Information about GB Non-native Species Risk Assessments

The Convention on Biological Diversity (CBD) emphasises the need for a precautionary approach towards non-native species where there is often a lack of firm scientific evidence. It also strongly promotes the use of good quality risk assessment to help underpin this approach. The GB risk analysis mechanism has been developed to help facilitate such an approach in Great Britain. It complies with the CBD and reflects standards used by other schemes such as the Intergovernmental Panel on Climate Change, European Plant Protection Organisation and European Food Safety Authority to ensure good practice.

Risk assessments, along with other information, are used to help support decision making in Great Britain. They do not in themselves determine government policy.

The Non-native Species Secretariat (NNSS) manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. Risk assessments are carried out by independent experts from a range of organisations. As part of the risk analysis process risk assessments are:

- Completed using a consistent risk assessment template to ensure that the full range of issues recognised in international standards are addressed.
- Drafted by an independent expert on the species and peer reviewed by a different expert.
- Approved by an independent risk analysis panel (known as the Non-native Species Risk Analysis Panel or NNRAP) only when they are satisfied the assessment is fit-for-purpose.
- Approved for publication by the GB Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAP.

To find out more about the risk analysis mechanism go to: www.nonnativespecies.org

Common misconceptions about risk assessments

To address a number of common misconceptions about non-native species risk assessments, the following points should be noted:

- Risk assessments consider only the risks posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Risk assessments are about negative impacts and are not meant to consider positive impacts that may also occur. The positive impacts would be considered as part of an overall policy decision.
- Risk assessments are advisory and therefore part of the suite of information on which policy decisions are based.
- Completed risk assessments are not final and absolute. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

Period for comment

Draft risk assessments are available for a period of three months from the date of posting on the NNSS website*. During this time stakeholders are invited to comment on the scientific evidence which underpins the assessments or provide information on other relevant evidence or research that may be available. Relevant comments are collated by the NNSS and sent to the risk assessor. The assessor reviews the comments and, if necessary, amends the risk assessment. The final risk assessment is then checked and approved by the NNRAP.

*risk assessments are posted online at:
https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=51
comments should be emailed to nnss@fera.gsi.gov.uk

GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

For more information visit: www.nonnativespecies.org

N	QUESTION	RESPONSE	COMMENT
	Name of Organism:	***Orconectes limosus* – Spiny-cheek Crayfish**	
	Objectives:	Assess the risks associated with this species in GB	
	Version:	FINAL 29/03/11	
N	**QUESTION**	**RESPONSE**	**COMMENT**
1	What is the reason for performing the Risk Assessment?		*Orconectes limosus* has been shown to be an invasive species that could spread in the Risk Assessment Area. Currently it is known from three locations in central England: 1. Catfish pond (SP 079 592) and the nearby R. Arrow near Alcester (Severn-Trent Environment Agency Region Lower Severn, West Midlands) – not checked since 2002 (specimen and photos seen by current author), but the R. Arrow is to be checked out in late April to confirm the continued presence of spiny-cheek crayfish; 2. Fishing ponds near Ancaster (SK 974 436) (Anglian EA Region, Lincolnshire) – checked out in 2006 by the Environment Agency and presence of spiny-cheek crayfish confirmed; 3. Lake in Attenborough Nature Reserve (SK 523 335) (Severn-Trent EA Region, Lower Trent, Nottinghamshire) – positive identification as shown in Holdich & Black (2006).
2	What is the Risk Assessment area?	GB	Currently only known from central England. There are no non-native crayfish in Ireland at present.
3	Does a relevant earlier Risk Assessment exist?	NO OR UNKNOWN (Go to 5)	
4	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?		
A	**Stage 2: Organism Risk Assessment SECTION A: Organism Screening**		
5	Identify the Organism. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES (Give the full name & Go to 7)	*Orconectes limosus* (Rafinesque, 1817) (Arthropoda, Crustacea, Astacida, Cambaridae) is characterised by the spiny sides to the carapace coupled with the orange/brown stripes across the abdominal segments (Pöckl *et al.* 2006, Souty-Grosset *et al*. 2006). Unfortunately, a mistake in a nationally used key led to a photo of *Orconectes virilis* being used instead of one of *O. limosus*, although it was labelled as *O. limosus* and the correct description was given. This led scientists to believe that the species in the R. Lee catchment north of London was *O. limosus*, when in fact they have recently been shown to be *O. virilis* (Ahern, 2008).
6	If not a single taxonomic entity, can it be redefined?		
7	Is the organism in its present range known to be invasive, i.e. to threaten species, habitats or ecosystems?		*O. limosus* is not particularly invasive in its native range, which is the eastern USA (Hamr, 2002), although it is spreading in eastern Canada (McAlpine *et al.*, 1991). However, since its introduction to continental Europe in 1890 it has become widely spread and has proved to be extremely invasive (Holdich, 2002; Souty-Grosset *et al.*, 2006). It can reach high densities in suitable locations (Brink *et al.*, 1988; Haertel-Borer *et al.*, 2005). In the USA it faces competition from other crayfish species, particularly *O. rusticus*, but in Europe it has few crayfish competitors and has been implicated in the demise of native crayfish populations through competition for resources and the transmission of crayfish plague (Souty-Grosset *et al*., 2006).
8	Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems?	YES or UNCERTAIN (Go to 9)	All the evidence points to the fact that *O. limosus* is the most invasive crayfish species in continental Europe and has been responsible for the demise of many native crayfish populations through the transmission of crayfish plague and competition (Souty-Grosset *et al.*, 2006). It has been shown to be able to burrow extensively (Holdich & Black, 2006). It has a more rapid growth rate and higher fecundity than UK's native white-clawed crayfish, which is also susceptible to effects of crayfish plague (Holdich *et al*., 2004). It is still spreading at a rapid rate, e.g. Lithuania (Burba, 1997), Belarus (Alekhnovich *et al*., 1999), and countries associated with the R. Danube (Beran & Petrusek, 2006; Kozubíková *et al*., 2007; Puky & Schád, 2006).
9	Does the organism occur outside effective containment in the Risk Assessment area?	YES (Go to 10)	The three locations where it occurs in England are ponds/lakes that are connected to or are very close to other waterbodies. The Alcester population has entered the R. Arrow (PJ Sibley, pers. comm., 2002), which flows into the R. Avon and then the R. Severn. The continued presence of *O. limosus* in the R. Arrow is to be investigated in April 2008 (D. Ahern, pers. comm., 2008).The Attenborough population is within a few metres of the R. Trent and could easily spread to it during periods of flooding, as well as into the adjacent water-filled gravel pits. The ponds containing the Ancaster population drain into a nearby beck that then drains into the R. Slea that enters the R. Witham. However, as the upper reaches of the beck dry up in the summer this may prevent movement of the crayfish (R. Page, pers. comm., 2008). According to the Environment Agency (R. Page, pers. comm., 2006) measures are not in place to contain the crayfish but this is due to be rectified in 2008 (R. Page, pers. comm., 2008). No *O. limosus* were located in the beck in autumn 2007 (R. Page, pers. comm., 2008). However, the *O. limosus* population is only 1 km from a tributary of Honington Beck, and that beck flows right into the middle of a large white-clawed crayfish, *Austropotamobius pallipes*, population in the R. Witham (R. Chadd, pers. comm., 2008).
10	Is the organism widely distributed in the Risk Assessment area?	NO (Go to 11)	It only occurs in three areas in central England (see 1 above).
11	Does at least one species (for herbivores, predators and parasites) or suitable habitat vital for the survival, development and multiplication of the organism occur in the Risk Assessment area, in the open, in protected conditions or both?	YES (Go to 12)	*O. limosus* is euryoecious and is capable of occupying a wide range of still and running water habitats, including polluted waters, within the Risk Assessment area. As an omnivore it can switch its food supply if one item runs out.
12	Does the organism require another species for critical stages in its life cycle such as growth (e.g. root symbionts), reproduction (e.g. pollinators; egg incubators), spread (e.g. seed dispersers) and transmission, (e.g. vectors)?	NO (Go to 14)	
13	Is the other critical species identified in question 12 (or a similar species that may provide a similar function) present in the Risk Assessment area or likely to be introduced? If in doubt, then a separate assessment of the probability of introduction of this species may be needed.		
14	Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment area or sufficiently similar for the organism to survive and thrive?	YES (Go to 16)	*O. limosus* is widely spread in NE USA, SE Canada and continental Europe and exists under a wide range of conditions (Hamr, 2002; Souty-Grosset *et al*., 2006). The whole of the Risk Assessment area is within the ecoclimatic zone for *O. limosus*.
15	Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment area?	YES (Go to 16)	If it was introduced into aquaculture facilities or ponds in zoological gardens then it is highly likely that *O. limosus* would become established if predation pressures allowed it to do so. It survives well under aquarium conditions (personal observation).

