resources effectively and deliver the national strategy in England (see [Appendix 1](#) and [2](#)). Note that a conservation strategy for White-clawed crayfish will not be effective unless it is planned in conjunction with policy on regulation of non-native crayfish.

Broadly, the recommended approach in developing a conservation strategy for White-clawed crayfish is:

Combine work and resources with others

- Identify groups likely to be involved regionally/locally in developing and/or implementing conservation strategy, including those dealing with non-native crayfish regulation and fisheries management. Identify a local lead agency or 'champion' to coordinate action planning (see [section 2.4](#)).

Manage data and information (collating information to underpin conservation strategy and action plans)

- Assess the existing status of White-clawed crayfish; the presence, extent and relative abundance of each population (see [section 3](#)).

Protect and improve habitats and populations (identifying actions)

- Assess the risks to each population of White-clawed crayfish, by carrying out a catchment risk assessment (see [section 4](#)).
- Identify any specific measures to safeguard and enhance the populations of White-clawed crayfish. This may include measures to help prevent further introductions of non-native crayfish or reduce the risk of crayfish plague (see [section 4](#)).

Invest in knowledge and communications

- Encourage awareness and local involvement in White-clawed crayfish conservation, research to aid conservation efforts, good data management and sharing of information to contribute to wider understanding (see [section 5](#)).

The success of a conservation strategy for White-clawed crayfish depends on being able to keep populations safely isolated from competition by non-native crayfish and from the lethal crayfish plague. There is a need to identify existing secure areas (ark sites) and to maintain or increase the protection of these isolated areas. These should ideally be as large as possible, with descending order of priority being whole countries (Northern Ireland and the Republic of Ireland); whole catchments, then sub-catchments and smaller areas or sites. Smaller areas or sites are listed last when considered in isolation, but can have a more important role in contingency planning as part of an action plan to conserve White-clawed crayfish within a catchment.

The priority is to conserve existing populations where they are. Where populations are under threat now, or may be so in the future, conservation strategy may include finding and setting up new ark sites to supplement the existing sites, or provide alternatives where loss of existing populations cannot be prevented.

## 2.4 Combine work and resources with others

This is mainly about matching work to resources among various organisations to get the most gain for conservation. Whether planning at the scale of River Basin District, region or catchment, combining work and resources will be essential to ensure outcomes are achieved. It is likely to involve the main stakeholders working together to plan action on crayfish. Stakeholder groups will usually include the main statutory agencies in the regions (in England and Wales these are the Environment Agency and Natural England/Countryside Council for Wales). They are also likely to include the wildlife trusts, rivers trusts, local planning authorities, British Waterways, angling groups and other interested groups. Additional groups and individuals may be involved in implementing actions within catchments and sites. It is advisable to have the coordinating role taken by one agency, as a local 'champion' to push forward the development of strategy and action by all participants.

It will not be possible to achieve successful conservation of White-clawed crayfish without taking into account non-native crayfish and this issue needs to be an important part of any strategy, with relevant stakeholders identified. For example, Environment Agency staff dealing with consents for crayfish trapping, fish stocking and fisheries management in general would be involved in planning and implementing the action plan, as well as those working on White-clawed crayfish conservation and on other biodiversity action plans. Any action plans for Signal crayfish in catchments without White-clawed crayfish should consider any conflicts and synergies with plans in nearby catchments with White-clawed crayfish. For example, does allowing wild harvest/control of Signal crayfish for fisheries management purposes in one area increase the risks to White-clawed crayfish in the same or adjacent catchment?

Relevant targets or provisions from action plans for crayfish need to feed through into other plans and policies, e.g.

- local development plans, including minerals plans;
- planning decisions on new developments;
- local Biodiversity Action Plans and Greenprint plans;
- management plans for protected sites;
- fisheries management plans, including crayfish trapping consents;
- invasive species management plans;
- local environmental data management;
- protected species licences and land drainage consents for works affecting White-clawed crayfish;
- targeted programmes of public awareness-raising;
- research links with Universities.

### **3. Collating information to underpin a conservation strategy and action plans**

The strategy needs to be based on the best possible regional information on crayfish. This section gives guidance on managing data effectively and on the kind of information needed for a strategy.

#### **3.1 Coordinating data management**

Data needs to be compiled locally on crayfish status and crayfish plague outbreaks from all the agencies using existing data management systems. An exchange of data should occur regularly within and between regional centres and national ones to make sure that all records of non-native crayfish, White-clawed crayfish and crayfish plague are accessible together in individual River Basin Districts and catchments. Most local biological records centres already compile species records and feed these to NBN (National Biodiversity Network). Data-holding agencies should agree targets for frequency of updates. Compilations of data made at national scale should be made available for use in the regions and individual catchments, but need to be kept updated. There is no provision for keeping records of crayfish plague outbreaks in NBN at present, although it is possible in the data model and is being explored as a possible future option. It is Defra that is responsible for records on animal health and keeping the relevant agencies informed, although, in most cases, alerts about possible outbreaks of crayfish plague go via the Environment Agency. Records of previous outbreaks of crayfish plague and records of native and non-native crayfish should be kept, accessibly, in the River Basin Districts/Regions for use in catchment risk assessments.

Stakeholders within River Basin Districts or regions should agree on roles and responsibilities for data management. Combining crayfish distribution data with other information held in the Environment Agency's GIS (e.g. watercourses, water quality data, floodplain maps, locations of barriers on watercourses) will provide much of the information required for a catchment-scale risk assessment for crayfish. Any of the stakeholder agencies could take a lead on preparing catchment risk assessments and/or updating of crayfish distribution maps locally as part of action plans.

The status of White-clawed crayfish can change for the worse very rapidly as a result of crayfish plague or pollution incidents, so even records less than three years old may not necessarily represent current conditions. By contrast, all verified previous records of Signal crayfish should be assumed to remain current. There may be some cases of misidentification or incorrect grid references still remaining in databases, but, in general, any previously recorded, well-established population of Signal crayfish is likely to persist and increase its range over time. Additional guidance on data management and crayfish identification is provided via the UK crayfish website ([www.crayfish.org.uk](http://www.crayfish.org.uk)).

For crayfish that cannot be identified using the information on the website, the Environment Agency is the best point of contact for identification. Specimens or good quality photographs should be provided – check with local Environment Agency offices.

The coverage of recent data, plus the status of White-clawed crayfish in a catchment could be used to set priorities for future surveys.

### 3.2 Priorities for surveys and monitoring

It is not generally necessary to monitor the areas already known to be occupied by well-established populations of Signal crayfish, unless it contributes to a research programme or provides other information that is needed. This might include monitoring of populations to assess the impacts on aquatic ecology of crayfish populations at different abundance; or estimate the rate of invasion of Signal crayfish over time (to predict how long it may take to reach a White-clawed crayfish population); or check the effectiveness of different types of barrier.

It can also be helpful to measure (or estimate from survey data) the total lengths of watercourse supporting native crayfish at detectable abundance, plus the number of standing waters with White-clawed crayfish, where these are separate from the watercourses. Use of lengths of watercourse to show change over time avoids the difficulty of using point locations alone where watercourses have been surveyed at different intensity in different time periods. Examples of change in watercourse length and in number of waterbodies were used by IUCN to estimate rates of loss in the past 10 years and hence determine the threat status of White-clawed crayfish as 'Endangered'. Such information is needed to help assess the success of crayfish action plans at a range of scales from catchment-scale to the whole of Europe.

Recommended priorities for crayfish surveys are:

- survey for the continued presence of existing White-clawed crayfish populations. In statutory designated sites (SSSI in England and Wales, or ASSI in Northern Ireland) condition monitoring is required every 6 years. This may be sufficient where populations are in favourable condition with few threats. Weaker populations, or those with more threats, may deteriorate or be lost in less than 6 years, so more frequent checks for presence are useful, even if they are not extensive surveys.
- survey for the presence of non-native crayfish in areas that might threaten an existing ark site for White-clawed crayfish, or a potential ark site, e.g. in on-line fishing ponds.
- other general surveillance for new populations of non-native crayfish that might be a threat to designated sites or other areas, especially in catchments or sub-catchments that have no previous records of non-native crayfish.

If condition monitoring is being carried out for White-clawed crayfish (in SSSIs/ASSI, or to assess the success of new ark sites) relevant measures are:

- whether the population is still present;
- the extent of the population, i.e. the length of watercourse or area of still water where the species is present, and
- the relative abundance category (Catch Per Unit Effort), by whatever survey method is appropriate for the site.

Estimates of total population of crayfish are unreliable and, in general, should not be attempted for condition monitoring.

Existing data on the distribution of crayfish will inform catchment risk assessments and action plans and those, in turn, will guide priorities for future surveys. For example, suppose signal crayfish have been found in a tributary and part of the main river. Which of the other tributaries have

populations of White-clawed crayfish and are there any existing barriers good enough to protect them? Suppose one of the tributaries has a good population of White-clawed crayfish, is upstream of a dam and so may be an ark site. Are there any large ponds or lakes upstream that might be harbouring non-native crayfish?

Obtaining alerts from the public about possible new records of non-native crayfish can be an important contribution to crayfish conservation plans, but records need to be verified, especially if they have come from an inexperienced recorder.

[Table 3](#) suggests priorities for investigation of new reports of non-native crayfish, based on the known status of crayfish, with importance and urgency shown. Categories shown as ‘very urgent’ need investigation within days to a few weeks, with additional checking later if findings are inconclusive, e.g. because survey conditions were sub-optimal when the case was initially investigated. If there is any scope to carry out a biocide treatment to eradicate a recently established population, or install some kind of barrier, the window of opportunity is likely to be very limited, so rapid response is important. Even new records that are ‘less urgent’ are worth investigating, or at least acknowledging, in order to encourage people to keep submitting their records.

In catchments with no historic or recent records of crayfish, even though it may not be worthwhile carrying out dedicated surveys for crayfish regularly, every opportunity should be taken to encourage provision of prompt alerts about the possible presence of crayfish, sightings from user groups such as anglers or scuba groups, as well as local people, signs of crayfish seen during surveys for other purposes etc. There may be undiscovered White-clawed crayfish present; or catchments may have previously undetected non-native crayfish present, which could have future ecological impacts, or be a threat to adjacent catchments with White-clawed crayfish due to human activity. Even in catchments extensively invaded by signal crayfish, possible sightings of new species of crayfish are worth investigating. There is not much information as yet about rates of invasion by the more recently introduced crayfish species, spiny-cheek crayfish, virile crayfish and red swamp crayfish. Any possible sightings of new crayfish species are a high priority for investigation of any reports. The marbled crayfish *Procambarus* sp., which is likely to be held illegally by some aquarium hobbyists, is parthenogenetic. It is capable of producing hundreds of young per year from a single animal and so of concern as a potential future invader.

**Table 3 Priority of response to a new alert about non-native crayfish in a catchment**

Current status of crayfish in the catchment	Importance of new record	Urgency
White-clawed crayfish only	Very high	Very urgent
No previous record of any crayfish	Very high	Very urgent
Sub-catchment with White-clawed crayfish considered to be an existing ark site	Very high	Very urgent
'Undefendable' sub-catchment with White-clawed crayfish in catchment already being invaded by non-native crayfish	High	Urgent
Sub-catchment without White-clawed crayfish being considered as potential ark	High	Moderately urgent
'Undefendable' sub-catchment without White-clawed crayfish	Medium	Less urgent
Catchment or sub-catchment already invaded, record is extension of range	Low	Less urgent

## 4. Identifying actions and formulating a strategy

### 4.1 Tools for action plans at catchment scale

Assessment of the threats to White-clawed crayfish is needed:

- at the scale of River Basin District/Region with respect to policy that affects White-clawed crayfish, e.g. on regulation of non-native species and campaigns to improve public awareness of the threats from non-native crayfish and crayfish plague.
- at catchment scale for existing populations of White-clawed crayfish to assess the current and future threats and the opportunities for conservation.

Guidance on assessing the risk to populations of White-clawed crayfish is set out in more detail in below. 'Criteria for selecting ark sites' (Peay, 2009, available from the crayfish website [www.crayfish.org.uk](http://www.crayfish.org.uk)) gives some additional guidance on how to assess the degree of isolation and biosecurity for individual sites or populations.

Different users may prefer to use different tools when carrying out a catchment risk assessment and action plan for crayfish. Three options for tools are given here. They can be used independently, or in combination. The first option is simply to answer a list of questions when formulating an action plan (see [Box 2](#) below). The second option is to use the flow charts in section 4.2 to assess the risks and identify potential actions that can then be customised into targeted action to be carried out by the various stakeholders involved. The third option is to use the status of crayfish in the catchment to guide strategy and action (see [Table 4](#) in section 4.4).

## Box 2 Conservation Action Plan for White-clawed crayfish – ten questions to answer

### Box 2

1. Where are crayfish in the catchment?
2. How safe are the populations of White-clawed crayfish at present from:
  - non-native crayfish,
  - crayfish plague and
  - environmental impacts?
3. How safe will they be in future and which populations are reasonably 'defendable' from any threats?
4. What measures, if any, will prevent or minimise the threats to the populations and which will give most benefit?
5. If future loss will occur, is there scope to keep parts of the populations, or supplement them with new ark populations?
6. What action is needed if there is an outbreak of crayfish plague - and who will do it?
7. What action is needed if somebody finds a new population of non-native crayfish – and who will do it?
8. What can you do to discourage people from moving non-native crayfish around?
9. How can you prevent the spread of crayfish plague?
10. How can you get more people interested in conservation of White-clawed crayfish and get them involved, e.g. to carry out surveys, report sightings or problems, or just become aware about crayfish?

## 4.2 Crayfish risk assessment and developing an action plan at catchment scale

This section gives some guidance on how to assess the threats to White-clawed crayfish and recommends actions in a single catchment. Each catchment should be assessed and then the identified priorities and actions can be merged into an overall regional or River Basin District strategy. A series of flow-charts is given here as a starting point for developing an action plan for crayfish, as follows:

Flowchart 1 [Developing strategy on crayfish](#)

Flowchart 2 [Developing strategy on crayfish \(no White-clawed crayfish\)](#)



Flowchart 3 [Catchment risk assessment for White-clawed crayfish - Status](#)

Flowchart 4 [Catchment risk assessment for White-clawed crayfish - Crayfish plague](#)

Flowchart 5 [Catchment risk assessment for White-clawed crayfish - Non-native crayfish](#)

Flowchart 6 [Catchment risk assessment for White-clawed crayfish - Water quality](#)

Flowchart 7 [Catchment risk assessment for White-clawed crayfish - Physical habitat](#)

[Box 3](#) below gives some information about using the flowcharts.

