

## Risk Assessment of *Orconectes limosus*

<b>Name of Organism:</b>	<i>Orconectes limosus</i> (Rafinesque 1817) – Spiny-cheek Crayfish
<b>Objective:</b>	Assess the risks associated with this species in Ireland
<b>Version:</b>	Final 15/09/2014
<b>Author(s)</b>	Michael Millane and Joe Caffrey
<b>Expert reviewer</b>	Julian Reynolds

### Stage 1 - Organism Information

### Stage 2 - Detailed Assessment

Section A - Entry  
Section B - Establishment  
Section C - Spread  
Section D - Impact  
Section E - Conclusion  
Section F - Additional Questions

### ***About the risk assessment***

This risk assessment is based on the **Non-native species Application based Risk Analysis (NAPRA)** tool (version 2.66). NAPRA is a computer based tool for undertaking risk assessment of any non-native species. It was developed by the European and Mediterranean Plant Protection Organisation (EPPO) and adapted for Ireland and Northern Ireland by Invasive Species Ireland. It is based on the Computer Aided Pest Risk Analysis (CAPRA) software package which is a similar tool used by EPPO for risk assessment.

**Notes:** Confidence is rated as low, medium, high or very high.  
Likelihood is rated as very unlikely, unlikely, moderately likely, likely or very likely.  
The percentage categories are 0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%.  
N/A = not applicable.

This is a joint project by Inland Fisheries Ireland and the National Biodiversity Data Centre to inform risk assessments of non-native species for the European Communities (Birds and Natural Habitats) Regulations 2011. It is supported by the National Parks and Wildlife Service.

## DOCUMENT CONTROL SHEET

<b>Name of Document:</b>	Risk Assessment of <i>Orconectes limosus</i>				
<b>Author (s):</b>	Dr Michael Millane and Dr Joe Caffrey				
<b>Authorised Officer:</b>	Dr Joe Caffrey				
<b>Description of Content:</b>	Non-native species risk assessment				
<b>Approved by:</b>	Dr Cathal Gallagher				
<b>Date of Approval:</b>	15/09/2014				
<b>Assigned review period:</b>	n/a				
<b>Date of next review:</b>	n/a				
<b>Document Code</b>	n/a				
<b>This documents comprises</b>	TOC	Text	List of tables	List of Figures	No. Appendices
	n/a	YES	n/a	n/a	0

### Version Control Table

Version No.	Status	Authors(s)	Reviewed by	Approved by	Date of issue
Draft 1	Complete	Dr Michael Millane	Dr Joe Caffrey		03/03/2014
Expert review	Complete	Dr Michael Millane	Dr Julian Reynolds	Dr Joe Caffrey	13/03/2014
Public Consultation 1	Complete	Dr Michael Millane	Dr Joe Caffrey		09/05/2014
Public Consultation 2	Complete	Dr Michael Millane	Dr Joe Caffrey		14/08/2014
Final	Complete	Dr Michael Millane	Dr Joe Caffrey	Dr Cathal Gallagher	15/09/2014

<b>Stage 1 - Organism Information</b>			
<i>The aim of this section is to gather basic information about the organism.</i>			
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>COMMENT</b>
1	What is the reason for performing the risk assessment?		A risk assessment is required as this species is listed as a "Non-native species subject to restrictions under Regulations 49 and 50" in the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011, SI 477/2011.
2	Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES	<i>Orconectes limosus</i> (Rafinesque 1817), <i>Astacus limosus</i> Rafinesque 1817, <i>Astacus affinis</i> Say 1817, <i>Cambarus affinis</i> (Girard 1852), <i>Cambarus limosus</i> (Ortmann 1905), <i>Orconectes limosus</i> (Hobbs 1942); Spiny-cheek Crayfish, American Crayfish, Striped Crayfish (Souty-Grosset <i>et al.</i> 2006).
3	If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	N/A	
4	Describe the organism.	-	<i>Orconectes limosus</i> is characterised by "spiny sides to anterior carapace and horizontal reddish brown stripes dorsally across tail segments. Body colour pale or dark brown to olive-green; may appear black from some lacustrine sites with dark sediments"(Holdich and Sibley 2009). The wrist segment below the chela has a prominent spine. Total length is ≤ 12 cm (Souty-Grosset <i>et al.</i> 2006). A more detailed description of distinctive morphological characters is provided in Souty-Grosset <i>et al.</i> (2006).
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment for Ireland)	YES	In Ireland, a preliminary risk assessment was previously carried out. This was a prioritisation risk assessment as part of the Risk Analysis and Prioritisation for Invasive and Non-native Species in Ireland and Northern Ireland (Kelly <i>et al.</i> 2013). It designed <i>Orconectes limosus</i> as a 'high risk' invasive species.
6	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	PARTIAL	Only a preliminary risk assessment was previously conducted in Ireland (refer to Question 5).
7	Where is the organism native?		Eastern USA (Souty-Grosset <i>et al.</i> 2006; Holdich and Sibley 2009).
8	What is the current global distribution of the organism (excluding Ireland)?		Austria; Belgium; Britain; Canada; Czech Republic; France; Germany; Hungary; Italy; Lithuania; Luxembourg; Montenegro; Morocco; Netherlands; Poland; Russian Federation (Kaliningrad); Switzerland; United States (Adams <i>et al.</i> 2010); Romania (Părvulescu <i>et al.</i> 2009); Serbia (Pavlović <i>et al.</i> 2006) Slovakia (Puky 2009) and Spain (Benejam <i>et al.</i> 2011).
9	What is the current distribution of the organism in Ireland?	-	This species is not present in the wild in Ireland.