16	Has the organism entered and established viable (reproducing) populations in new areas outside its original range, either as a direct or indirect result of man's activities?	YES (Go to 17)	The home range of *O. limosus* is the Atlantic watershed of SE Canada and NE USA (Hamr, 2002). It has been spread either naturally or by man to a number of states where it is not native. It has been reported as expanding its range downstream in the St Lawrence catchment (Hamr, 2002) and into New Brunswick (McAlpine *et al*., 1991). In Europe it has become the most widely-spread alien crayfish since its introduction in 1890 (Machino & Holdich, 2006). It has spread naturally through canals and river systems to occupy much of central continental Europe and still spreading eastwards via the R. Danube (Souty-Grosset *et al.*, 2006). In addition, it has been introduced to many waterbodies by man, both intentionally and accidentally (e.g. caught up in fishing nets). Intentional introductions were initially as a source of food, but the species never became popular, and later introductions were probably as food for fish. Many introductions in North America (Lodge *et al.*, 2000a, b) and Europe (PJ Laurent, pers. comm., 2008) are probably due to escaped bait and bait-bucket introductions.
17	Can the organism spread rapidly by natural means or by human assistance?	YES (Go to 18)	See 16.
18	Could the organism as such, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment area?	YES OR UNCERTAIN (Go to 19)	*O. limosus* can carry crayfish plague caused by the fungus-like organism *Aphanomyces astaci* (Oidtmann *et al*., 2006) and so is a threat to our native crayfish, *Austropotamobius pallipes*. It is a very prolific omnivore that burrows (Holdich & Black, 2006). It may therefore have an adverse impact on the freshwater environment like other North American crayfish species introduced into Europe (Holdich, 1999). It may impact on angling in the same way that the signal crayfish, *P. leniusculus*, has (Peay & Hiley, 2004). This has proved to be the case in the Attenborough population (personal observation).
19	This organism could present a risk to the Risk Assessment area and a detailed risk assessment is appropriate.	Detailed Risk Assessment Appropriate GO TO SECTION B	
20	This organism is not likely to be a harmful non-native organism in the Risk Assessment area and the assessment can stop.		