### **Box 3 Instructions for using the flowcharts**

#### **Box 3**

The aim of the charts is to show how different conditions in catchments warrant different actions and priorities.

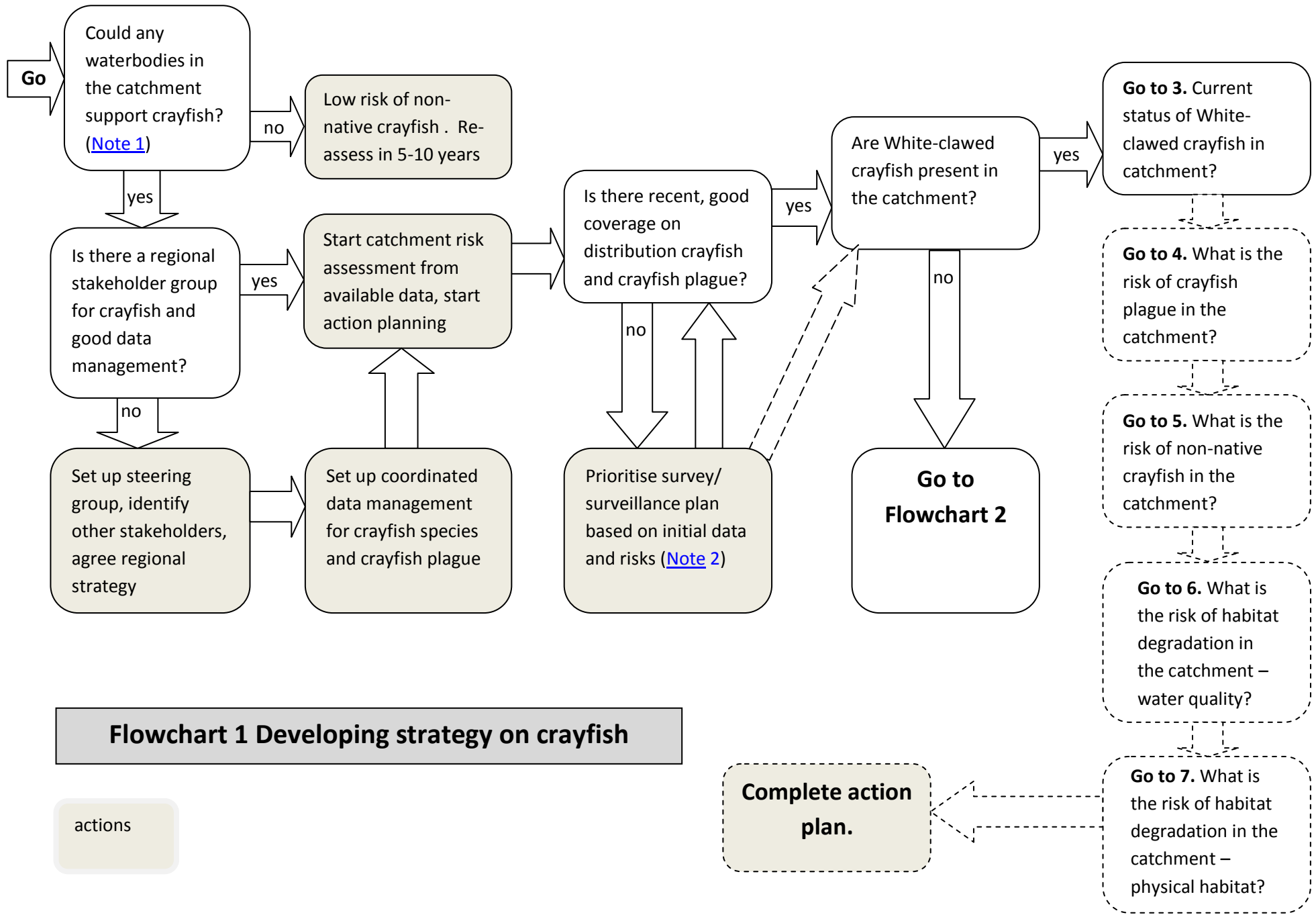
Start with Flowchart 1 Developing strategy on crayfish (at the top left). Choose responses to the questions for the catchment being assessed. Where coloured boxes are reached, these give potential actions for inclusion in an action plan for crayfish, although they will still need to be customised for individual catchments. The process stops after Flowchart 2 if there are no White-clawed crayfish present, although there will still be some relevant action points for the catchment and/or Region that can be taken from these charts.

If there are White-clawed crayfish present, work through each of the flowcharts 3 to 7 that form the catchment risk assessment for White-clawed crayfish. Start by selecting the description of risk factor that best fits conditions in the catchment, then follow the arrows to comments and select recommended actions.

Where numbered Notes are given in the flowcharts, supplementary text notes are provided after the flowcharts.

The descriptions of risks in each topic are a guide and may not fit exactly with the conditions in particular catchments; for example there may be some situations that relate to both 'poor' and 'bad' risks. Some local judgement will be needed. These overlaps can be taken into account when customising and prioritising actions for a specific catchment. The different actions identified by the charts would need to be considered in more detail for individual catchments; based on known conditions, but taking into account that they may change in the future.

The risk factors relate to the likelihood of survival of White-clawed crayfish. If all the topics have risk factors 'excellent' or 'good' the population is likely to be in favourable condition, with a high likelihood of survival – provided measures are in place to avoid or minimise any deterioration/increased risk. Populations with several risk factors ranked as 'poor' or 'bad' have a low likelihood of long term survival and are likely to need remedial action urgently within months to a few years, if any of the population is to survive.