**Stage 1 - Organism Information**

*The aim of this section is to gather basic information about the organism.*

<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>COMMENT</b>
10	Is the organism known to be invasive anywhere in the world?	YES	<i>Orconectes limosus</i> is not particularly invasive in its native range, although it is spreading in eastern Canada. Since its introduction to Poland in 1890 it has become widely spread in continental Europe, in part through activities of fishermen (Souty-Grosset <i>et al.</i> 2006) and has proved to be extremely invasive (reviewed in GB Non-Native Species Secretariat 2011).

**Stage 2 - Detailed assessment: Section A - Entry**

This section evaluates the probability of entry of an organism into Ireland. For organisms which are already present, only complete the entry section for currently active pathways of entry and potential future pathways. The entry section need not be completed for pathways which have allowed an organism to enter in the past but are no longer active.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.01	How many active/future pathways are relevant to the potential entry of this organism (n/a, very few, few, moderate number, many or very many)?	MODERATE	HIGH	
1.02	List <u>significant</u> pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	1. Aquarium trade 2. Food trade for humans or fish 3. Fish stocking 4. Angling	HIGH	The 'aquarium trade' and 'food trade for humans and fish' are the principal pathways responsible for the introduction and establishment of non-native crayfish in Europe to date (Holdich 2002). Crayfish also have the potential to be inadvertently introduced as a contaminant of fish stocking and angling practices or if used as live bait for angling.

**Pathway 1 – Aquarium trade**

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	INTENTIONAL	LOW	A variety of potentially invasive, non-native crayfish are periodically for sale in Irish aquarium shops and can be purchased on the internet (Reynolds and O'Keeffe 2009). It is uncertain whether <i>Orconectes limosus</i> is imported for sale through the aquarium trade as no such information was found. In general, there is potential for the release of non-native crayfish to the wild from aquarium dumps.
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	MODERATELY LIKELY	LOW	It is uncertain whether <i>Orconectes limosus</i> is imported to Ireland for sale through the aquarium trade.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	VERY HIGH	As the organism would be deliberately distributed for trade and transported in an aquatic environment, survival is highly likely.

Pathway 1 – Aquarium trade				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY HIGH	According to GB Non-Native Species Secretariat (2011), “the reproductive period of <i>O. limosus</i> 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 2007), and in spring in central England (Holdich and Black 2007). However, it is likely that <i>O. limosus</i> could become established at any time of the year [in the UK], and then start to breed when conditions are right.” This is also considered to be very likely the case for Ireland, although there is no information available to ascertain whether imports occur. It was recently established that female <i>Orconectes limosus</i> can reproduce asexually via facultative parthenogenesis under experimental conditions. However, the occurrence of this phenomenon in the wild is unknown (Buřič <i>et al.</i> 2011).
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	MODERATELY LIKELY	HIGH	The deliberate introduction of crayfish to a suitable habitat as an aquarium dump is the most likely mechanism for transfer from this pathway. Alternatively, escape may be dependent on how securely live crayfish are stored and their proximity to a suitable water for survival. They do have some ability to walk over-land to access a watercourse (Baldry, pers. com. 2006 as cited in Holdich and Black 2007).
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	HIGHLY LIKELY	VERY HIGH	There is no specific information available to assess the level of entry of this crayfish species to Ireland <i>via</i> this pathway.
1.10	Do other pathways need to be considered?	YES		