B	SECTION B: Detailed assessment of an organism's probability of entry, establishment and spread and the magnitude of the economic, environmental and social consequences			
	Probability of Entry	**RESPONSE**	**UNCERTAINTY**	**COMMENT**
1.1	List the pathways that the organism could be carried on. How many relevant pathways can the organism be carried on?	moderate number - 2	LOW - 0	There are three pathways by which *O. limosus* could have entered the UK. It is most likely that any introductions came from continental Europe where *O. limosus* is widespread, (Holdich, 2002) rather than North America, as the only known introduction into Europe was in 1890 (Hamr, 2002).1. Via the aquarium trade. 2. Via the food market. 3. Via members of the public, especially anglers. 4. Via the transport of other animals such as fish. The first published record of *O. limosus* in the Risk Assessment area was for one purchased from an aquarist centre in 1995 (Foster, 1995). There are no known records of *O. limosus* being sold as food or eaten in the UK. It is relatively unpopular as a food in continental Europe, although it is harvested in some countries (Souty-Grosset *et al*., 2006). *O. limosus* is commonly used as bait in countries such as France. Laurent (pers. comm., 2008) thinks that *O. limosus* have been dispersed from one waterbody to another in France mostly by line anglers who bait their hooks with small crayfish for catching pike and perch, especially perch. He believes that, in France, anglers are the first and principal people responsible for the propagation of *O. limosus* and that accidental introductions would appear to be the rule, rather than deliberate ones. It is possible that anglers visiting France encountering this habit may have brought some back to the UK. There is also a view in Europe that the presence of crayfish in a waterbody is usually indicative of good fishing (personal conversations). It is possible that *O. limosus* was transferred with other aquatic animals being imported into the UK. Once in the UK *O. limosus* could have been introduced to the wild and spread either accidentally or purposely by one of the following routes: 1. The sale of crayfish through aquarist centres and their subsequent release into the wild by the owners. 2. Escapes from holding facilities. 3. Anglers using crayfish as bait (a common practice in the past). Such a practice can lead to the escape of the crayfish. The practice is now banned. 4. Anglers/fish farm managers using them to increase production in fishing ponds/lakes. 5. With consignments of other aquatic animals. 6. Transfer between locations by man or predators, particularly birds, e.g. herons, coots. It is possible that somebody bought a berried female *O. limosus* from an aquarist centre and cultured it before releasing the offspring into the wild. It is unlikely that anybody would buy a quantity from an aquarist centre as crayfish are very expensive in such establishments, i.e. £5-10 each. A female *O. limosus* can produce as many as 300 juveniles. These could have been sold on or used as bait or for stocking in fish ponds. A single berried or inseminated female escaping from a holding facility could start a new population. If they were brought into the country with consignments of fish then it would have been easy for them to become established in the recipient water body (see below). Considering the distance between the three locations with *O. limosus* it is unlikely that a predator could have transferred them from one to another. However, an angler could easily have done so, either as bait or in the hope of enhancing production of fish. The is what happened with the Attenborough location, where a carp angler introduced *O. limosus* in the hope of increasing fish production in the lake – however, he died soon after and nobody knows where the crayfish came from or how many were introduced. However, within three years there were large numbers in the 16 ha lake.
1.2	Choose one pathway from the list of pathways selected in 1.1 to begin the pathway assessments.	3-4 under 1.1. above.		The actual origin of *O. limosus* in the UK is unknown. The source of the *O. limosus* in the three known populations is unknown.
1.3	How likely is the organism to be associated with the pathway at origin?	moderately likely - 2	MEDIUM -1	The three populations that have developed in England are in fish ponds/lakes. No details are available for the Alcester catfish pond but it seems likely that they would have been added for the fish to eat. How they got into the nearby R. Arrow is unknown. The site near Ancaster consists of a series of fishing lakes and it is possible that the crayfish were derived from deliberate (stocking) or accidental (bait) introductions. Some other established populations of non-native crayfish in the UK, e.g. signal crayfish in Boxmoor Fishery (Holdich & Domaniewsky, 1993), and other sites (J. Brickland, P. Bradley, S. Peay, pers. comms, 2008), have developed from anglers/fishery managers adding crayfish to improve the fishing, particularly for rainbow trout.
1.4	Is the concentration of the organism on the pathway at origin likely to be high?	unlikely - 1	MEDIUM -1	One berried, or even an inseminated, female *O. limosus* can carry/produce more than 300 eggs. When they hatch into juveniles they grow quickly and can reproduce within 18 months or less. So, in theory, a small number of individuals can start a thriving population. However, it is highly unlikely that in the three known cases the populations have arisen from single individuals, but more likely from a number of both sexes.
1.5	How likely is the organism to survive existing cultivation or commercial practices?	very likely - 4	LOW - 0	It is unlikely that *O. limosus* would ever be cultivated in the UK in the future. However, if it were, then due to its high growth rate and fecundity, and its ability to tolerate a wide variety of conditions, then it would be likely survive as long as predation pressures were not too high.
1.6	How likely is the organism to survive or remain undetected by existing measures?	moderately likely - 2	MEDIUM -1	Current legislation is likely to stop entry through the aquarist trade. However, somebody could risk bringing *O. limosus* in from continental Europe by car on a ferry. My personal opinion is that this is probably the pathway by which *O. limosus* reached the UK, e.g. an angler fishes a lake in France (see comments from Laurent under 1.1 above) and is told that the crayfish there are good for the fish, so he brings a few home to introduce into his favourite fishing lake. As pointed out by Holdich & Pöckl (2005) legislation against the spread of non-native crayfish in Europe has not been very effective. Anglers and members of public are often ignorant of the law and will move crayfish from one site to another (S. Peay, pers. comm., 2007). Records of *O. limosus* in central England have been reported by observant anglers and the Environment Agency as a result of routine surveys. Except for targeted surveys this is the only way that new populations will come to light. However, it is likely that such finds may be identified as some other crayfish and not reported. Even photographic evidence can lead to a misidentification as happened with the population at Attenborough (Holdich & Black, 2006).
1.7	How likely is the organism to survive during transport /storage?	very likely - 4	LOW - 0	From the wide range of habitats it can occupy (Souty-Grosset *et al*., 2006) it is clear that *O. limosus* is very tolerant of varied environmental conditions including those experienced in transport and storage.
1.8	How likely is the organism to multiply/increase in prevalence during transport /storage?	unlikely - 1	LOW - 0	Although an increase in numbers is unlikely, mating could probably occur during transport – I have seen this happen in the native crayfish during the breeding season. I have observed *O. limosus* mating in a few mm of water.
1.9	What is the volume of movement along the pathway?	minor - 1	HIGH -2	This is unknown but, as pointed out above, it may only need a single berried female (or an inseminated one) to start a population. The important thing to note here is that crayfish do not have larvae like crabs, but the eggs develop directly into independent juveniles (Holdich, 1992).
1.10	How frequent is movement along the pathway?	rarely - 1	MEDIUM -1	Considering the small number of populations that may have arisen via this pathway, i.e. three are known then it is likely to be a rare event.
1.11	How widely could the organism be distributed throughout the Risk Assessment area?	very widely - 4	LOW - 0	At the current time they are already widely-spread, i.e. Warwickshire, Nottinghamshire and Lincolnshire and these populations could act as focal points for further introductions. All the populations known have been reported since 1999, however, some could have been there much longer, e.g. that in East Anglia. This population was unknown until 2006 but is thought to have been introduced long before that, (R. Page, pers. comm., 2002), so there is a strong possibility that others remain undiscovered or unreported.
1.12	How likely is the organism to arrive during the months of the year most appropriate for establishment ?	very likely - 4	LOW - 0	The reproductive period of *O. limosus* is very variable in Europe occurring in most months in some locations in western France and Switzerland (Stucki, 2002; Neveu, 2006), in autumn in eastern France (Baldry, 2007c), and in spring in central England (Holdich & Black, 2006). However, it is likely that *O. limosus* could become established at any time of the year in the Risk Assessment area, and then start to breed when conditions are right.
1.13	How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) or other material with which the organism is associated to aid transfer to a suitable habitat?	moderately likely - 2	MEDIUM -1	If an angler used the crayfish as bait (which is against current laws) then he may transport these from one site to another. Crayfish may also be transferred in weed, with stocked fish, water itself, and as a supplemental feed.
1.14	How likely is the organism to be able to transfer from the pathway to a suitable habitat?	very likely - 4	LOW - 0	For the pathway suggested - an angler or fishery manager using the crayfish as a food supplement, then the crayfish would have to be introduced manually. If the crayfish were used as bait (before the current legislation) then they could often presumably escape. Unwanted bait may also have been tipped into a waterbody at the end of the day – a bait bucket introduction is thought to be responsible for many crayfish introductions in North America (Lodge *et al*., 2000a, b).