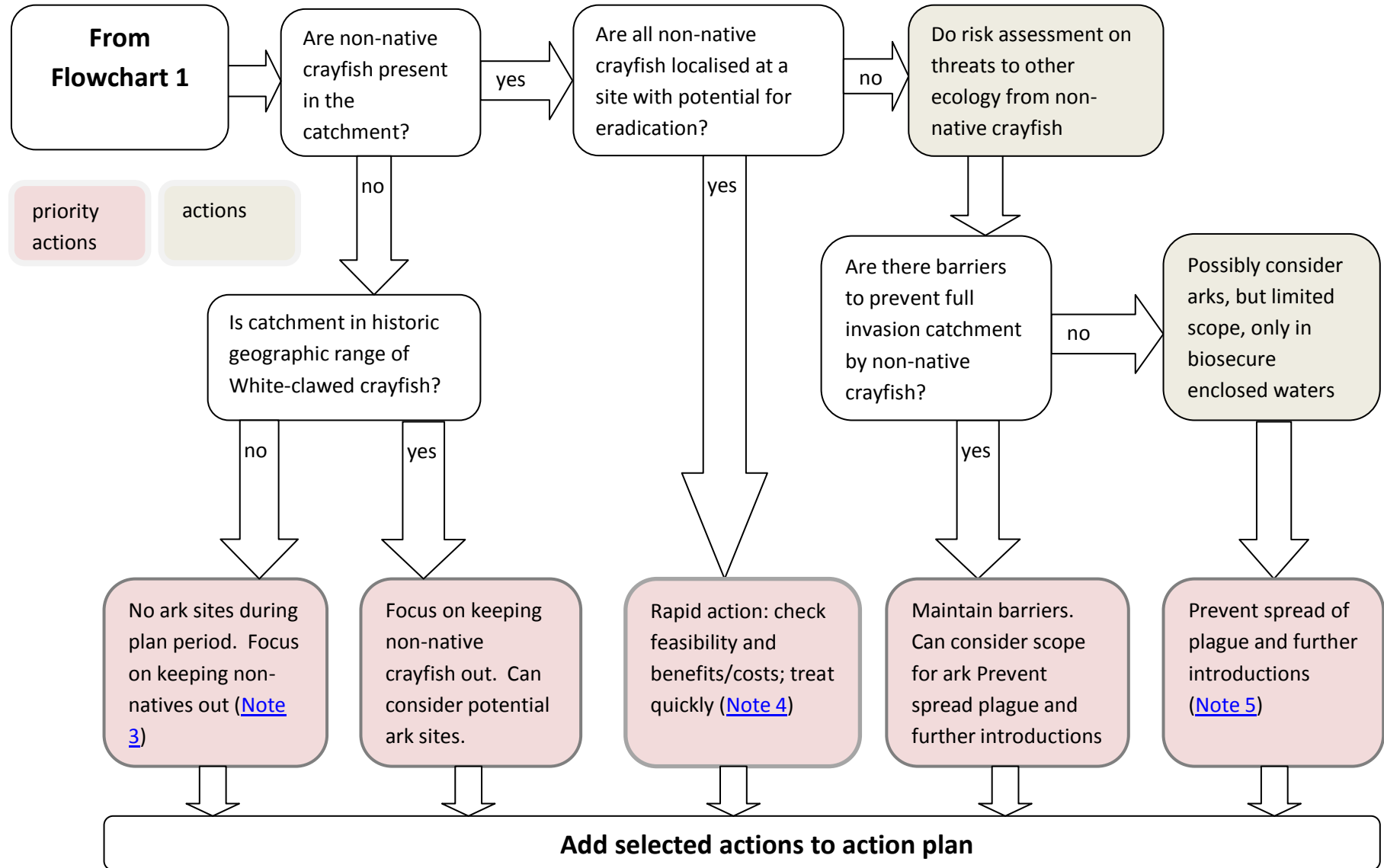


**Flowchart 1 Developing strategy on crayfish**

actions

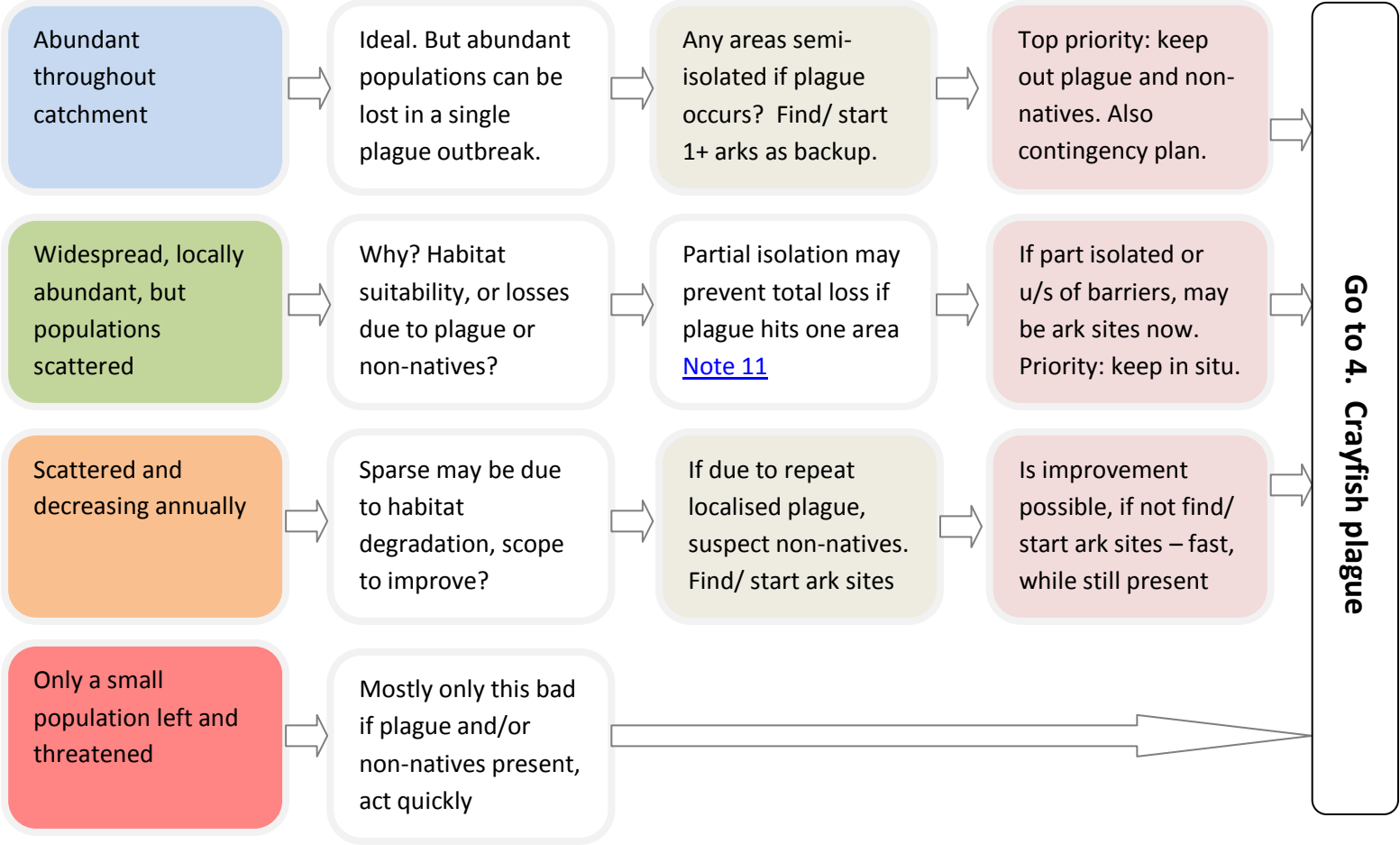
**Complete action plan.**

## Flowchart 2 Developing strategy (no White-clawed crayfish)



**Current status of White-clawed crayfish in catchment?**

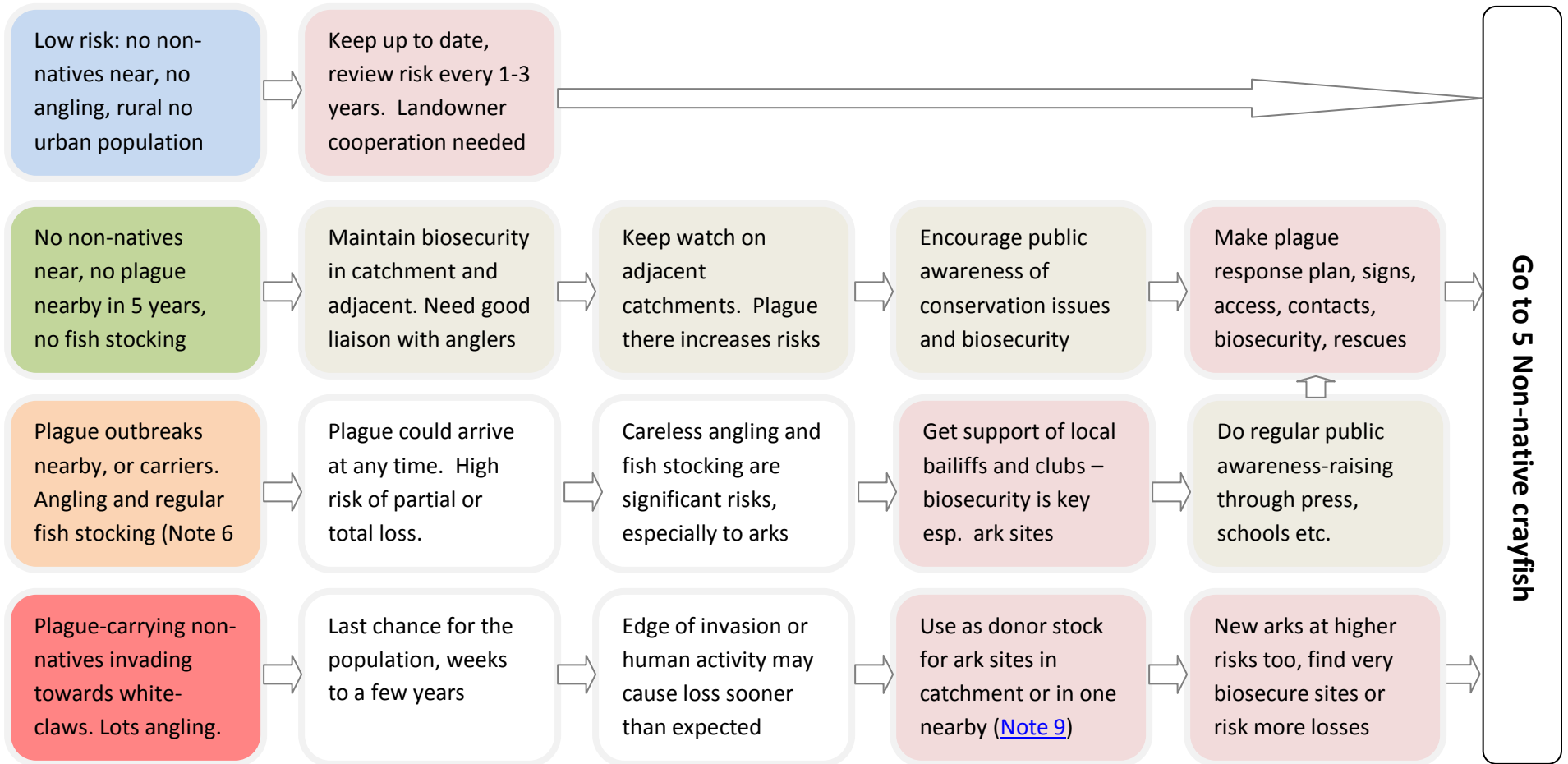
**Flowchart 3 Catchment risk assessment for White-clawed crayfish - status**



Risk factor:	Excellent	Good	Poor	Bad	comments	actions	priority actions
--------------	-----------	------	------	-----	----------	---------	------------------

What is the risk of crayfish plague in the catchment?

### Flowchart 4 Catchment risk assessment for White-clawed crayfish – crayfish plague

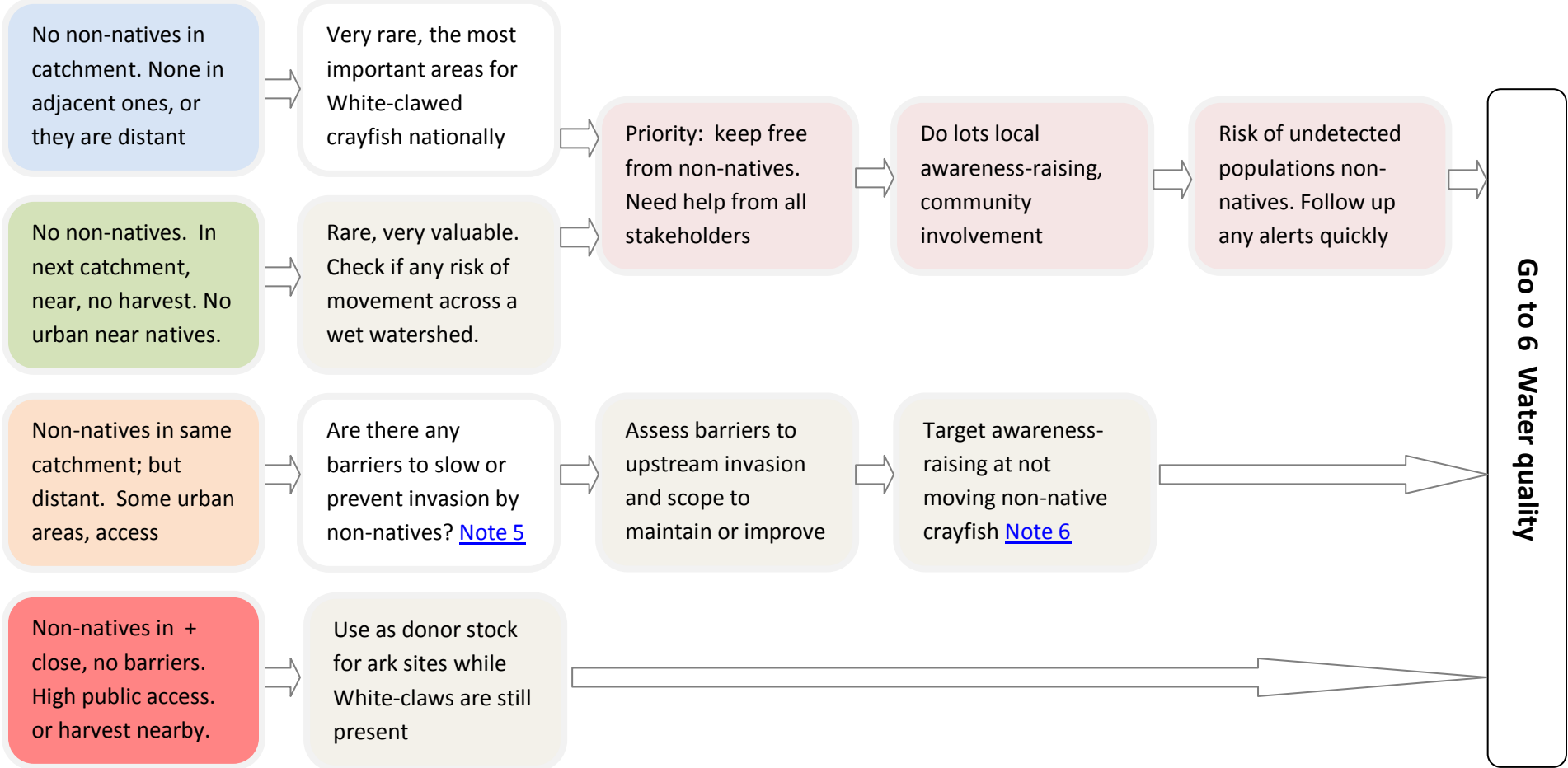


Risk factor: Excellent Good Poor Bad

comments actions priority actions

**What is the risk of non-native crayfish in the catchment?**

**Flowchart 5 Catchment risk assessment for White-clawed crayfish – non-native crayfish**

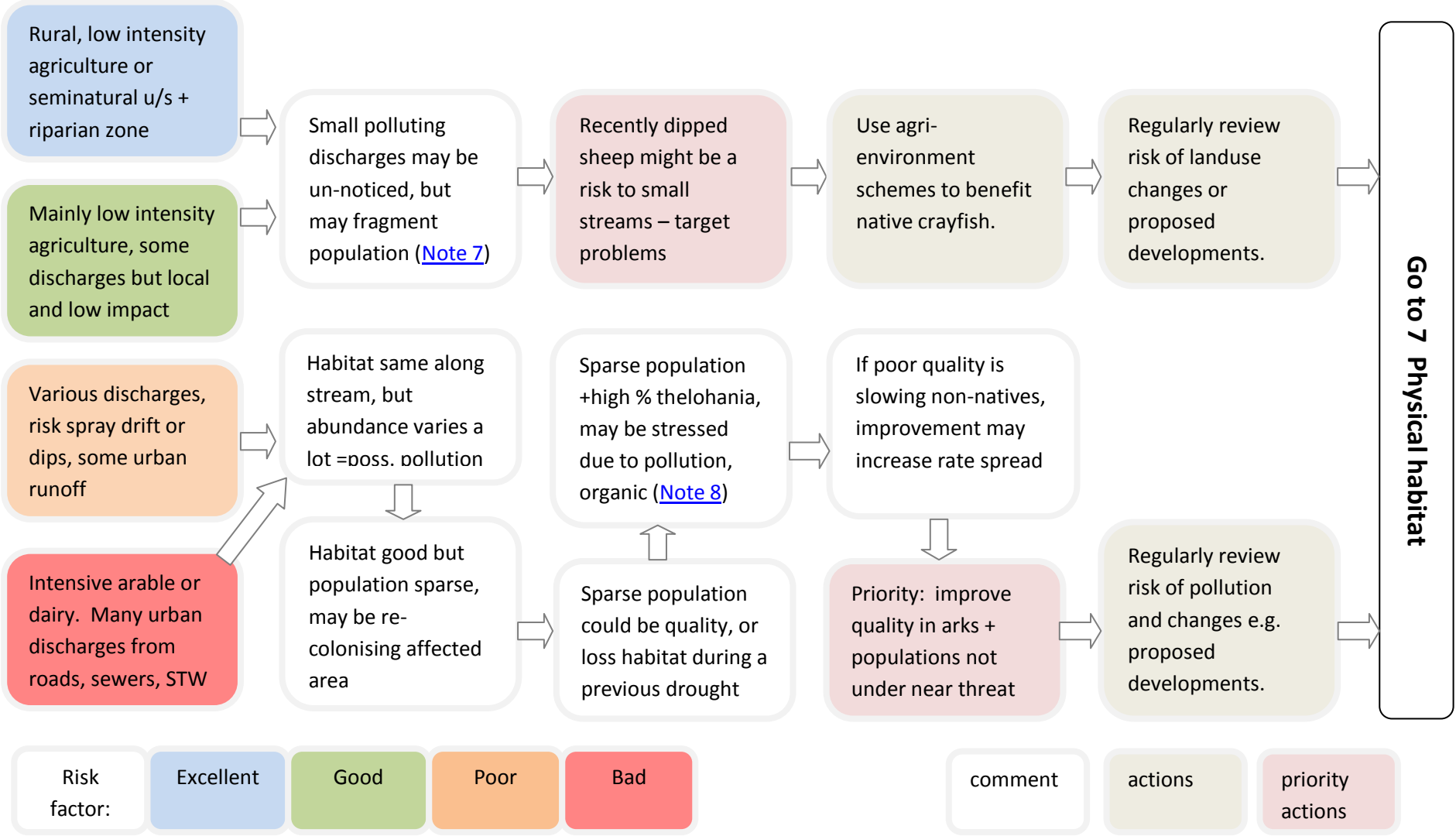


Risk factor: Excellent Good Poor Bad

comments actions priority actions

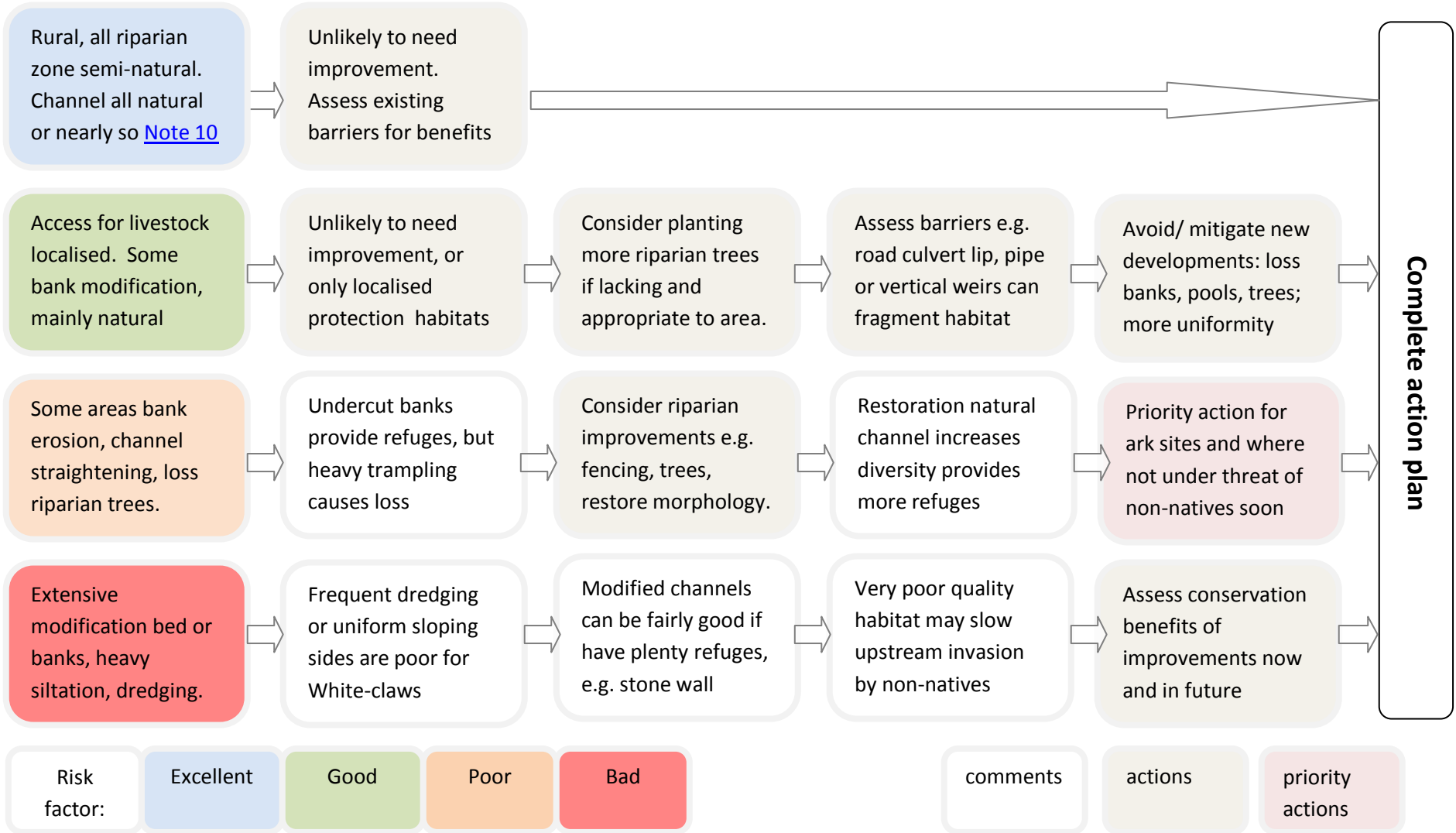
What is the risk of habitat degradation in the catchment – water quality?