	Probability of Establishment	RESPONSE	UNCERTAINTY	COMMENT
1.15	How similar are the climatic conditions that would affect establishment in the Risk Assessment area and in the area of current distribution?	very similar - 4	LOW - 0	*O. limosus* naturally occurs in NE USA and SE Canada where climatic conditions are very similar (although perhaps more extreme) to those in the UK. It is known to be active under ice in France during the winter (Baldry, 2007b). It could colonise any suitable area of the UK without difficulty, but most likely lowland rivers, ponds and lakes.
1.16	How similar are other abiotic factors that would affect establishment in the Risk Assessment area and in the area of present distribution?	very similar - 4	LOW - 0	*O. limosus* occurs in rivers, streams, lakes, ponds and water-filled gravel pits in continental Europe and in the UK. It is not known to inhabit estuaries. It mainly occurs in rivers and lakes in NE USA and SE Canada. Abiotic conditions are likely to very similar.
1.17	How many species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism species are present in the Risk Assessment area? Specify the species or habitats and indicate the number.	very many - 4	LOW - 0	Any freshwater habitat in the UK could in theory be invaded by *O. limosus*. However, it is more likely to be lowland rivers and lakes. Its survival would depend on predation pressure and the availability of food, not so much on the quality of the water. However, as *O. limosus* is an omnivore (Baldry, 2007a) food is not likely to be really a problem as the crayfish can switch diets
1.18	How widespread are the species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism in the Risk Assessment area?	widespread - 4	LOW - 0	Any freshwater habitat in the UK could in theory be invaded by *O. limosus.* However, it is more likely to be lowland rivers and lakes. Its survival would depend on predation pressure and the availability of food, not so much on the quality of the water.
1.19	If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the risk assessment area?	N/A	LOW - 0	
1.20	How likely is it that establishment will not be prevented by competition from existing species in the Risk Assessment area?	very likely - 4	LOW - 0	Any freshwater habitat in the UK could in theory be invaded by *O. limosus*. However, it is more likely to be lowland rivers and lakes. Its survival would depend on predation pressure and the availability of food, not so much on the quality of the water.
1.21	How likely is it that establishment will not be prevented by natural enemies already present in the Risk Assessment area?	very likely - 4	LOW - 0	*O. limosus* is eaten by a wide range of fish and bird species. However, observations on French and British populations have not indicated that these pressure decrease numbers (Baldry, 2007a-c; Holdich & Black, 2007). Due to the spinous nature of the crayfish and its habitat of rolling up when attacked it may be difficult for fish to swallow. However, birds, particularly coots, have no difficulty in taking them out of the water and attacking them on land (Holdich & Black, 2007).
1.22	If there are differences in man's management of the environment/habitat in the Risk Assessment area from that in the area of present distribution, are they likely to aid establishment? (specify)	unlikely - 1	LOW - 0	The opposite is more likely to be true. Legislation is more stringent for non-native crayfish in the UK than in continental Europe and North America, but is difficult to enforce (Sibley, 2003; Holdich *et al*., 2004, Holdich & Pöckl, 2005). *O. limosus* is currently being considered for inclusion on Schedule 9 of the Wildlife & Countryside Act.
1.23	How likely is it that existing control or husbandry measures will fail to prevent establishment of the organism?	likely - 3	LOW - 0	All the methods (prior to the work of Peay *et al.* (2006)) on eradication and control of nuisance crayfish populations were reviewed in Holdich *et al.* (1999). This was a very extensive review and the conclusion was that there were no effective methods for eradicating or even controlling crayfish known at the time. Existing control methods in the UK usually involve some form of trapping but this method has never been proven to be 100% effective as juveniles are rarely caught in traps. Hundreds of thousands of pounds have been spent on the eradication of signal crayfish in the R. Clyde catchment – all to no avail (Collins 2006)! Also, spiny-cheek crayfish are often quite difficult to catch with traps as mentioned by McAlpine *et al*. (1991) and Holdich & Black (2006), although Baldry (2007a-c) has had much more success with trapping a French population. Even draining down a waterbody containing a nuisance population and letting it dry out may not work as North American crayfish are known to be able to survive for long periods in damp conditions, as supplied by rain, especially if they are able to burrow (Holdich *et al.* 1995). Sibley (2003) did have excellent success in trapping signal crayfish out of an irrigation lake, but this only applied to the adults, and no follow up study was ever undertaken. The author (Sibley 2000) was involved in the removal by netting and by hand of thousands of signal crayfish from a brook, but again the impact that this had was never followed up to my knowledge. Intensive trapping, netting and manual searching for crayfish is very labour intensive and costly of time and money. An unpublished study I carried out on the trapping of signal crayfish showed that they come in and out of the traps if the traps are left down over a 24 h period. Even using special baits in traps is unlikely to entice the juveniles into them. Hein *et al.* (2007) had considerable success in trapping a related species, *O. rusticus*, in a North American lake, but even after 5 summers of intensive trapping they failed to eliminate the crayfish, although its abundance was reduced. Sibley & Nöel (2002) chaired a roundtable discussion at a CRAYNET meeting at which management and control of non-native crayfish were discussed by delegates from most European countries. Methods highlighted were biological control (predators, disease), chemicals (pesticides, derivatives of natural compounds), chemical barriers (pollution), crayfish fishing, draining down, electric fishing, electrical barriers, legislation, manual (hand searching, netting), mechanical (traps), pheromones, physical barriers (waterfalls, weirs etc.), sex ratio manipulation, and sterilisation. However, no one method was highlighted as being particularly effective and it was recommended that management strategies should be formulated on a site by site basis. It was mentioned that a suite of methods had been examined in the UK, but none had resulted in the successful elimination of target crayfish populations (Environment Agency 1998).Peay *et al.* (2006) has shown that eradication of signal crayfish may be possible using a biocide under controlled conditions. I imagine that the method would also work with spiny-cheek crayfish. However, due to the expense involved and the fact that it could not be applied to flowing water as there would be too little control, it is likely that the method will have limited appeal.
1.24	How often has the organism been recorded in protected conditions, e.g. glasshouses, elsewhere?	very rare - 0	LOW - 0	The first record by Foster (1995) was from a pet shop. A subsequent record (found on a lawn!) in the south of England was probably an escapee from an aquarium.
1.25	How likely is the reproductive strategy of the organism and duration of its life cycle to aid establishment?	very likely - 4	LOW - 0	The reproductive strategy of O. limosus in the UK appears to be different from that in continental Europe populations (see 1.12 above) and also different from the astacid species in the UK, i.e. Astacus astacus, A. leptodactylus, Austropotamobius pallipes and Pacifastacus leniusculus. Mating and production of juveniles takes place in spring and early summer and is over in a much shorter space of time as is typical of cambarid crayfish species (Lindqvist & Huner, 1999). This, coupled with a higher fecundity, confers an advantage on the survival of O. limosus and on its establishment.
1.26	How likely is it that the organism's capacity to spread will aid establishment?	very likely - 4	LOW - 0	The speed with which *O. limosus* can colonise a lake is well shown for Lake Geneva (Dubois *et al*., 1999). Although this crayfish was known to be present in the lake in 1976, the real invasion did not start until 1986 when a fishmonger released an unknown quantity of crayfish into the lake in the south-east corner at the harbour of Meillerie (France). They subsequently spread eastwards and westwards aided by strong currents. Internal deep currents carried them to the deepest parts of the lake (306 m) and they are now encountered everywhere in the lake. Large quantities are caught by fishermen in their nets and traps, but the yield is unprofitable because people do not want to buy them (Dubois *et al*., 1999). In Hungary, its colonisation speed has been calculated to be more than 13 km yr-1 in the River Danube (Puky and Schád 2006). Out of 300 lakes recently examined in N. E. Germany, 214 were found to have *O. limosus*, and in Poland, populations of *O. limosus* increased from 57 in 1959 to at least 1383 by 2004 (Souty-Grosset *et al.*, 2006). Not only can *O. limosus* move through waterbodies but it can move across land, even in frosty conditions (D. Baldry, pers. comm., 2007).
1.27	How adaptable is the organism?	very adaptable - 4	LOW - 0	*O. limosus* lives in a wide range of habitats and waters of different quality, from clean to polluted. Pöckl (1999) mentions that in Austria *O. limosus* has reached a high density in a waterbody that is oily and muddy, with other aquatic fauna excluded, indicating low water quality. It also appears able to tolerate drying conditions for many weeks (Laurent 1988). It can move across land, even in frosty conditions (D. Baldry, pers. comm., 2007).
1.28	How likely is it that low genetic diversity in the founder population of the organism will not prevent establishment?	very likely - 4	LOW - 0	There has only been one successful introduction of *O. limosus* into Europe from the USA and that was of 100 individuals in 1890 (Machino & Holdich, 2006). Recent sequencing studies have confirmed this assumption (L. Filipová, pers. comm., 2008).However, it has since been spread naturally and by man into at least 20 countries, including England.
1.29	How often has the organism entered and established in new areas outside its original range as a result of man's activities?	very many - 4	LOW - 0	There must be thousands of populations throughout Europe and *O. limosus* is still spreading eastwards via the R. Danube (Souty-Grosset *et al*., 2006).

1.30	How likely is it that the organism could survive eradication campaigns in the Risk Assessment area?	very likely - 4	LOW - 0	It depends on the method used. If it was by trapping or manual removal after a draindown, then there is good chance that some individuals would survive or escape. If biocides were used then this would be much more successful. See comments under 1.23. As has been found by Peay *et al*. (2006) for signal crayfish, a sufficient dose of a biocide will probably kill all the crayfish, but the waterbody needs to be monitored for a number of years afterwards to see if this is the case. It is a drastic method as all fish have to be removed and other invertebrates will also be affected. As pointed out above it is unlikely to work in flowing water, even if the authorities allowed it. There are currently only three known populations of *O. limosus*, which have not spread very far, so eradication by one or other of the methods might be worth considering.
1.31	Even if permanent establishment of the organism is unlikely, how likely is it that transient populations will be maintained in the Risk Assessment area through natural migration or entry through man's activities (including intentional release into the outdoor environment)?	very likely - 4	LOW - 0	Permanent populations have become established and some are likely to spread in the future. Transient populations are likely to occur naturally during pulses of migration in rivers as occurs with signal crayfish, and these may result in permanent populations. Intentional release or transfer by a predator, even of a single inseminated or berried female, could result in a population becoming established within a couple of years.

	Spread	RESPONSE	UNCERTAINTY	COMMENT
2.1	How rapidly is the organism liable to spread in the Risk Assessment area by natural means?	intermediate - 2	LOW - 0	Once it gets into a system of connected waterbodies then it is likely to spread rapidly. Even in a closed system it colonises the whole area quickly. In the Nottingham population it has only taken 4-5 years for it to colonise a 16 ha lake. Canals and water transfer schemes, as well as floods, could aid the spread of *O. limosus*.
2.2	How rapidly is the organism liable to spread in the Risk Assessment area by human assistance?	intermediate - 2	LOW - 0	It is most likely to be spread by anglers from the West Midlands, East Midlands and Lincolnshire populations.
2.3	How difficult would it be to contain the organism within the Risk Assessment area?	very difficult - 4	LOW - 0	Only three populations are known to exist at present but they are widely separated geographically and could act as focal points for spread. The Alcester population has already entered the R. Arrow.
2.4	Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism.	Almost all the Risk Assessment area	LOW - 0	Where there are lowland rivers, and ponds and lakes in England, Scotland and Wales.

	Impacts	RESPONSE	UNCERTAINTY	COMMENT
2.5	How important is economic loss caused by the organism within its existing geographic range?	moderate - 2	LOW - 0	Any economic loss that has occurred (is occurring) is to the crayfish industry in continental Europe where its spread has had a moderate economic impact since its introduction in 1890 (Laurent, 1988). It was introduced to increase stocks of crayfish in Europe that had been decimated by crayfish plague. In terms of economic loss, it is not really possible to separate the effects caused by crayfish plague and *O. limosus* . Also, since the 1960s other North American crayfish have been introduced into Europe that also carry crayfish plague. *O. limosus* has never fulfilled its promise. One of the reasons it has not proved popular as a food item is because the public perceive it as living in eutrophic or polluted waters (Souty-Grosset *et al* ., 2006). It also has a lower meat yield than other introduced species. It has been implicated in the demise of some noble crayfish, *Astacus astacus* , populations in many countries, where noble crayfish were extensively harvested. *O. limosus* is gradually spreading eastwards in Europe and is now widespread in western parts of the Czech Republic (Petrusek *et al* ., 2006). Whilst the main catch in Hungary was *A. astacus* in the 1990s, it is now dominated by *O. limosus* (Souty-Grosset et *al.* , 2006). Recently it has been found in Croatia (Maguire & Gottstein-Matočec, 2004) and Serbia (Karaman & Machino, 2004). It will probably spread into Bulgaria, Romania and the Ukraine via the R. Danube before long (Machino & Holdich, 2006). It has also proved virtually impossible to restock native crayfish where *O. limosus* is present (Souty-Grosset *et al* ., 2006). So, it has obviously had an economic impact on crayfisheries in continental Europe. However, this would be extremely difficult to quantify as the data is just not available. *O. limosus* is said to have eliminated some *O. virilis* populations in North America, although this species is of no economic importance (Hamr, 2002).
2.6	Considering the ecological conditions in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, livestock health and production, likely to be? (describe) in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, likely to be?	minor - 1	MEDIUM -1	At the present time there is no economic loss in the UK. It is likely that at the present time *O. limosus* occupies less than 50 ha of lentic and lotic waters in the UK. As there is no recent tradition for eating crayfish in the UK, and there is only a small industry based on wild and cultivated crayfish (*Pacifastacus leniusculus* and *Astacus leptodactylus* - both non-native species), then *O. limosus* is unlikely to have much of an effect on this. It could in theory compete for resources with the signal crayfish, *P. leniusculus* and *A. leptodactylus* and become the dominant crayfish, if mixed populations develop (none are known at present), but unlike them it is not likely to be saleable in fish markets. In addition, as a vector of crayfish plague (Vey *et al* ., 1983; Kozubíková *et al* ., 2006, 2007) it could eliminate *A. leptodactylus* in mixed populations, as the latter is susceptible to the disease. The same effect could happen if it enters water courses where the native *Austropotamobius pallipes* occurs, but this only has conservation value, as it is not harvested. *O. limosus* can reach high numbers so it is likely to impact on the freshwater environment, especially as it appears to burrow. In large numbers it will consume large quantities of many types of food. This could have an impact on the food chain as has happened during invasions by related North American crayfish such as *Orconectes rusticus* into new areas of North America (Olsen *et al* ., 1991; Olden *et al* ., 2006) and *Procambarus clarkii* in continental Europe (Geiger *et al.* , 2005; Rodriguez *et al* ., 2005). They may also act as geomorphic agents and ecosystem engineers (Statzner *et al* ., 2000), especially as it has recently been discovered that they can burrow (Holdich & Black, 2007). In a lake in Germany it was found that *O. limosus* made up 49% of the macroinvertebrate biomass, and was equal to 35% and 81% of the non-predatory and predatory fish biomass respectively (Haertel-Borer *et al* ., 2005). However, at the same time *O. limosus* also heavily subsidised the pelagic and benthic food webs.
2.7	How great a loss in producer profits is the organism likely to cause due to changes in production costs, yields, etc., in the Risk Assessment area?	minor - 1	MEDIUM -1	It is likely to have only a minor impact (if any) on producer profits of other species of crayfish (see above). It may influence the trophic structure of some waterbodies, but this might not be entirely negative as it may subsidise the food web for peleagic and benthic animals, as well as some land and aerial predators. If large populations build up then they may impact on angling activities and may reduce recruitment of some species of fish by eating their eggs and reducing cover.