### Flowchart 6 Catchment risk assessment for White-clawed crayfish – water quality



What is the risk of habitat degradation in the catchment – physical habitat?

### Flowchart 7 Catchment risk assessment for White-clawed crayfish – physical habitat





### 4.3 Additional notes on the Flowcharts on developing crayfish strategy

#### *Note 1 (flowchart 1) Could any waterbodies in the catchment support crayfish?*

For habitat requirements of White-clawed crayfish see [Holdich \(2003\)](#) and [Peay \(2003\)](#). Broadly, White-clawed crayfish are generally found in clean, perennial freshwater (Biological GQA water quality grade A or B) (Environment Agency General Quality Assessment for biology is rated on a 6-point qualitative scale: A very good to F bad, but note recent change in the assessment due to switch to Water Framework Directive requirements). Sites with White-clawed crayfish generally have pH around neutral or higher, with calcium content usually above 5mg/l, and usually in waters with moderate to very low nutrient status. They occur in a relatively wide range of habitats, especially streams, on-line lakes and canals.

For potential of non-native crayfish to survive see non-native species risk assessments for Signal crayfish, Red swamp crayfish, Spiny-cheek crayfish and Virile crayfish

<https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=51>

Broadly, any habitat capable of supporting native freshwater fish is potentially suitable for Signal crayfish and some other non-native crayfish. Downstream limits in tidal rivers are not yet known. Signal crayfish can survive and breed in brackish water (at salinity 20‰ seawater) and can survive in higher salinity for short periods, days to weeks or more ([Holdich et al., 1997](#)). Upstream limits in moorland streams are not yet known. Signal crayfish can survive in waterbodies that dry out occasionally, but need damp conditions and partial seasonal drying is likely to markedly limit abundance. Red swamp crayfish survive well in seasonal wetlands, but may be limited by the cool summers in the far north and west of Great Britain, so are more likely in the south (currently London only). Signal crayfish tolerate poorer water quality than native crayfish, assume GQA grades A to D can be colonised, but lower limits of water quality tolerance are uncertain. There may be some highly acidic, high energy watercourses in northwest Scotland and Wales that are not suitable for crayfish, but most catchments will have at least some ponds or lowland watercourses that could potentially support one or more species of crayfish.

#### *Note 2 (flowchart 2) Develop survey/surveillance plan based on any historic information on the distribution of crayfish*

1. **The non-native crayfish population is still there.** Assume that the population is still present wherever there has been a known introduction of non-native crayfish for aquaculture or other purposes, unless intensive and/or repeated surveys show it is not there anymore, i.e. do not limit historic data on non-natives to records from just the past 5 years. Reasons for non-native crayfish being absent when previously recorded include:
  - a. Error in recording location, e.g. wrong grid reference;
  - b. Misidentification of crayfish species, e.g. juvenile White-clawed crayfish with dark claws have been mistaken for Signal crayfish;

- c. Population lost to crayfish plague - European species only, i.e. Turkish crayfish and Noble crayfish, which are both susceptible to crayfish plague (but note that this might be due to introduction of one of the North American species of crayfish, which often carry crayfish plague, i.e. a different non-native species now present);
  - d. Severe pollution incident caused local reduction or loss of non-native crayfish (but check for any recovery after 2-5 years);
  - e. Introduced population failed (can only be confirmed following surveys, as the population may have stabilised at low abundance due to environmental factors, but a few cases of failed introduction of Signal crayfish have been reported).
2. **The non-native crayfish population is more extensive than last recorded.** Assume that any established population of non-native crayfish will have continued to expand its range since the last time it was surveyed or reported, so any verified records represent the minimum extent. The longer the time interval the more the population will have extended, unless there is a significant barrier to invasion. Recently established populations have a build-up period with slow expansion of range and this period may be in the order of 5 to 20 years. The leading edge of the invading population of crayfish is always at very low density and has a high probability of not being detected in surveys. The implication of this is that invading Signal crayfish may reach a threatened population of White-clawed crayfish sooner than expected. If any of them are carrying crayfish plague, this may cause sudden loss of the White-clawed crayfish population, before there is time to use it as donor stock for a new ark site.
  3. **White-clawed crayfish populations can disappear rapidly.** Status of White-clawed crayfish in a catchment can change rapidly from abundant to extinct within months to a year if an outbreak of crayfish plague occurs. Even though mass mortality occurs, it may go un-noticed or unreported at the time. Crayfish plague spreads upstream by direct contact between White-clawed crayfish, as well as downstream. Sudden mass mortality may not necessarily be plague, it may be a pollution incident or another disease.
  4. **There may be survivors.** Where crayfish plague has occurred there may still be semi-isolated relict sub-populations in parts of the catchment, especially upstream of natural or man-made barriers such as waterfalls or weirs, or in sparse populations in suboptimal habitat near the upstream limits. If there are survivors, these may be able to slowly re-colonize after the outbreak. Alternatively, there may be individuals trickling down over a physical barrier just often enough to keep crayfish plague going and this may prevent restocking of the watercourse downstream, as well as being a long-term threat to the relict population, because an infected crayfish might return over the barrier.
  5. **Online ponds may be opportunities or threats.** Ornamental ponds and fishing lakes are sites that are more likely to have had Signal crayfish deliberately stocked in the past than are rivers. Any that are upstream of existing or potential ark sites should be investigated if possible, in case non-native crayfish are present and can compromise the ark site. However, such sites may have

some scope as potential ark sites if no non-native crayfish are present and the risk of crayfish plague is relatively low.

***Note 3 (flowchart 2) Catchments outside the geographic range of White-clawed crayfish***

There is still scope for in situ conservation of White-clawed crayfish within catchments or River Basin districts where White-clawed crayfish are still present, or where they would have been present historically, even if there are no actual survey records. Although there are two populations of White-clawed crayfish in Scotland and at least one of them is now considered to be an ark site, there should be a presumption against further introductions there or in west Wales, at least in the period 2010-2015.

***Note 4 (flowchart 2) Eradication feasibility***

The only method that has succeeded in eradicating any populations of Signal crayfish is treatment with a biocide, which is not selective to crayfish, but is recoverable. There are few cases where this is feasible – only on sites that are relatively small and in the early stage of colonisation. If it is to be done at all, treatment needs to be done quickly, as a rapid response to detection of a population. Delay increases the scale, complexity, cost and the risk of not achieving 100% mortality of Signal crayfish. A biocide treatment requires expert advice and rigorous attention to details at all the stages of planning and treatment. Additional guidance on how to carry out a preliminary assessment of feasibility of a biocide treatment is given in a technical note available on the crayfish website [www.crayfish.org.uk](http://www.crayfish.org.uk).

***Note 5 (flowchart 2, 5) Barriers to invasion by signal crayfish***

Sloping surfaces are readily climbed by crayfish. Even vertical ones can be climbed if they are rough rock or stone, or are covered by mosses and filamentous algae. It is assumed (but not proven) that the higher the vertical climb, the less likely a crayfish will scale it. Vertical, smooth and preferably largely dry barriers will be the most effective, especially if >2m height. Water supply reservoirs or hydro-schemes tend to have the largest dams. Inspect the outfall for any compensation flow released under normal conditions, plus any spillway for the overflow if different. These may already be secure barriers, or they may be made more secure by relatively minor alterations, which can sometimes be included at low cost during maintenance work on the dam and associated structures. Invading crayfish are not able to climb out of water and walk upside down on a smooth surface (e.g. a pipe projecting beyond a concrete headwall and free fall of water to the channel). Simple barriers are unlikely to stop downstream spread. Retaining barriers may conflict with fishery policy to extend access for fish throughout catchments. However, barriers to colonization by non-native crayfish may be very important for protecting the spawning sites of non-migratory fish in headwaters (extract from Table 3 in [Peay, 2009](#)).

#### *Note 6 (flowchart 5) Reduce the risk of crayfish plague and further introductions*

This is dependent on increasing public awareness of the importance of biosecurity and in some cases encouraging changes in behaviour. Deliberate release of crayfish is a major risk, whether it is done for future wild harvest, for management reasons (such as clearing up dead fish or weed control in fishing ponds), or casual release of catches by children or others. Even if the majority of people do behave responsibly, this can be negated by one or a few individuals who don't know or don't care. Clear consistent messages in public communications will help, as shown by the success of a small leaflet produced by the South West Crayfish Conservation group in encouraging anglers to adopt a clean gear policy.

Encouraging anglers and other users of waterbodies to disinfect and/or dry gear between sites warrants regular publicity, especially from clubs themselves and Environment Agency fisheries staff. Some angling clubs already require members to use only clean, dry landing nets and other gear, because this reduces the risk of transmission of some diseases and parasites of fish and so helps to protect their sport, as well as reducing the risk of transmission of crayfish plague.

As described in Table 6 of the selection criteria for ark sites (Peay, 2009), the presence of angling can rate risks from good (low risk) through to bad (high risk). White-clawed crayfish populations can survive well on sites with responsible angling; where all anglers follow high standards of biosecurity with clean, dry gear and the club takes particular care with management operations (e.g. stocking, management of vegetation or lake restoration). Some clubs have achieved this successfully for many years, are well aware of the plight of White-clawed crayfish and do what they can to minimize the risks.

By contrast, angling can be considered to be high risk for White-clawed crayfish if:

- there is angling by a large club or general public angling, in a catchment where there are extensive populations of non-native crayfish that are known to carry crayfish plague and some of those waters are fished by the same angling club or other anglers;
- there is little interest in biosecurity among club members, there is frequent match angling with no requirement for clean gear, or there is a lot of unauthorised angling activity/poaching at the site;
- there is frequent stocking of fish from a variety of sources including fish farms with Signal crayfish, or netted stock from other fisheries that have Signal crayfish;
- there is intensive management of vegetation, possibly including regular extensive herbicide treatments;
- there is a high density of predatory fish (e.g. carp) and few refuges for crayfish that are inaccessible to the fish.

If most or all of these risk factors apply, the site would be unlikely to be successful as an ark site in the long term.

Risks of moving live crayfish with stocked fish can be removed or eliminated by good practice in handling. In some cases, installation of handling equipment at fish farms (e.g. slotted gratings to let crayfish drop back into tanks when fish are removed) may be enough to prevent transfer of crayfish. Where excess coarse fish are to be netted and transferred from a waterbody with signal crayfish to another site, they should be put into temporary floating cages with mesh large enough to allow crayfish to drop out before the fish are moved. Weed should also be removed. This is done by the Environment Agency, but not necessarily by other fishery managers. Any disinfection applied to fish for stocking, to control fish parasites, would also prevent or minimise the risk of transfer of crayfish plague spores.

Simple “do and don’t” points to communicate to anglers and the general public are:

**X Do not introduce crayfish to the wild**

**X Do not trap or remove crayfish (without a trapping licence)**

**X Never use crayfish as bait**

**✓ Disinfect or wash and dry equipment and footwear**

**✓ Protect native crayfish habitat**

**✓ Report crayfish sightings to the Environment Agency.**

#### **Note 7 (flowchart 6) Landuse issues**

Insecticides are a potential risk to White-clawed crayfish and other aquatic invertebrates. This may be a risk in arable areas, or where there are orchard crops. Most reported cases of mortality have been incidents with sheep-dip. Whilst a trend to use spray or drench application rather than immersion dipping has reduced the risks to watercourses, there are still risks where recently dipped sheep are released onto pastures with unfenced watercourses. This problem can occur even in areas where pasture is managed at relatively low intensity with little input of fertilisers. Another potential source of insecticides is cypermethrin applied to recently planted conifer plantations. Streamside areas tend not to be planted, to reduce runoff, and sprays are not applied to watercourses, but there may still be a risk in some areas where White-clawed crayfish occur in small streams. Other localised water quality problems in rural areas tend to be related to runoff from livestock yards, muckheaps, silage clamps, stock-watering areas and informal fords, and domestic properties not on mains drainage.

#### **Note 8 (flowchart 6) Disease and other mortality**

Mass mortality of White-clawed crayfish is often due to crayfish plague. However, there are other diseases that can affect native and non-native crayfish, notably porcelain disease, which is caused by the microsporidian parasite *Thelohania contejeani* (Imhoff et al. 2009). There has been relatively little study of other diseases and not enough is known ([Freeman et al., 2009](#)). A response plan is needed to quickly collect affected and dead crayfish to identify the cause where possible. Records should be kept within the River Basin District and coordinated nationally via the Fish Health

Inspectorate at CEFAS. Mass mortality may also be due to pollution. If pollution passes un-noticed at the time, other aquatic invertebrates, which may also have been affected, may have had time to recover and the fauna may appear normal within months to a year or two. By contrast, full recovery of a White-clawed crayfish population may take several years. The presence of a sparse population in what appears to be very favourable habitat may be an indication of past pollution, or other environmental effect such as drought, (see [note 10](#)).

Natural incidence of diseases or parasites may also cause previously abundant populations to decrease, although there is relatively little information so far on any such biological cycles in White-clawed crayfish populations.

#### *Note 9 (flowchart 4) Donor stock*

Within its overall European range, the White-clawed crayfish is considered to be a species complex and distinct genetic variations and subspecies occur, notably in Croatia, Italy and France (Souty-Grosset et al., 2006). By contrast, the populations that have undergone genetic testing in England and Wales are all very similar and indistinguishable from those in northern France, whereas those from Ireland are recognisably different and are related to populations in western France, the probable source of the original introductions there. Kemp et al. (2003) gave recommendations on taking donor stock for re-stocking or for new ark sites in England and Wales, in descending order of preference: from the same catchment as the recipient site, the same Region, adjacent Regions, but with additional selection criteria based on the degree of threat and the status of the donor populations. The principle of geographic preference still applies, but in the time-period 2011-2015 at least, there should be a presumption against movement of White-clawed crayfish between different River Basin Districts. Any proposal for movement of White-clawed crayfish from one River Basin District to another should only be considered if there is an urgent need, there is no better alternative for conservation of White-clawed crayfish and crayfish from one River Basin District are kept separate from any from another District. A careful, permanent record should be kept of the origin of any White-clawed crayfish used in the stocking of any site.

The preference based on degree of threat proposed in [Kemp et al. \(2003\)](#) is pragmatic. Populations that cannot be maintained in situ (e.g. due to invasion by non-native crayfish) are a higher priority as donor stock than safe populations. If, however, the threatened population has become so sparse that it is difficult to obtain enough stock, it may be better to take some donor stock from an abundant population in a more secure area.

In addition, the degree of isolation can be considered. If a site is wholly enclosed and isolated, it may be reasonable to take a donor stock from another catchment in the region, where a population is at imminent risk of loss, rather than one in the same catchment which is sparse, for example because it is recovering from a pollution incident. If there is re-stocking into a watercourse after pollution or crayfish plague and the re-stocked populations will come into contact with a surviving

population over time, it is highly preferable to use stock from within the same catchment. In every case the source of White-clawed crayfish stock must be kept on record. Records of stocking have to be provided to Natural England as a condition of a protected species licence for conservation and to Environment Agency national fisheries laboratory to obtain consent to stock, but at present there does not appear to be a system in place to keep track of this information in the regions/River Basin Districts, where this information will be needed for catchment-scale conservation action plans for White-clawed crayfish.

#### ***Note 10 (flowchart 7) Physical habitat and drought***

White-clawed crayfish cannot survive for more than a few hours to a day or so without water, so they cannot remain in still waters that dry out every few years, such as many farm ponds, nor can they cope with droughts if all the available refuges in the channel become exposed. In a drought, White-clawed crayfish may survive in pools in watercourses if there are enough refuges in the channel and submerged banks, but the population is likely to have much less habitat available, be more at risk from predation from fish and other predators, be more susceptible to pollution from e.g. drainage from private waste-water systems or other pollution events and there may be greater damage to the banks and channel by livestock seeking water. With White-clawed crayfish becoming isolated in headwaters in some invaded catchments, they are potentially more vulnerable to periodic droughts. Furthermore, where their survival is dependent on effective barriers to invasion, there may be less opportunity for re-colonization of temporarily unsuitable habitat if White-clawed crayfish are displaced downstream. After a drought when normal flows have resumed, it may not be evident that the area has been badly affected, except by the low abundance or absence of White-clawed crayfish, because the population may take several years to recover, if at all. In addition, climatic impacts may be exacerbated by abstractions of surface water or groundwater. The frequency of dry summers may need to be considered in assessing existing or future ark sites where they extend to the perennial limit of streams. Within a catchment, it is advisable to have a range of different types of ark sites to give the best chance that populations will survive in at least some of them, whatever the climatic conditions.

#### ***Note 11 (flowchart 3) Status of population and barriers to crayfish plague***

If a population of White-clawed crayfish is abundant along a whole watercourse it means conditions are very favourable and it is a single unit of population. If an outbreak of crayfish plague occurs the epidemic will tend to spread quickly downstream carried by the spores and progressively upstream due to crayfish to crayfish contact (assuming no human-assisted spread of infection). In a dense, continuous population there is a high risk that all the crayfish will become infected and die. If the population is partly fragmented, there is the possibility that none of the individual crayfish from upstream may move into the area downstream until after the last spores of crayfish plague has died off (within hours to two weeks after the last mortality). Sections of watercourse with unfavourable habitat or physical barriers may provide enough quarantine to prevent the population upstream from being lost to crayfish plague. This break in the epidemic is more likely if all infected

crayfish are still downstream of the barrier at the start of winter, when White-clawed crayfish are much less likely to roam than during the summer. This does not mean there should be no improvements carried out in areas where pollution or damage to physical habitat have led to the population being more sparse than it otherwise would be.

Part of contingency planning for a catchment or individual watercourse with White-clawed crayfish may include predicting whether potential quarantine barriers exist at present and whether they could be made more effective during any future outbreak of crayfish plague. If the epidemic dies out completely and there are no potentially infective non-native crayfish downstream, there is potential for either gradual re-colonisation over the barrier, or re-stocking. Obtaining information about the barriers that stopped particular epidemics of crayfish plague would help in future contingency planning for other catchments.

#### **4.4 Additional notes on ark site strategy and contingency planning**

*“An ark site for white-clawed crayfish is a discrete waterbody, comprising running and/or still water, which supports a healthy, recruiting population of white-clawed crayfish and which can be reasonably expected to sustain a population in favourable condition for the foreseeable future, without significant management intervention”* South West Crayfish Conservation Group 2009.

Rating a waterbody with population of White-clawed crayfish as an ark site means we are making assumptions about the risks to the population, or the likelihood of its survival. Whether an existing population is classed as an ark site or not depends on the existence of physical barriers to invasion by non-native crayfish and the likelihood of human-assisted introductions of non-native crayfish or crayfish plague.

Where watercourses or still waters already have White-clawed crayfish the existence of the population there confirms that the environmental conditions are suitable. There is none of the uncertainty involved in establishing a new population of White-clawed crayfish, where there is a risk that some element of the conditions may not be favourable, the initial small population is more at risk of loss by chance (stochastic processes) and it will take years before the population builds up enough to know whether it has established successfully or not.

Having an existing ark site is generally better than a new ark site, if the population can be kept secure. So identifying, protecting and, if necessary, improving existing, ‘defendable’ ark sites should be the top priority.



Some additional points in developing conservation action plans are:

- Small, new ark sites may be part of a conservation strategy to provide 'back up' sites for larger existing ark sites.
- A large site is better than a small one, to maintain viable population in the long term, but a large site may be more at risk of invasion or crayfish plague, due to factors such as more human access, or more uncertainty as to whether non-native crayfish are already present within a large geographic area.
- Many sites are better than one or only a few, because some may be lost or fail for any of a variety of reasons. The higher the risk of loss of individual sites the more sites that are needed to give a fair chance that some of them will survive.
- Running water sites (if biosecure) tend to be largely self-maintaining, although populations may fluctuate due to periodic natural floods or droughts.
- Still waters will have a finite life unless maintained periodically, due to the process of natural succession.

Hence having a variety of types of well-established and new ark sites probably gives the best prospects for success in conserving White-clawed crayfish in a catchment. An existing population of White-clawed crayfish may not be 'defendable' because there are already non-native crayfish invading the catchment and there are no adequate physical barriers to block an invasion over time. In such cases, loss is inevitable sooner or later, if no effective remedial action is possible. Even though an 'undefendable' site is not an ark site as such, it may still be of strategic importance to conservation of White-clawed crayfish within a catchment or river basin district/region. Invasion of headwaters of a catchment may take years, or even decades if the invasion starts in the lower catchment or far up a tributary. In the meantime, the existing population of White-clawed crayfish may be a source of donor stock for new ark sites (see also [note 9](#)), or it may be possible to install new physical barriers to isolate one or more headwater streams with native crayfish.

Management options for 'undefendable' sites are:

1. do nothing and leave the native crayfish to be replaced by non-native crayfish;
2. install physical barriers to secure all or part of the existing population of White-clawed crayfish
3. translocate part of the White-clawed crayfish population to potential new ark sites in the same catchment, or if necessary to another catchment within the river basin district or region; (either once, or periodically when opportunities for new ark sites arise),
4. take a sample for captive-breeding and use the stock produced as soon as potential ark sites are available

Option 1 is undesirable and represents failure, but it will occur by default if there isn't enough time before non-native crayfish or crayfish plague reach the site, or if there are inadequate resources of people or funding for conservation action. Options 2, 3 and 4 could be used individually or in combination. Option 4 captive-breeding facilities are not ark sites, but may contribute to public

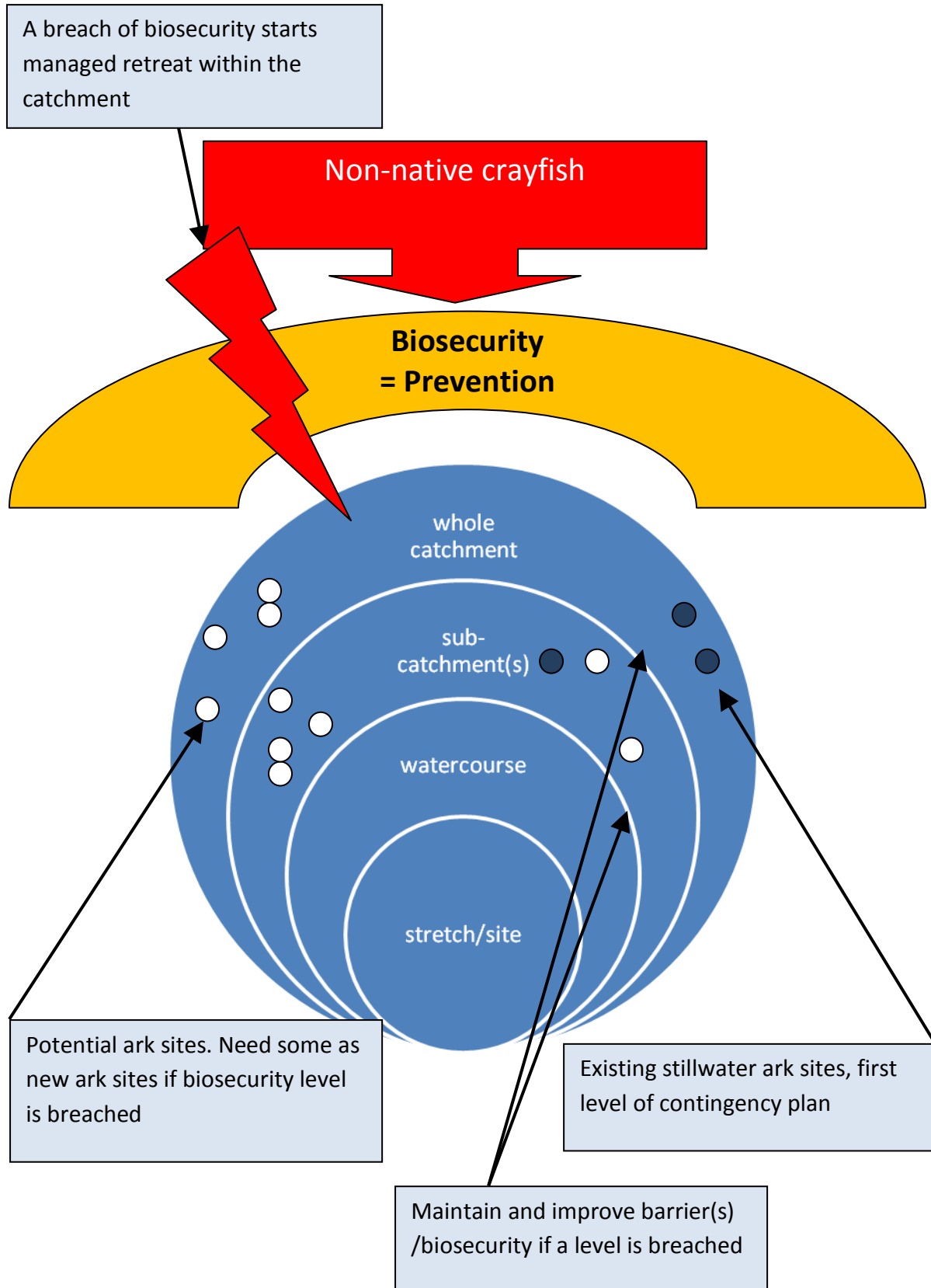
education programmes on conservation and to help stock new ark sites where other donor populations are weak. As wild populations of White-clawed crayfish are the priority (at scales from whole catchments to individual sites), it is recommended that the resources used for captive-breeding should only be a minor part of the overall conservation effort used for White-clawed crayfish.

Conservation action plans for White-clawed crayfish should plan for contingencies. The aim is to protect and keep as many populations of White-clawed crayfish as practicable and bolster them with additional ark sites, but consider what to do if prevention fails and there is a breach of biosecurity.

When there are no non-native crayfish, most of the effort needs to go into prevention at catchment scale and beyond, plus contingency planning and selected action.

If non-native crayfish get into a catchment that previously had none, 'managed retreat' is likely to be needed (as with the controlled retreat setting back of coastal defences to cope with rising sea level, leaving some areas to be invaded by the sea). When invasion cannot be stopped at the point of establishment, the focus of effort has to change to take account of the change of status. Effort still needs to go into prevention of further introductions and crayfish plague, but there will be much more emphasis on protecting defensible sub-catchments and starting more new ark sites from those already identified as feasible sites, while there is still time to do so. Figure 4.1 shows a schematic of the process.

**Figure 4.1 Schematic of contingency planning for biosecurity of White-clawed crayfish**



## 4.5 Protection and management – combining the actions in a catchment

The Flowcharts set out in [section 4.2](#) show an approach to preparing an action plan based on a combination of the status of crayfish and the risk factors present. The risk factors from Flowcharts 3-7 are shown in summary, without the actions, in [Appendix 3](#). When all the actions selected from the flowcharts are brought together they can be worked into an overall plan. The action plan can contain objectives, but should have some clear targets with measurable outcomes, so the success of the plan can be reviewed at regular intervals.

Supplementary recommendations on strategy are given here in [Table 4](#), or as an alternative approach to using the flowcharts.

The table gives five examples of plans for catchments, which have:

- White-clawed crayfish only
- Mainly White-clawed crayfish
- Mainly non-native crayfish
- Only non-native crayfish
- No crayfish

For each type of catchment recommendations are set out under the following headings:

- Protection of White-clawed crayfish
  - Site protection/designation
  - Ark sites
  - Monitoring/surveillance
- Management issues with non-native crayfish
  - Fisheries management
  - Harvest/control of non-native crayfish
  - Eradication of non-native crayfish
- Overall issues
  - Education/promotion
  - Potential priorities

[Table 4](#) sets out recommendations on crayfish strategy, but it would still need to be developed into an action plan for specific catchments or regions. Measurable and realistic targets would also need to be added to create action plans, together with responsibilities for relevant organisations, specific work items and appropriate time-scales. If threats to White-clawed crayfish are imminent, delays of a few years before actions are started may threaten the success of conservation measures.