2.8	How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area?	minimal - 0	MEDIUM -1	There is no real demand for crayfish for eating in the UK. If a negative impact were to occur then this could easily be supplemented by imports. Nuisance from crayfish taking bait in coarse fisheries may reduce the value of some recreational fisheries, as has happened with signal crayfish (Peay & Hiley, 2004). Anglers may move away from fishing waters if they are 'contaminated' with crayfish and so reduce their value to the owner (Peay & Hiley, 2004).
2.9	How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets?	moderately likely - 2	MEDIUM -1	Much of the *P. leniusculus* and *A. leptodactylus* that are farmed or derived from wild stocks in the UK are exported to continental Europe. If *O. limosus* were to become the dominant crayfish in UK waters as it has in continental Europe, then it would affect this export market, which is, however, relatively small.
2.10	How important would other economic costs resulting from introduction be? (specify)	moderate - 2	MEDIUM -1	It is possible that due to its burrowing activities *O. limosus* could damage banks and consequently flood defences. However, it has only been recorded as burrowing at the Nottingham site. It needs to be assessed as to whether or not it burrows at the other known sites in the UK. If the numbers are sufficiently high then the crayfish could impact on angling activities and have an impact on the income derived from angling at such sites as has happened with signal crayfish (see comments by S. Peay on signal crayfish assessment).
2.11	How important is environmental harm caused by the organism within its existing geographic range?	minimal - 0	MEDIUM -1	*O. limosus* has not been recorded as causing much environmental harm in North America, unlike some of its cogeners (Olsen *et al* ., 1991; Lodge *et al.* , 2000a, b; Olden, 2006). However, it is one of the most widely-spread non-native crayfish in Europe, and certainly the one with the most populations. It has been implicated in leading to the demise of native crayfish populations. Other than causing problems to anglers due to its high numbers it has not been reported as causing damage as such. Baldry (2007a) stated that despite being in Cessy pond in eastern France for many years, he could detect no damage during the period 2001-06.
2.12	How important is environmental harm likely to be in the Risk Assessment area?	moderate - 2	MEDIUM -1	If *O. limosus* spreads either naturally or by human assistance it is likely to become established in any suitable waterbody. Under suitable conditions it will quickly build up its numbers and have an initial impact on the freshwater environment and its biota, including cover, slow-moving macroinvertebrates, fish spawning sites and benthic fish such as bullheads. Its burrowing and general activities may change the stability of the substrate (Stazner *et al* ., 2000). If it enters waters with the native crayfish or the introduced narrow-clawed crayfish it is likely to outcompete them and may kill them through the transmission of crayfish plague (if they are carrying it). The extent to which *O. limosus* burrows is unknown as this has only been recorded in the Nottingham population. If this activity turns out to be extensive as in the signal crayfish then damage to banks could be considerable. (See comments by S. Peay on signal crayfish assessment).
2.13	How important is social and other harm caused by the organism within its existing geographic range?	moderate - 2	LOW - 0	*O. limosus* does not appear to have caused much social or other harm in North America. However, it has affected those whose livelihoods depend on harvesting native crayfish in continental Europe (Souty-Grossett *et al* ., 2006), but this has never been quantified even though *O. limosus* has been in continental Europe since 1890. At the present time the impact mainly seems to be in the R. Danube in Eastern Europe, where it is displacing the noble crayfish, but a recent report from Switzerland (Vielle, 2007) indicates that it is has impacted on native populations in one area during the last 10 years. Its presence in much of Europe makes it very difficult to restock with native crayfish, particularly in France, Germany, Poland and Hungary (Souty-Grossett *et al* ., 2006).
2.14	How important is the social harm likely to be in the Risk Assessment area?	moderate - 2	MEDIUM -1	If it spreads then the main impact will be on the native crayfish and on anglers. In the first case this will be due to competition and the spread of crayfish plague. In the second case this will be due to the large numbers of crayfish interfering with angling, e.g. eating bait and getting entangled in nets (due to their spinous nature they are quite difficult to handle and remove from nets). In the case of the Attenborough population the crayfish were added to the pond in the belief that this would improve the fishing for carp. In fact within 3 years other anglers were complaining that the crayfish were interfering with their fishing! It may also impact on flood defences due to its burrowing activities. (See comments by S. Peay on signal crayfish assessment).
2.15	How likely is it that genetic traits can be carried to native species, modifying their genetic nature and making their economic, environmental or social effects more serious?	very unlikely - 0	LOW - 0	The native crayfish is in the family Astacidae whilst the spiny-cheek crayfish is in the family Cambaridae. There are no reports of cambarid crayfish cross mating with astacid crayfish, although they do with other cambarid crayfish (Lodge *et al* ., 2000a).
2.16	How probable is it that natural enemies, already present in the Risk Assessment area, will have no affect on populations of the organism if introduced?	very likely - 4	LOW - 0	Natural enemies such as fish and birds will have some impact but probably not enough to eliminate an expanding population.
2.17	How easily can the organism be controlled?	very difficult - 4	LOW - 0	At the present time there is no easy way to control *O. limosus* , or any other invasive crayfish (Holdich *et al* ., 1999). Intensive trapping is unlikely to have an impact as adults tend to be trap shy, and juveniles do not enter traps anyway (Holdich & Black, 2007). Dewatering would be better, but because *O. limosus* burrows many individuals would not be caught. The use of biocides as being developed by Peay *et al* . (2006) would seem to be a possible answer, although may be impractical due to the nature of the sites. See comments under sections 1.23 and 1.30.

2.18	How likely are control measures to disrupt existing biological or integrated systems for control of other organisms?	unlikely - 1	MEDIUM -1	If a draindown or use of biocides were implemented then this is likely to be of a benefit to the control of other damaging organisms.
2.19	How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms?	very likely - 4	LOW - 0	An expanding population of *O. limosus* will be of benefit to non-native predators such as birds and fish, and some mammals (e.g. mink), and even some macroinvertebrates. *O. limosus* has been reported as being a vector of the fungus-like organism carrying crayfish plague in Europe, to which the native crayfish is highly susceptible. All the current populations in the UK should be tested for this disease as it is currently unknown if they are harbouring it.
2.20	Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur	Throughout	LOW - 0	In areas where native crayfish occur, i.e. mainly central and northern parts of England and Wales (Holdich *et al*., 2004). (Ireland currently has no non-native crayfish but native crayfish populations could be affected if *O. limosus* were introduced). Also, any body of water used for angling in the UK could be affected, as has happened with signal crayfish, but most likely in lowland areas.

Summarise Entry	moderately likely - 2	LOW - 0	The North American spiny-cheek crayfish, *Orconectes limosus* , has been found at three sites in central England. It is not known how *O. limosus* entered the UK or where the crayfish for the introductions came from. In the 1990s *O. limosus* was found for sale in a pet shop and then on a lawn away from water. Since 1999 three widely separated populations have been found, all associated with fishing lakes. In one of the cases the crayfish were added to the pond in the belief that this would improve the fishing for carp. In fact within 3 years other anglers were complaining that the crayfish were interfering with their fishing! In one case it is known for certain that an angler carried out the exercise, but he died soon after and it is not known where the crayfish came from. The crayfish may also have been used as bait. This is practiced extensively by line anglers in France (see 1.1 above) and may have occurred in the UK before the current ban. *O. limosus* is the commonest crayfish in continental Europe and it is possible that they have been introduced into the UK by anglers returning from fishing trips. If it spreads in the UK it could quickly become a keystone species and have an adverse impact on freshwater ecosystems by: a) competing with and transmitting crayfish plague to the native crayfish; b) reducing the quality of freshwaters due to its burrowing activities, omnivorous habit, rapid breeding and growth, and large numbers; c) interfering with fish spawning sites and cover as well as impacting on benthic fish due to predation; d) consuming large numbers of macroinvertebrates and plant material; e) interfering with angling.
Summarise Establishment	likely - 3	LOW - 0	*O. limosus* is a very adaptable crayfish and occurs in a wide range of environmental conditions. Other than estuaries and fast flowing rivers there are few waterbodies that it could not become established in, although it prefers conditions in lowland rivers and pond/lakes. It can survive in waters with large fish populations.
Summarise Spread	intermediate - 2	LOW - 0	All the known populations are connected to or are adjacent to flowing water (at least at certain times of the year). In the Nottingham population the crayfish have not yet been recorded as having entered the R. Trent or adjacent water-filled gravel pits. This is the only population for which a proper study has been carried (Holdich & Black, 2006), although this was done without any funding, other than staff and equipment support from the Nottinghamshire Trust for Nature Conservation. In the Warwickshire (nr Alcester) population they were reported as being in the adjacent R. Arrow in 2002 some 3 miles downstream of the introduction site (P. Sibley, pers. comm., 2002). This is being followed up the Environment Agency in 2008, but this should have been done much earlier. In the Lincolnshire (nr. Ancaster) population *O. limosus* has only been recorded from the fishing ponds, but could easily enter nearby water courses in times of flood. The Environment Agency visited the site in 2006 and confirmed the presence of *O. limosus* , and a detailed survey was undertaken by contractors in 2007, but the report has not yet been submitted (R. Page, pers. comm., 2008). There is concern (R. Chadd, pers. comm., 2008) that the crayfish may get into a tributary of Honington Beck that flows into the middle of a large population of the protected native crayfish, *A. pallipes* , in the R. Witham. *O. limosus* has the potential to spread quickly by natural means. In addition it could be spread by anglers and members of the public.
Summarise Impacts	moderate - 2	LOW - 0	At the present time the only impact *O. limosus* is likely to be having is on angling. However, this is because its spread is not very advanced. As it can act as a vector of crayfish plague it is a potential threat to the survival of the native crayfish. Anglers fishing at the three sites could transmit crayfish plague spores to other waters - if the crayfish are carrying the disease (this is not known). It has been found to burrow extensively at the Nottingham site. If it does this elsewhere it could affect the stability of banks as has happened with the signal crayfish. If its numbers become high in a waterbody it could affect the trophic structure, at least initially. Interestingly, *O. limosus* has not been found to burrow extensively in continental Europe or North America (Holdich & Black, 2006).
Conclusion of the risk assessment	MEDIUM -1	MEDIUM -1	Due to current legislation it is less likely that *O. limosus* could enter via the aquarium trade these days. However, it would be very difficult to stop anglers and others bringing in non-native crayfish to the UK if they are travelling by car from continental Europe where *O. limosus i*s very common (except by educating them in the dangers). *O. limosus* is very tolerant of changing environmental conditions and is easy to transport. All species of non-native crayfish introduced into the UK have become established (Holdich, 1999), although two, *Astacus astacus* and *Procambarus clarkii* , have a very limited distribution (Holdich *et al* ., 2004). *O. limosus* is likely to become established in any waterbody it is introduced to and is likely to build up its numbers quickly. It may cause damage to banks by burrowing. However, numbers are likely to stabilise after a few years. On the positive side birds, fish and some mammals will benefit from the additional food source. Native crayfish may be eliminated if spiny-cheek crayfish enter their environment, either through the transmission of crayfish plague or by direct competition for resources. Anglers are likely to be affected by high numbers of crayfish interfering with their sport (Peay & Hiley, 2004).
Conclusions on Uncertainty		LOW - 0	Due to current legislation it is less likely that *O. limosus* could enter via the aquarium trade these days. However, it would be very difficult to stop anglers and others bringing in non-native crayfish to the UK if they are travelling by car from continental Europe where *O. limosus* is very common (except by educating them in the dangers). *O. limosus* is very tolerant of changing environmental conditions and is easy to transport. All species of non-native crayfish introduced into the UK have become established (Holdich, 1999), although two, *Astacus astacus* and *Procambarus clarkii* , have a very limited distribution (Holdich *et al* ., 2004). *O. limosus* is likely to become established in any waterbody it is introduced to and is likely to build up its numbers quickly. It may cause damage to banks by burrowing. However, numbers are likely to stabilise after a few years. On the positive side birds, fish and some mammals will benefit from the additional food source. Native crayfish may be eliminated if spiny-cheek crayfish enter their environment, either through the transmission of crayfish plague or by direct competition for resources. Anglers are likely to be affected by high numbers of crayfish interfering with their sport (Peay & Hiley, 2004).

References

Alekhnovich AV, Ablov SE, Kulesh VF and Pareiko OA (1999) The American spiny-cheek crayfish, Orconectes limosus in the fauna of Belarus. In: Gherardi F & Holdich DM (eds) Crayfish in Europe as alien species. How to make the best of a bad situation? AA Balkema, Rotterdam, Brookfield, pp 237-242

Ahern D, England D & Ellis A (2008) The virile crayfish Orconectes virilis (Hagen, 1870) [Crustacea: Decapoda: Cambaridae], identified in the UK. Aquatic Invasions (in press).

Baldry D (2007a) Étude de l'écrevisse américaine Orconectes limosus (Rafinesque, 1817) dans l'étang de Cessy, Pays de Gex, 01170 (France). I. Objectifs, l'étang, les techniques utilisées et quelques observations initiales. L'Astaculteur de France 91: 2-12.

Baldry D (2007b) Étude de l'écrevisse américaine Orconectes limosus (Rafinesque, 1817) dans l'étang de Cessy, Pays de Gex, 01170 (France). II. Observations d'Orconectes limosus à de faibles températures environnmentales. L'Astaculteur de France 92: 2-14.

Baldry D (2007c) Étude de l'écrevisse américaine Orconectes limosus (Rafinesque, 1817) dans l'étang de Cessy, Pays de Gex, 01170 (France). III. Le cycle reproductive d'Orconectes limosus. L'Astaculteur de France 93: 2-13.

Beran L. & Petrusek A. (2006) First record of the invasive spine-cheek crayfish Orconectes limosus (Rafinesque, 1817) (Crustacea: Cambaridae) in the Bohemian Forest (South Bohemia, Czech Republic). Silva Gabreta 12(3): 143-146

Brink FWB Van Den, Velde G Van Der & Geelen JFM (1988) Life history parameters and temperature-related activity of an American crayfish, Orconectes limosus (Rafinesque, 1917) (Crustacea, Decapoda), in the area of the major rivers in The Netherlands. Archives of Hydrobiology 114(2): 275-289

Burba A (1997) Distribution of crayfish of the genera Astacus and Pacifastacus (Astacidae) in Lithuanian waters and spreading of the species Orconectes limosus (Cambaridae). Freshwater Crayfish 11: 99-105

Dubois J-P, Gillet C & Laurent PJ (1999) Alien crayfish in Lake Geneva. Freshwater Crayfish 12: 801-810

Environment Agency (1998) Eradication of alien crayfish populations. R&D project. Environment Agency/English Nature.

Foster J (1995) First record of O. limosus in England. Crayfish NEWS – International Association of Astacology Newsletter 16(4): 6

Geiger W, Alcorlo P, Baltanás A & Montes C (2005) Impact of an introduced crustacean on the trophic webs of Mediteranean wetlands. Biological Invasions 7: 49-73

Haertel-Borer SS, Dominik Z, Eckmann R, Baade U & Hölker F (2005) Population density of the crayfish, Orconectes limosus, in relation to fish and macroinvertebrate densities in a small mesotrophic lake – implications for the lake's food web. International Reviews in Hydrobiology 90(5-6): 523-533

Hamr P (2002) Orconectes. In: Holdich DM (ed) Biology of freshwater crayfish. Blackwell Science, Oxford, pp 585-608

Hein CL, Vander Zanden MJ & Magnuson JJ (2007) Intensive trapping causes massive population decline of an invasive crayfish. Freshwater Biology (ms only seen).