**Table 4: Developing strategy on crayfish based on status of crayfish in the catchment – summary recommendations**

Topic	White-clawed crayfish only	Mainly White-clawed crayfish	Mainly non-native crayfish	Only non-native crayfish	No crayfish
<b>Protection of White-clawed crayfish</b>					
<b>Site protection/ designation</b>	All catchments with White-clawed crayfish only are nationally important and populations are worthy of protection/ designation if not already in SSSI/ASSI. Designation, on its own, will not protect the crayfish from threats.	Existing populations are important at scale of catchment (and county). Sites with abundant populations and some biosecurity are especially so. Conservation designation may be appropriate, especially if it encourages actions to improve biosecurity.	Conservation designation may be helpful for established ark sites, e.g. county wildlife site, SINC etc, but the priority is management to keep the sites safe from non-native crayfish and crayfish plague.	Non-native crayfish have potential to degrade aquatic features of wetland SSSIs and SACs leading to unfavourable conditions. Identifying barriers to invasion and measure to keep non-natives out is important, even at a distance from the SSSI boundaries	Accidental or deliberate introduction of non-native crayfish is a potentially damaging activity for any wetland SSSI, both into the site directly and anywhere in the catchment if the SSSI can be invaded via a natural watercourse or canal.
<b>Ark sites</b>	Whole catchments are currently ark sites. But large areas are most at risk. Consider starting some backup ark sites for each White-clawed crayfish catchment, and/or identify areas where barriers might stop non-native crayfish and/or crayfish plague, if they arrive.	Identifying existing ark sites is a high priority – do risk assessments on all. High priority to set up new ark sites for populations under threat from invasion. Do it while there are still abundant donor populations.	Ark sites will be increasingly hard to find and protect, especially if crayfish plague is frequent in local non-native crayfish. Still worthwhile setting up ark sites where can get good biosecurity.	Low priority where White-clawed crayfish are already lost and there are widespread non-native crayfish – unless have biosecure options for new arks and it is part of planned support for catchments with White-clawed crayfish.	Do not set up in river basin districts that had no native crayfish historically. Where did have native crayfish historically, can set up ark sites in some minor catchments, i.e. streams direct to sea; - but not in all of them and only after ecological assessment.

<b>Topic</b>	<b>White-clawed crayfish only</b>	<b>Mainly White-clawed crayfish</b>	<b>Mainly non-native crayfish</b>	<b>Only non-native crayfish</b>	<b>No crayfish</b>
<b>Monitoring</b>	<p>Highest priority is surveillance/ alert for possibility of non-native crayfish (from crayfish surveys, other surveys or public reports). Carry out rapid follow-up of suspect cases and make prompt decisions on feasibility of eradication treatment if any found.</p> <p>Re-visit unconfirmed suspect sites within 3 years, in case population was present but at low density.</p> <p>Also do periodic monitoring for White-clawed crayfish population status.</p>	<p>Priority is surveillance/ identification of any new non-native crayfish populations, especially any that might threaten existing or new ark sites.</p> <p>Carry out periodic monitoring of the success of existing and new ark sites.</p> <p>Also check status of any populations due to be lost, but still of value as donor stock.</p> <p>Obtain information on rates of invasion and effectiveness of barriers if have opportunity.</p>	<p>Priority is surveillance/ identification of any new non-native crayfish populations that might threaten ark sites. Also surveillance for new non-native crayfish species.</p> <p>Obtain information on rates of invasion and on the effectiveness of barriers protecting uninvasion parts of catchments.</p> <p>Monitor status of ark sites periodically and other populations including potential donor stock</p>	<p>Priority is surveillance for new non-native crayfish species. Also for new records in previously uninvasion subcatchments.</p> <p>Take opportunities to obtain information on rates of invasion and on the effectiveness of barriers protecting uninvasion parts of catchments. Take opportunities for long-term monitoring of abundance and ecological impacts.</p>	<p>Priority is surveillance/ identification of any new non-native crayfish populations. Use surveys for other purposes, plus public reporting to alert to possibility of non-native crayfish.</p> <p>Carry out rapid follow-up of suspect cases and make prompt decisions on feasibility and merit of eradication treatment</p>
<b>Management issues with non-native crayfish</b>					
<b>Fisheries management</b> (Live Fish)	Site Permit should always have conditions to avoid or minimise	Site Permit should always have conditions to avoid or	Generally no conditions re. crayfish on site permits, except	Generally no conditions on stocking fish into waters that	Site Permit and Supply Permit should have conditions to prevent

<b>Topic</b>	<b>White-clawed crayfish only</b>	<b>Mainly White-clawed crayfish</b>	<b>Mainly non-native crayfish</b>	<b>Only non-native crayfish</b>	<b>No crayfish</b>
Movement Scheme)	risk of introducing crayfish plague and/or non-native crayfish	minimise risk of introducing crayfish plague and/or non-native crayfish	in ark sites, or where ark site could be affected by accidental introduction of non-native crayfish or crayfish plague	already have non-native crayfish.	accidental introduction of non-native crayfish to new sites.
<b>Harvest/control non-native crayfish</b>	None, not applicable. Prevent/actively discourage in adjacent catchments	None. Do not permit trapping for control – it increases risk to White-clawed crayfish by encouraging authorised or unauthorised wild harvest.  Prevent/actively discourage in adjacent areas, or with strict conditions only. Need vigilance to spot any illegal harvesting.	Only permit if have controls to prevent risk to remaining populations of White-clawed crayfish.  Trapping to relieve angling nuisance in areas where harvest for consumption is not allowed may encourage more demand for wild harvest and increase risks.	Unless Defra agrees to ban sale of non-native crayfish and/or keeping or taking them, consents for trapping for harvest or control of angling nuisance are likely to continue in southern England. Conditions are needed to minimise risk of escape/introduction to new sites. Allowing northward spread of harvesting may threaten remaining catchments with White-clawed crayfish.	Not applicable. But acceptance of harvest/control in adjacent catchments increases the risk of accidental or illegal introductions.
<b>Eradication non-native crayfish</b> (is only possible in early	Highest priority is to set up rapid response plan if non-native crayfish are found in a	May be worthwhile doing a biocide treatment if feasible and have features of	Generally not worth doing, except if can eradicate a new species of high risk	Generally not worth doing, except if can eradicate a new/recently	High priority is to set up rapid response plan for eradication if non-native crayfish are

<b>Topic</b>	<b>White-clawed crayfish only</b>	<b>Mainly White-clawed crayfish</b>	<b>Mainly non-native crayfish</b>	<b>Only non-native crayfish</b>	<b>No crayfish</b>
stage of establishment/ invasion and in relatively small waterbodies)	feasible site to treat, including rapid emergency access to funding and expertise.	importance to defend and one-off or staged treatment gives long-lasting benefits.	invasive non-native crayfish, e.g. marbled crayfish if found. May be worthwhile if treatment protects features of high importance - and there will not be invasion from other sources, e.g. there are barriers against further invasion.	established species of invasive non-native crayfish, e.g. if marbled crayfish or rusty crayfish are found.	found for the first time in a catchment, including rapid emergency access to funding and expertise. Cost/effort is easy to justify when catchment has features of importance, or where presence of non-native crayfish would be a risk to adjacent catchments.
<b>Overall issues</b>					
<b>Education/ promotion</b>	Engage public with White-clawed crayfish, and in understanding threat of invasive non-native crayfish.  Involve riparian owners, angling clubs, and other recreational users.	Engage public with White-clawed crayfish, and in understanding threat of invasive non-native crayfish. Involve riparian owners, angling clubs, other recreational users. Actively discourage interest in wild harvest or other trapping of non-native crayfish.	Promote the risks of non-native crayfish. Promote coping strategy for angling. Discourage wild harvest/control; Where it is tolerated, promote safe practice in trapping. Emphasise importance of preventing spread of crayfish plague and further introductions.	Promote the risks of non-native crayfish. Tolerate wild harvest/control within 'go' areas.  Emphasise importance of preventing spread of crayfish plague and further introductions.	Emphasise threat of non-native introductions especially to angling interests.  Make sure traders understand existing restrictions on sale of crayfish for aquaria or food (in Scotland and Northern Ireland in particular).



Topic	White-clawed crayfish only	Mainly White-clawed crayfish	Mainly non-native crayfish	Only non-native crayfish	No crayfish
<p><b>Potential Priorities:</b></p> <p><b>Biosecurity</b> (see also education and fishery management)</p>	<p>Biosecurity is the highest priority.</p> <p>Require stringent efforts to keep out crayfish plague and non-native crayfish.</p> <p>Also need contingency plans and resources in case of arrival of plague or non-natives, to keep parts of catchment with intact population White-clawed crayfish.</p>	<p>Biosecurity is the highest priority, especially for avoiding crayfish plague. Need contingency plans for plague or non-natives to keep sub-catchments secure.</p> <p>Need to keep any populations of non-natives which are not carrying crayfish plague free of it too, else they will become a permanent risk, (e.g. clean angling gear, fish-stocking, if any, preferably from sources without non-native crayfish).</p>	<p>Priority will be biosecurity for a few 'defendable' ark sites.</p> <p>Need contingency plans for populations under threat. If they cannot be defended, consider using as donor stock for secure ark sites elsewhere.</p> <p>Also try to prevent non-native crayfish and crayfish plague being spread to other areas (e.g. clean gear campaign; enforcement action on un-consented crayfish trapping).</p>	<p>Priority is to try to prevent non-native crayfish or crayfish plague from being spread to other areas (e.g. campaign on crayfish code), especially if there are areas with White-clawed crayfish, or no crayfish, in the region/ River Basin District.</p>	<p>Highest priority is education for water users and public on keeping non-native crayfish out.</p>

## 4.6 Developing strategy - from catchments to River Basin Districts

[Table 4](#) is primarily intended for use at catchment scale. If applied to a whole River Basin District, [Table 1](#) shows that none of the River Basin Districts in England and Wales would be in the categories 'White-clawed only' or 'Mainly White-clawed crayfish'. Even in Scotland, there is a dwindling number of the major river catchments still completely free from Signal crayfish ([Gladman et al., 2009](#)). Only the River Basin Districts in Northern Ireland can be considered to be 'White-clawed crayfish only' and these are therefore of the highest importance nationally and internationally. If a River Basin District contains catchments with a range of different status, adoption of all of the recommendations under 'Mainly non-native crayfish' would tend to mean less protection for the individual catchments with good populations of White-clawed crayfish and is therefore not recommended. For example, the North West River Basin District includes some partly invaded catchments in the south and the nationally important White-clawed-only catchments in Cumbria in the north and even in the south there are some sub-catchments with abundant populations of White-clawed crayfish at present.

This issue of status is especially relevant for the management issues with non-native crayfish. For example, if choice of status led to the authorisation of wild harvesting of Signal crayfish in areas where it is not allowed at present, within or close to catchments with White-clawed crayfish, this would increase the risk of spread of crayfish plague and would potentially provide an incentive for further illegal introductions. This suggests that a precautionary approach is needed, especially because once consent for action such as wild harvesting or stocking is given, it is more difficult to withdraw consent later. Above all, when introductions of non-native crayfish occur, it is generally not feasible to do anything to remedy them, so new introductions of non-native crayfish represent permanent deterioration of conditions.

Planning at River Basin District or regional scale as well as within individual catchments is important, however, because conditions in one catchment may be influenced by those in adjacent catchments, with respect to the risks of human-assisted introductions of crayfish plague and non-native crayfish. Administrative areas, e.g. local authority boundaries generally do not follow catchment boundaries, such that catchments are typically overlapped by a range of boundaries. This means that stakeholder groups may need to operate at Regional or River Basin District scale for setting conservation priorities overall, but the best scale for specific action plans is catchment scale, in general. At present there are some initiatives for conservation of White-clawed crayfish within some local authority Districts. These can be very helpful in encouraging public involvement and in identifying potential ark sites, but to be effective they need to work within the context of the catchment.

As an aid to planning new ark sites, there may be benefits in keeping a database in each River Basin District showing the wild populations of White-clawed crayfish that are potentially suitable as donor populations for new ark sites, together with details on their abundance, current trend/degree of threat and where and when they have been used previously. Within-catchment transfers are preferred, but introductions might be made to enclosed sites from elsewhere in the River Basin District, e.g. if there is a good opportunity to take stock from a population at imminent risk of loss.

## 5 Developing knowledge and communications

### 5.1 Research – information for future best practice guidance

Future research needs for crayfish conservation and management are not discussed in detail in this guidance, however, the crayfish website ([www.crayfish.org.uk](http://www.crayfish.org.uk)) has information on recent projects and is intended to give an overview of current work, together with the relevant contacts.

Recent reviews of current and potential methods of eradication or control of non-native crayfish have been given in [Freeman et al., 2009](#) and [Peay and Bryden, 2010](#). The latter includes a critical review of projects carried out in field conditions, including trapping, manual removal and various biocide treatments. Trapping and manual removal are not considered to be methods of eradication. The report includes a description of the operations involved in biocide treatments, with guidance on the scope and limitations, to inform future treatments. Summary guidance on the feasibility of biocide treatment against signal crayfish will be made available via the crayfish website. It is only likely to be suitable as a rapid response to small, recent populations and the benefits of successful treatment, the impacts/costs of not carrying out treatment and the full resources necessary to do it should be considered before starting any eradication treatment with biocide, or indeed any other methods that become available in future.

It is important to ensure that all the small-scale conservation projects for White-clawed crayfish are well recorded at planning and implementation stages, and that the outcomes are recorded in future years. The case studies need to be kept, accessibly, because the long time scale means that the same individuals may not be involved throughout and the case studies individually may not necessarily be published in the scientific literature, but remain as project reports, or a succession of them. Good case-study information is essential to provide evidence-based guidance on best practice in future.

Determining outcome is especially important with new ark sites, because populations develop quite slowly. A test of success is whether there is a detectable population present 5 years and 10 years after introduction.

If White-clawed crayfish are introduced and a survey is carried out the following summer, there will only be surviving founder stock plus young of year and in a large site it may be difficult to detect the founder stock. That first new generation of White-clawed crayfish will probably not breed until they are 3+ years. [Appendix 4](#) shows the development of year classes and comments on how readily they could be detected.

Understanding reasons for the overall outcome are important, whether the project succeeds as a long-term ark site or not. Did establishment occur? If the stocking was successful, were there problems later, e.g. crayfish plague? Catchment action groups should make sure monitoring and reporting is carried out. Project reports generally go to Natural England/Countryside Council for Wales nationally. Information should be kept regionally too and records and plans updated accordingly. A summary project record sheet can be downloaded from the UK crayfish website [www.crayfish.org.uk](http://www.crayfish.org.uk). Case studies and other projects will be made available through the website.

Other information of value to future projects would include:

- estimates of the rates of invasion by signal crayfish and other non-native crayfish species in different habitats;
- the effectiveness of different types of barriers in preventing upstream spread of crayfish plague and the invasion by non-native crayfish;
- the upstream limits of signal crayfish in upland catchments;
- more information on the time taken for White-clawed crayfish populations to develop and spread;
- the required size of founder population required for an ark site and the lower and optimal stocking strategy;
- all case-study information on attempted eradication treatment for non-native crayfish and reasons for not doing treatment if it was considered but not undertaken;
- the impact of predation by fish on White-clawed crayfish in ark sites;
- any interactions between White-clawed crayfish and amphibians;
- the long-term survival of White-clawed crayfish in still water ark sites and any effects of siltation and maintenance operations;
- future reviews of the effectiveness of catchment-scale action plans for conservation of White-clawed crayfish.

## 5.2 Involving people in crayfish conservation

Local stakeholder groups (see [section 2.4](#)) can help provide good local coordination of efforts to add value and increase capacity in many aspects of a strategy. Some examples are given below:

- If British Waterways, water companies or other organisations propose to carry out works on waterbodies that will affect White-clawed crayfish, it may be possible to plan this work so it can provide donor stock for a potential ark site that has been identified and made ready in advance.
- A local angling club may have fishing on a lake with White-clawed crayfish and also have fishing rights on a river that has Signal crayfish. A talk to club members about the risk of transmission of crayfish plague (and the benefits of a disinfection protocol in reducing the risk of transfer of diseases and parasites of fish) may encourage the club to require all members to disinfect angling gear before fishing at the lake and encourage the club bailiff and members to enforce the regulation.

- An angling club bailiff reports to the Environment Agency fisheries officer having seen home-made crayfish traps on a small on-line pond upstream of an area that appears to have potential as an ark site. This may be the first indication of an illegal introduction of Signal crayfish and one that might rule out the watercourse as a future ark site, so it should be investigated as a priority.
- The local wildlife trust and conservation volunteers may have been involved in habitat creation work to make a biosecure potential ark site suitable for White-clawed crayfish, e.g. using woodland thinnings to make faggot bundles to create refuges for crayfish in a gravel pit. The local press may do a story about this community effort towards conservation of native crayfish. It is not helpful if the press juxtapose the story with recipes for Signal crayfish, as this may encourage demand for wild harvest and its associated risks.
- An ecologist carrying out a survey for otter may find the remains of a crayfish in the upper part of a catchment where there were no recent records, after a historic outbreak of crayfish plague. This may indicate that an isolated population of White-clawed crayfish is still present. The consultant needs to take samples and/or good photographs and inform the Environment Agency so further confirmation can be sought.
- A crayfish monitoring survey may be an opportunity to engage school groups or other members of the public with crayfish and help put across the message to leave them where found and not keep crayfish in aquaria.
- A Rivers Trust carrying out a fisheries survey may spot dead or dying White-clawed crayfish. An early alert about a possible outbreak of crayfish plague may allow a) the Environment Agency and River Trust time to alert all the local angling clubs about the extra high risk of spreading plague during the outbreak and b) see whether part of the population can be saved, either by barriers, or by rescue of some stock ahead of upstream spread into temporary holding and future re-stocking.
- Local stakeholders may be able to attend a game fair, agricultural show, or other event where information can be given about good practice with crayfish. Members of the public may offer details of sites where they know there are crayfish.
- A student at a local University may want to carry out a short project on crayfish, but has no prior survey experience. With suitable briefing, the student may be able to carry out an initial desk study for existing or potential ark sites in a catchment plus a walkover survey to assess barriers.
- A project with local restaurants may make those that buy crayfish aware of the risks to native crayfish from wild harvesting unless done responsibly. It may encourage the restaurants to assess their crayfish sourcing and if they continue to purchase live crayfish make them appreciate the importance of complying with best practice in secure handling and safe disposal of any surplus stock, i.e. killed before disposal.

Experience of developing and carrying out action plans for crayfish can be collected locally within regional groups and shared nationally by contributing case-studies for the UK crayfish website [www.crayfish.org.uk](http://www.crayfish.org.uk), which can be used to help develop best practice for the future.

The White-clawed crayfish has been seen by some people as a 'lost cause', a species sure to become extinct, perhaps based on perceptions in the south-east of England, where most populations of White-clawed crayfish have already been lost. There is no doubt that there will be further reduction of the range of White-clawed crayfish in England and Wales, because of further unavoidable losses of populations due to non-native crayfish. Despite this, we still have some catchments that have only White-clawed crayfish and can certainly be considered to be of high importance for conservation of the species at a European scale. Even in catchments with White-clawed crayfish where non-native crayfish have already established, there are still opportunities to conserve the native species, even though we have to cope with the impacts of the non-native crayfish.

By planning at catchment scales and above now and by encouraging people to get involved in action for conservation at local scale, the prospects for White-clawed crayfish are still hopeful. All those involved in planning and implementing action plans for White-clawed crayfish will help to increase the number of populations that survive for future generations.

## References

- Alderman J (1993). Crayfish plague in Britain, the first twelve years. *Freshwater Crayfish* 9: 266-272.
- Bean, C. (2007). North American signal crayfish implementation plan. Species Action Framework report. Scottish Natural Heritage.
- Cosgrove, P.J., Maguire, C.M. and Kelly, J. (2008). Non-native crayfish exclusion strategy and contingency plan. Prepared for NIEA and NPWS as part of Invasive Species Ireland.  
<http://www.invasivespeciesireland.com/files/public/Management%20contingency/Non%20Native%20crayfish.pdf>
- Christmas, M. (2009). England Biodiversity Strategy 2010 to 2015 Atlantic Stream or White-clawed Crayfish. Environment Agency. (see [Appendix 2](#))
- Freeman, M. A., Turnbull, J. F., Yeomans, W. E. and Bean, C. (2010). Prospects for management strategies of invasive crayfish populations with an emphasis on biological control. *Aquatic Conservation* 20(2), 211-223.
- Füreder, L., Gherardi, F., Holdich, D., Reynolds, J., Sibley, P. & Souty-Grosset, C. (2010). *Austropotamobius pallipes*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <[www.iucnredlist.org](http://www.iucnredlist.org)>.
- Gladman, Z., Adams, C., Bean, C., Sinclair, S. and Yeoman, W. (2009). Signal crayfish in Scotland. In: Brickland J., Holdich D. M. and Imhoff, E. (eds.) *Crayfish Conservation in the British Isles*. Proceedings of a conference held on 25th March 2009 at the British Waterways Offices, Leeds. pp 43-48.
- Holdich, D. M. (2003). Ecology of the White-clawed Crayfish. *Conserving Natura 2000 Rivers Ecology Series No. 1*. English Nature, Peterborough. <http://www.english-nature.org.uk/lifeinukrivers/species/crayfish.pdf>
- Holdich, D. M., Harlioglu, M. M. and Firkins, I. (1997). Salinity adaptations of crayfish in British waters with particular reference to *Austropotamobius pallipes*, *Astacus leptodactylus* and *Pacifastacus leniusculus*. *Estuarine, Coastal and Shelf Science* 44, 147-154.
- Holdich, D. M., Palmer, M., Sibley, P. J. (2009). The indigenous status of *Austropotamobius pallipes* (Lereboullet) in Britain. In: Brickland J., Holdich D. M. and Imhoff, E. (eds.) *Crayfish Conservation in the British Isles*. Proceedings of a conference held on 25th March 2009 at the British Waterways Offices, Leeds. pp 1-12.
- Holdich, D. M., Rogers, W. D. and Reader, J. P., (1995). *Crayfish Conservation*. Final project report record to National Rivers Authority 1995. NRA R&D 378/10/N. Environment Agency, Bristol.
- Imhoff, E. M., Mortimer R. J. G., Christmas M. and Dunn A. M. (2009). Porcelain disease in white-clawed and signal crayfish in the UK. In: Brickland J., Holdich D. M. and Imhoff, E. (eds.) *Crayfish Conservation in the British Isles*. Proceedings of a conference held on 25th March 2009 at the British Waterways Offices, Leeds. pp 49-56.

IUCN, (2010). Red List of Threatened Species *Austropotamobius pallipes*  
<http://www.iucnredlist.org/apps/redlist/details/2430/0>

Kemp, E., Birkinshaw, N., Peay, S., Hiley, P.D., (2003). Re-introducing the White-clawed crayfish *Austropotamobius pallipes*. Conserving Natura 2000 Rivers Conservation Techniques Series No. 1. English Nature, Peterborough. [http://www.english-nature.org.uk/lifeinukrivers/species/crayfish\\_reintroduction.pdf](http://www.english-nature.org.uk/lifeinukrivers/species/crayfish_reintroduction.pdf)

Palmer, M. (1994). Action Plan for the conservation of the native freshwater crayfish *Austropotamobius pallipes* in the United Kingdom. JNCC Report No. 193. Joint Nature Conservation Committee, Peterborough, UK.

Peay, S. (2003). Monitoring the White-clawed Crayfish *Austropotamobius pallipes* Conserving Nature 2000 Rivers Monitoring Series No. 1. English Nature, Peterborough. 58 pp. [http://www.english-nature.org.uk/lifeinukrivers/species/crayfish\\_monitoring.pdf](http://www.english-nature.org.uk/lifeinukrivers/species/crayfish_monitoring.pdf)

Peay, S. (2003). Guidance on Habitat for White-clawed Crayfish. R&D Technical Report W1-067/TR, Environment Agency, Bristol.

Peay, S. (2009). Criteria for selecting Ark sites for White-clawed crayfish – a spreadsheet tool. Buglife <http://www.buglife.org.uk/conservation/currentprojects/Species+Action/Conserving+our+Crayfish/Crayfish+Ark+Site+Selection+Criteria>

Peay, S. and Bryden, P.D. (2010). A Review of Crayfish Eradication or Control – Cost Implications. Scottish Natural Heritage Commissioned Report.

Peay, S., Guthrie, N., Spees, J., Nilsson, E. and Bradley, P. (2009). The impact of signal crayfish (*Pacifastacus leniusculus*) on the recruitment of salmonid fish in a headwater stream in Yorkshire, England. Knowledge and Management of Aquatic Ecosystems.

Peay, S., Hiley, P. D., Collen, P. and Martin, I. (2006). Biocide treatment of ponds in Scotland to eradicate signal crayfish. Knowledge and Management of Aquatic Ecosystems, 380-381, 1363-1380.

Reynolds, J. D. (2009). The current status of White-clawed crayfish in Ireland. In: Brickland, J., Holdich, D. M. and Imhoff, E. (eds.) Crayfish Conservation in the British Isles. Proceedings of a conference held on 25th March 2009 at the British Waterways Offices, Leeds. pp 35-41.

Souty-Grosset, C., Holdich, D., Noël, P., Reynolds, J. and Haffner, P., (2006). Atlas of crayfish in Europe, *Patrimoines naturels*, 64, Muséum national d’Histoire naturelle, Paris, 187 p.



## Appendix 1 How conservation strategy for White-clawed crayfish has developed in the UK

### A1.1 The development of White-clawed crayfish conservation

Up until the mid 1970s the threats to White-clawed crayfish were losses due to reductions of habitat quality; due to urban and agricultural pollution and modification of channels, either for land drainage or by trampling from livestock. Even so, the only freshwater crayfish native to Britain ([Holdich et al., 2009](#)) was widespread and was not considered to be at risk.

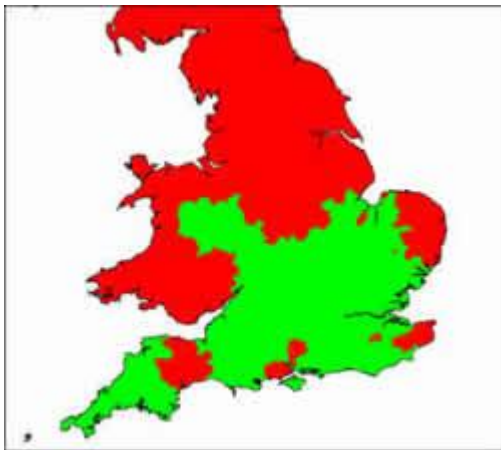
From the late 1970s the introduction of Signal crayfish for aquaculture in England quickly led to the first outbreaks of crayfish plague and wild-living populations of the invasive crayfish ([Alderman, 1993](#)). The loss of whole populations in some watercourses led to the White-clawed crayfish being added to the Wildlife and Countryside Act 1981 (as amended) from 1988. This gave protection from 'taking and sale'. This was strengthened by the protection for White-clawed crayfish at European scale under the EC Habitats Directive 1992. The introduction into UK legislation under the Conservation (Natural Habitats and Species) Regulations 1994 (as amended, now Conservation of Species and Habitats Regulations 2010), which provided for SACs to be selected for White-clawed crayfish. The equivalent provision in Northern Ireland is given in the Conservation (Natural Habitats &c.) Regulations (Northern Ireland) 1995 (as amended).

From 1992 non-native species known to be established in England were added to Schedule 9 of the Wildlife and Countryside Act: Signal crayfish, Turkish or Narrow-clawed crayfish and Noble crayfish, which made it an offence to release them into the wild. Red Swamp crayfish and Spiny-cheek crayfish were also added to Schedule 9 in 2010.

The first action plan for White-clawed crayfish was developed by JNCC ([Palmer, 1994](#)). Key recommendations of the action plan included: legislative controls on the keeping of live crayfish; containment measures to prevent the escape of non-native crayfish; use of legislation to control the release of non-native crayfish; control of effluent from crayfish farms; controls on the use of crayfish as live bait; removal of non-native crayfish populations where feasible; establishment of protected areas for native crayfish; research directed at conservation; monitoring the status of native crayfish and promotion on the risks of crayfish plague.

The action plan followed work on the distribution and status of White-clawed crayfish and Signal crayfish and outbreaks of crayfish plague ([Holdich et al., 1995](#)). The action plan proposed greater controls on keeping of non-native crayfish, including the requirement for licences and the setting up of 'no-go' areas (Appendix [Figure 1](#)). In England and Wales, the relevant legislation is the Import of Live Fish (England and Wales) Act 1980. A new regulation on crayfish was introduced under this Act, as the Keeping of Live Fish (Crayfish) Order 1996 in England and Wales. This prohibited the keeping of crayfish in England and Wales except under licence. Certain areas in southern England where wild populations of Signal crayfish were very widely established were exempt from the requirement for a licence. In addition, it was not possible to regulate retrospectively, so there were many populations of Signal

crayfish already established in the 'no go' area. The regulations were intended to restrict further introductions. In Scotland the main legislation against introductions of non-native crayfish are the Import of Live Fish (Scotland) Act 1978 (as amended 1996) and from this the Prohibition of Keeping or Release of Live Fish (Specified Species) (Scotland) Order 2003 specifically refers to crayfish. This makes it an offence to release any species crayfish or to have them in your possession in Scotland. There is no exemption for keeping Redclaw crayfish in aquaria or sale for human consumption as there is in England and Wales.



**Appendix Figure 1 Keeping of Live Fish (England and Wales) Act 1996 areas where keeping of crayfish is exempt from the requirement for a licence, shown in green.**

The UK Biodiversity Action Plan for White-clawed crayfish 1994 was updated in 2009, reflecting the introduction of the regulations on non-native crayfish and the complete ban on the use of crayfish as angling bait in 2005. It set out broad objectives under the topics of Policy and legislation, Site Safeguard and management, Species management, Research and Monitoring and Communications that were to be developed by the relevant agencies in England, Wales and Northern Ireland.