Holdich DM (1992) Crayfish nomenclature and terminology: recommendations for uniformity. Finnish Fisheries Research 14: 157-159

Holdich DM (1999) The negative effects of established crayfish introductions. In: Gherardi F & Holdich DM (eds) Crayfish in Europe as alien species. How to make the best of a bad situation? AA Balkema, Rotterdam, Brookfield, pp 31-47

Holdich DM (2002) Distribution of crayfish in Europe and some adjoining countries. Bulletin Français de la Pêche et de la Pisciculture 367(4): 611-650

Holdich DM & Black J (2007) The spiny-cheek crayfish, Orconectes limosus (Rafinesque, 1817) [Crustacea: Decapoda: Cambaridae], digs into the UK. Aquatic Invasions 2(1): 1-16.

Holdich DM & Domaniewsky JCJ (1995) Studies on a mixed population of the crayfish Austropotamobius pallipes and Pacifastacus leniusculus in England. Freshwater Crayfish 10: 37-45

Holdich DM, Gydemo R & Rogers WD (1999) A review of possible methods for controlling alien crayfish populations. In: Gherardi F & Holdich DM (eds) Crayfish in Europe as alien species. How to make the best of a bad situation? AA Balkema, Rotterdam, Brookfield, pp 245-270

Holdich DM & Pöckl M (2005) Does legislation work in protecting vulnerable species? Proceeding of CRAYNET Innsbruck conference 2004. Bulletin Français de la Pêche et de la Pisciculture 376-377: 809-827

Holdich DM, Rogers WD & Reader JP (1995) Crayfish conservation. Project Record 378/10/N&Y. National Rivers Authority, Bristol, 278 pp.

Holdich D, Sibley P & Peay S (2004) The white-clawed crayfish – a decade on. British Wildlife 15(3): 153-164

Karaman I & Machino Y (2004) Occurrence of the spiny-cheek crayfish (Orconectes limosus) and the Chinese mitten crab (Eriocheir sinensis) in Serbia. Crayfish NEWS – International Association of Astacology Newsletter 26(2): 11, 19-20

Kozubíková E, Petrusek A, Ďuriš Z, Kozák P, Geiger S, Hoffmann R & Oidtmann B (2006) The crayfish plague in the Czech Republic – review of recent suspect cases and a pilot detection study. Bulletin Français de la Pêche et de la Pisciculture 380-381: 1313-1323

Kozubíková E, Petrusek A, Ďuriš Z & Oidtmann B (2007) Aphanomyces astaci, the crayfish plague pathogen, may be a common cause of crayfish mass mortalities in the Czech Republic. Bulletin of the European Association of Fish Pathologists 27(2): 79-82.

Laurent PJ (1988) Austropotamobius pallipes and A. torrentium, with observations on their interactions with other species in Europe. In: Holdich DM & Lowery RS (eds) Biology of freshwater crayfish: biology, management and exploitation. Croom Helm, London and Sydney, pp 341-364

Lindqvist OV & Huner JV (1999) Life history characteristics of crayfish: What makes some of them good colonizers? In: Gherardi F & Holdich DM (eds) Crayfish in Europe as alien species. How to make the best of a bad situation? AA Balkema, Rotterdam, Brookfield, pp 23-30.

Lodge DM, Taylor CA, Holdich DM & Skurdal J (2000a) Nonindigenous crayfishes threaten North American freshwater biodiversity. Fisheries 25 (8): 7-20

Lodge DM, Taylor CA, Holdich DM & Skurdal J (2000b) Reducing impacts of exotic crayfish introductions. Fisheries 25 (8): 21-23

Machino Y & Holdich DM (2006) Distribution of crayfish in Europe and adjacent countries: updates and comments. Freshwater Crayfish 15: 292-323

Maguire I & Gottstein-Matočec S (2004) The distribution pattern of freshwater crayfish in Croatia. Crustaceana 77(1): 25-47

McAlpine DF, Fletcher TJ, Osepchook MA & Savoie J-C (1991) Orconectes limosus (Crustacea: Cambaridae), an addition to the crayfish fauna of New Brunswick. Canadian Field-Naruralist 105: 386-387.

Neveu A (2006) Les écrevisses étrangères sont elles invasives? Quelles caractéristiques expliquent leur développement? (Alien crayfish are they invasive species? What characteristics explain their conquest?). L'Astaciculteur de France 86: 2-11.

Oidtmann B, Geiger S, Steinbauer P, Culas A & Hoffmann RW (2006) Detection of Aphanomyces astaci in North American crayfish by polymerase chain reaction. Diseases of Aquatic Organisms 72: 53-64

Olden JD, McCarthy JM, Maxted JT, Fetzer WW & Vander Zanden MJ (2006) The rapid spread of rusty crayfish (Orconectes rusticus) with observations on native crayfish declines in Wisconsin (U.S.A.) over the past 130 years. Biological Invasions 8: 1621-1628

Olsen TM, Lodge DM, Capelli, GM & Houlihan RJ (1991) Mechanisms of impact of an introduced crayfish (Orconectes rusticus) on littoral congeners, snails, and macrophytes. Canadian Journal of Fisheries and Aquatic Sciences 48(10): 1853-1861

Peay S & Hiley PD (2004) Review of angling and crayfish. Environment Agency, Thames Region. 33 pp.

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

Petrusek A, Filipová L, Ďuriš Z, Horká I, Kozák P, Policar T, Štambergová M & Kučera Z (2006) Distribution of the invasive spiny-cheek crayfish (Orconectes limosus) in the Czech Republic. Past and present. Bulletin Français de la Pêche et de la Pisciculture 380-381: 903-918

Pöckl M, Holdich DM & Pennerstorfer J (2006) Identifying native and alien crayfish species in Europe. European Project CRAYNET. 47 pp

Puky M & Schád P (2006) Orconectes limosus colonises new areas fast along the Danube in Hungary. Bulletin Français de la Pêche et de la Pisciculture 380-381: 919-926

Rodriguez CF, E Bécares, M Fernández-Aláez & C. Fernández-Aláez (2005) Loss of diversity and degradation of wetlands as a result of introducing exotic crayfish. Biological Invasions 7: 75-85

Sibley PJ (2000) Signal crayfish in the River Wreake catchment. In: Rogers D & Brickland J (eds) Crayfish conference Leeds. Environment Agency, IAA, English Nature, pp.95-107.

Sibley PJ (2003) Signal crayfish in Britain with reference to the Tweed catchment. In: Proceedings of a seminar held in December, 2001. Tweed Forum, pp. 25-41.

www.tweedformum.com/publications/conferences/invasives

Sibley P & Nöel P (2002) Control and management of alien crayfish. In: Souty-Grosset C and Grandjean F (eds) Knowledge-based management of European native crayfish. Crayfish special. Bulletin Français de la Pêche et de la Pisciculture Vol. 4. 367(4): 833-844.

Souty-Grosset C, Holdich DM. Noël PY, Reynolds JD & Haffner P (Eds) (2006) Atlas of Crayfish in Europe. Muséum national d¹Histoire naturelle, Paris, (Patrimoines naturels, 64) 187 pp. ISBN: 2-85653-579-8

Statzner B, Fièvei E, Champagne J-Y, Morel R & Herouin E (2000) Crayfish as geomorphic agents and ecosystem engineers: Biological behaviour affects sand and gravel erosion in experimental streams. Limnology & Oceanography 45: 1030-1040

Stuki TP (1999) Differences in life history of native and introduced crayfish species in Switzerland. Freshwater Crayfish 12: 463-476

Vey A, Söderhäll K & Ajaxon R (1983) Susceptibility of Orconectes limosus Raff. to crayfish plague. Freshwater Crayfish 5: 192-291

Vielle A (2007) Dix ans après (Ten years later). L'Astaciculteur de France 90: 11-12