### **A1.2 England White-clawed crayfish strategy 2010 to 2015**

The Environment Agency, as the lead agency for White-clawed crayfish in England and Wales, held a workshop in July 2009 to discuss the issues and develop a more detailed strategy for England than the UK Biodiversity Action Plan. The resulting strategy set out broad aims, a series of actions and measures of success.

There are five broad sections in the England strategy, which follows generally similar themes to those in the UK BAP.

1. Introduction
2. Combine our work and resources with others
3. Effectively manage data and information
4. Protect and improve habitats and populations
5. Invest in knowledge and communication

For each of the sections there is an overall aim, a series of broad actions and general criteria for success.

The England Biodiversity Strategy 2010 to 2015 Atlantic Stream or White-clawed Crayfish *Austropotamobius pallipes* (Christmas, 2009 ) is the starting point for action planning in England and also in Wales and has been used as a basis for this guidance.

Crayfish conservation strategy will be most effective as part of the all-Ireland strategy, as Northern Ireland has three international River Basin Districts. The highest priority there is to keep non-native crayfish and crayfish plague out of Ireland ([Cosgrove et al. 2008](#)).

Scotland is beyond the natural geographic range of White-clawed crayfish, but many lowland catchments now have populations of Signal crayfish and an action plan for introduced Signal crayfish has been produced by Scottish Natural Heritage as part of the Species Action Framework for Scotland ([Bean, 2007](#)). Differences in regulation between the countries are outlined briefly in [Box 1](#). In addition, there are two populations of White-clawed crayfish which were introduced into still water sites historically, one in the central lowlands, the other in the far north of Scotland in Sutherland ([Gladman et al. 2009](#)). No further introductions are proposed, but these two sites are now considered to be ark sites in Scotland, especially the site in Sutherland which is currently far from any known populations of signal crayfish.

The regulations prohibiting the keeping of non-native crayfish in Scotland do not exempt Redclaw, which is not permitted to be sold or kept in aquaria, nor is any sale of live crayfish allowed for human consumption. In addition, the Wildlife and Natural Environment (Scotland) Act 2011 allows the Scottish government to take action against a person who has released invasive species, including non-native crayfish, or has them in their possession or control. If necessary the new legislation allows for a species control order to be served on a person who is keeping invasive species illegally. In future this would mean, for example, a person who had illegally stocked Signal crayfish or another invasive non-native crayfish species into a garden pond would have to carry out, or allow access for, an eradication treatment if required under the species control order.

## **Appendix 2: England Biodiversity Strategy 2010 to 2015 Atlantic Stream or White-Clawed Crayfish – *Austropotamobius pallipes***

Martin Christmas, Environment Agency, Leeds, 2009.

### **Introduction**

The White-clawed or Atlantic stream crayfish is the only native crayfish in the UK. Populations are becoming highly fragmented and population numbers are dwindling. The two major threats are: habitat/prey competition and disease that both come from the introduction of non-native crayfish during the 1970's and 80's aquaculture boom. Subsequent escapes and deliberate releases of non-natives into the wild have left the native crayfish facing extinction in many counties of England and Wales.

Crayfish attract considerable conservation effort from both the statutory and NGO sectors. However, some of the actions are too small scale to be sustainable in the long term and other efforts would benefit from a more strategic approach. The variable distribution of natives, non natives, disease prevalence and habitat means that although consistency is sought, a one size fits all solution is not appropriate. This strategy sets out the core aims and desired outcomes for the successful conservation of native crayfish in England and Wales. It sets out where we want to get to over the next five years, from 2010 to 2015. It will be underpinned by supporting documents which will form the roadmap of how we are going to get there.

### **Combine our work and resources with others**

#### **Our Aims**

People work better in teams and by bringing teams together we get greater outcomes for our effort. By working together we can share a direction and invest together in common goals.

#### **What we will do**

- Statutory group alignment – Environment Agency, Natural England, British Waterways, Cefas will adopt the same conservation approach
- Target resources to get more effective outcomes more efficiently
- Create regional delivery plans appropriate to the needs of the regional geography and conservation need
- Use the expertise and resources of regional exemplars to improve our efforts – e.g. Bristol Zoo project in SW

#### **We will know we are succeeding when**

- Each local government region has a 5-year costed action plan for crayfish conservation
- Business plans and project bids are aligned between organisations
- Statutory organisations provide one consistent crayfish conservation service nationally

## **Effectively manage data and information**

### **Our Aims**

We will work towards having the best possible information on which to base our decisions and we will highlight best practice and guidance to coordinate conservation effort.

### **What we will do**

- We will quality assure our existing information and publish a 2012 baseline of populations and their status
- We will share new survey data with the National Biodiversity Network
- We will continue to fund species specific and general quality survey work
- We will provide catchment scale decision making tools to guide conservation effort
- We will make clear the threats to native populations through disease and non-native risk maps

### **We will know we are succeeding when**

- We are confident we understand the distribution of native crayfish
- We can describe changes to populations over the next five years
- Regional plans align adopt best practice guidance through catchment scale decision tools
- We have a clear understanding of risk at a catchment scale

## **Protect and improve habitats and populations**

### **Our Aims**

We will work towards the best possible protection and habitat improvement for native crayfish. We will have secure areas where native crayfish thrive as a sustainable part of the freshwater ecosystem

### **What we will do**

- Work towards full protection under European and UK conservation legislation
- Improve bio security measures for Special Areas of Conservation designated for crayfish
- Agree those sites outside SAC boundaries which support genetically and geographically similar populations to those within the boundary
- Regional plans will contain pollution and disease contingency plans for major populations
- Review policy on the keeping and sale of non-native crayfish species
- Review policy on the import of non-native species
- Provide guidance on habitat preference and management

- Provide guidance on feasibility, identification and sustainability of 'Ark sites' and native crayfish translocation

#### **We will know we are succeeding when**

- Native crayfish status in SAC is improving
- Incidents of mass mortality through disease are rare
- Populations in non-designated sites receive equivalent protection and are thriving
- Spread of non-native species is reduced
- No new non-native species are introduced to the wild

## **Invest in Knowledge and Communication**

### **Our Aims**

To research options to improve crayfish conservation and to ensure best practice is freely available to all, so we work strategically to conserve and enhance native crayfish populations.

### **What we will do**

- Continue to research tools to eradicate non-native species
- Continue to better understand diseases that cause large mortalities
- Use new media to make information readily available
- Combine efforts with others to ensure publicity campaigns are more joined up

#### **We will know we are succeeding when**

- We have effective control measures for non-native species
- Independent surveys suggest the public is aware of the issues surrounding crayfish conservation

## Appendix 3: Summary

### Catchment-scale risk assessment for White-clawed crayfish: summary of risks

Current <b>status</b> of white-clawed crayfish in catchment?	What is the risk of <b>crayfish plague</b> in the catchment?	What is the risk of <b>non-native crayfish</b> in the catchment?	What is the risk of <b>habitat degradation</b> in the catchment – <b>water quality</b> ?	What is the risk of <b>habitat degradation</b> in the catchment – <b>physical habitat</b> ?	
Abundant throughout catchment	Low risk: no non-natives near, no angling, rural no urban population	No non-natives in catchment. None in adjacent ones, or they are distant	Rural, low intensity agriculture or seminatural u/s + riparian zone	Rural, all riparian zone semi-natural. Channel all natural or nearly so	Excellent
Widespread, locally abundant, but populations scattered	No non-natives near, no plague nearby in 5 years, no fish stocking	Non-natives in next catchment, near. No urban near natives. No wild harvest.	Mainly low intensity agriculture, some discharges but local and low impact	Access for livestock localised. Some bank modification, mainly natural	Good
Scattered and decreasing annually	Plague outbreaks nearby, or carriers. Angling and regular fish stocking	Non-natives in same catchment; but distant. Some urban areas, access	Various discharges, risk spray drift or dips, some urban runoff	Some areas bank erosion, channel straightening, loss riparian trees.	Poor
Only one or a few small populations left and threatened	Plague-carrying non-natives invading towards white-claws. Angling.	Non-natives in + close, no barriers. High public access. Wild harvest	Intensive arable or dairy. Many urban discharges from roads, sewers, STW	Extensive modification bed or banks, heavy siltation, dredging.	Bad

## Appendix 4: Time-scale of development of a new population of White-clawed crayfish

The table below shows how a population of White-clawed crayfish might develop in an ark site following a single introduction, assuming the crayfish reach sexual maturity at 3+ years. The time required to confirm the successful introduction and establishment of the population depends on:

- the size of the founder population;
- the birth rate, growth rate and the mortality of life stages each year;
- the extent to which crayfish disperse within the site, and
- the method of survey used and effort applied.

The original founder population may be detected in the first year of introduction, but the catch may decline during the next few years due to natural mortality. It may take four or five years, or more, before the first generation starts to be caught in traps (i.e. the offspring produced by the founders) and it may be 13 years before the second generation (offspring of the first generation) is large enough to be detected in traps. With small founder populations, establishment may take longer and the small population may be more vulnerable to failure in the early years e.g. due to heavy predation of juveniles by coarse fish than if the founder stock is relatively abundant.

**Appendix table 4.1: Potential year classes of White-clawed crayfish after introduction to an ark site**

Year after introduction	Year classes of White-clawed crayfish after introduction	Comments
0 introduction	Founders	Mixed age range of donor stock (founders), usually 1+ and older, if from wild stock
1	Surviving founders and young of year (0+), 1 <sup>st</sup> cohort).	Founders may sometimes be detected if there is a large founder population and an intensive survey is carried out, or there may be no catch because the population is sparse.
2	Founders, (0+, 2 <sup>nd</sup> cohort), (1+, 1 <sup>st</sup> cohort).	Founders may sometimes be detected in intensive surveys even though some mortality has occurred. Numbers caught in traps may increase slightly if founders included 1+ and 2+ crayfish caught in manual searches, i.e. too small to appear in traps in year 1.
3	Founders, (0+, 3 <sup>rd</sup> cohort), (1+, 2 <sup>nd</sup> cohort), (2+, 1 <sup>st</sup> cohort)	Founders reduced in number and may not be detectable. 1 <sup>st</sup> cohort is still too small to reliably detect in traps, although may be found in manual surveys. Females from the 1 <sup>st</sup> cohort may still be too small to breed. May be no catch
4	Founders, (0+, 4 <sup>th</sup> cohort), (1+, 3 <sup>rd</sup> cohort), (2+, 2 <sup>nd</sup> cohort), (3+, 1 <sup>st</sup> cohort)	Presence of 0+ depends on whether any of the original founder population has survived and whether any crayfish from the 1 <sup>st</sup> cohort were big enough to mate last autumn and produce young this year. 1 <sup>st</sup> cohort is big enough to detect in fine-mesh traps and



Year after introduction	Year classes of White-clawed crayfish after introduction	Comments
		expected to mate this year. May be no catch, or few crayfish.
5	(0+, 5 <sup>th</sup> cohort), (1+, 4 <sup>th</sup> cohort), (2+, 3 <sup>rd</sup> cohort), (3+, 2 <sup>nd</sup> cohort), (4+, 1 <sup>st</sup> cohort)	The 0+ cohort represents the second generation, although there may still be young from some of the founder population if they were introduced at 1+ or 2+ ages. The 1 <sup>st</sup> and 2 <sup>nd</sup> cohorts are of trappable size, so the population should show an increase – if the founder population was detectable previously. If the founder population was too small or widely dispersed to detect it initially, it may take a few more years to detect the first generation.
6	(0+ 6 <sup>th</sup> cohort) (1+ 5 <sup>th</sup> cohort), (2+ 4 <sup>th</sup> cohort), (3+, 3 <sup>rd</sup> cohort), (4+, 2 <sup>nd</sup> cohort), (5+, 1 <sup>st</sup> cohort)	The 6 <sup>th</sup> cohort comprises young that were bred from the 1 <sup>st</sup> and 2 <sup>nd</sup> cohorts and possibly a few from the 3 <sup>rd</sup> cohort. At least the first three cohorts are potentially detectable by fine-mesh trapping or night-viewing and can be expected to breed this year.
7	(0+ 7 <sup>th</sup> cohort) (1+ 6 <sup>th</sup> cohort), (2+ 5 <sup>th</sup> cohort), (3+ 4 <sup>th</sup> cohort), (4+, 3 <sup>rd</sup> cohort), (5+, 2 <sup>nd</sup> cohort), (6+, 1 <sup>st</sup> cohort)	The 7 <sup>th</sup> cohort comprises young from the first 3 cohorts, although the 1 <sup>st</sup> cohort may be few in number by now. With up to four cohorts potentially detectable by trapping, failure to detect crayfish with intensive survey may indicate a problem.
8	(0+ 8 <sup>th</sup> cohort) (1+ 7 <sup>th</sup> cohort), (2+ 6 <sup>th</sup> cohort) (3+ 5 <sup>th</sup> cohort), (4+ 4 <sup>th</sup> cohort), (5+, 3 <sup>rd</sup> cohort), (6+, 2 <sup>nd</sup> cohort), (7+, 1 <sup>st</sup> cohort ?)	The 8 <sup>th</sup> cohort comprises young from the first 4 cohorts, but is still all bred from the 1 <sup>st</sup> generation unless some of the 5 <sup>th</sup> cohort have bred.
9	(0+ 9 <sup>th</sup> cohort) (1+ 8 <sup>th</sup> cohort), (2+ 7 <sup>th</sup> cohort) (3+ 6 <sup>th</sup> cohort), (4+ 5 <sup>th</sup> cohort), (5+, 4 <sup>th</sup> cohort), (6+, 3 <sup>rd</sup> cohort), (7+, 2 <sup>nd</sup> cohort ?)	The 9 <sup>th</sup> cohort comprises young from the first 5 cohorts, although the 1 <sup>st</sup> cohort may have gone by now. The 0+ includes a proportion of 2 <sup>nd</sup> generation crayfish (although not distinguishable).
10	(0+ 10 <sup>th</sup> cohort) (1+ 9 <sup>th</sup> cohort), (2+ 8 <sup>th</sup> cohort), (3+ 7 <sup>th</sup> cohort) (4+ 6 <sup>th</sup> cohort), (5+ 5 <sup>th</sup> cohort), (6+, 4 <sup>th</sup> cohort), (7+, 3 <sup>rd</sup> cohort), (8+?)	The 10 <sup>th</sup> cohort has bred from a mix of 1 <sup>st</sup> and 2 <sup>nd</sup> generation White-clawed crayfish, a well-established population. But if crayfish are not detected in trapping until 3+ (or older if large-mesh traps are used), the 2 <sup>nd</sup> generation may not be reliably detected until year 13.