<b>Pathway 2 – Food trade for humans or fish</b>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	INTENTIONAL	LOW	Non-native crayfish have been deliberately transferred to the wild to establish a food source for humans and fish in Europe (Holdich 2002; GB Non-Native Species Secretariat 2011). A variety of potentially invasive, non-native crayfish is periodically for sale in Irish aquarium shops and can be purchased on the internet (Reynolds and O’Keeffe 2009). It is uncertain whether <i>Orconectes limosus</i> is imported for use as food for humans or fish as no such information was found.
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	UNLIKELY	LOW	It is uncertain whether <i>Orconectes limosus</i> is imported to Ireland for use as food for humans. There are no known instances of non-native crayfish being stocked in Irish waters to provide a food source for fish.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	HIGH	The crayfish would be kept alive when moved <i>via</i> these pathways to ensure their survival. Non-native crayfish are imported in wooden crates in a damp environment and are sometimes placed in cold storage after import (Declan MacGabhann pers. comm.).
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY HIGH	Refer to Pathway 1, Question 1.07.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	UNLIKELY	HIGH	This is considered unlikely when live specimens are imported or traded for human consumption as it would necessitate escape to a suitable habitat or a deliberate act of introduction. However, direct transfer is virtually assured if stocked as a fish food source. Deliberate dumping of surplus or undersized crayfish could occur. There are no known instances of non-native crayfish being stocked in Irish waters to provide a food source for fish.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	UNLIKELY	MEDIUM	As previously stated, it is uncertain whether <i>Orconectes limosus</i> is imported for use as food for humans or fish as no such information was found.
1.10	Do other pathways need to be considered?	YES		

<b>Pathway 3 – Fish stocking</b>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	ACCIDENTAL	VERY HIGH	There is the potential for introduction as a contaminant of fish stocking.
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	UNLIKELY	HIGH	It is unlikely but fish stocking from foreign waters which have <i>Orconectes limosus</i> has the potential to inadvertently transfer this species to Ireland.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	HIGH	The crayfish would be moved in association with the fish to be stocked giving a high chance of survival, except in conditions where the fish may prey on the crayfish during transit.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	VERY HIGH	Refer to Pathway 1, Question 1.07.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	VERY LIKELY	VERY HIGH	Direct transfer is very likely as the crayfish would be transported in water.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	UNLIKELY	MEDIUM	This is considered unlikely due to the low frequency of fish stocking undertaken from abroad. However, there remains some potential for introduction <i>via</i> this pathway, if the fish are sourced from a location where crayfish are present. It is likely that any such introduction would be associated with illegal stocking practices.
1.10	Do other pathways need to be considered?	YES		



<b>Pathway 4 – Angling</b>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	INTENTIONAL OR ACCIDENTAL	VERY HIGH	The movement of angling equipment (particularly landing or keep nets and stink bags) from a foreign water that has non-native crayfish has the potential to inadvertently introduce such species to Ireland. In addition, if used as live bait for angling there is potential for escape. The use of <i>Orconectes limosus</i> as live bait for angling has been suggested as a mechanism responsible for the spread of this species in Europe (Holdich and Black 2007).
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	UNLIKELY	HIGH	It is unlikely but there is an increased potential for the inadvertent spread of non-native crayfish in the absence of implementing appropriate biosecurity measures.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	MODERATELY LIKELY	HIGH	The crayfish are moderately likely to stay alive if kept damp and cool when inadvertently carried on angling gear. This would further depend on the duration of transfer. If used as live bait for angling, survival is highly likely.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	VERY HIGH	Refer to Pathway 1, Question 1.07.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	LIKELY	HIGH	Direct transfer is likely in association with angling gear (e.g. keep nets) which are redeployed into a receiving water. This is also the case for live bait, which could be dumped after a fishing excursion.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	UNLIKELY	MEDIUM	Although unlikely, there is some potential for entry <i>via</i> this pathway if the angling gear has previously been used, and not subsequently disinfected, in a location where non-native crayfish are present.
1.10	Do other pathways need to be considered?	NO		

<b>Overall likelihood</b>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
1.11	Estimate the overall likelihood of entry into Ireland based on all pathways (comment on the key issues that lead to this conclusion).	HIGH	HIGH	The most likely pathways for non-native crayfish to gain entry to suitable waters in Ireland are considered to be through the deliberate introduction from an aquarium dump or through the food trade for human consumption.

**Stage 2 - Detailed assessment: Section B - Establishment**

*This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.*

<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
2.01	Is the organism well established in Ireland (if there is any uncertainty answer 'unsure')	NO	VERY HIGH	This species has not been recorded in the wild in Ireland to date.
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local <u>climatic conditions</u> and the organism's current global distribution?	VERY LIKELY	VERY HIGH	The wide range of climatic conditions experienced by <i>Orconectes limosus</i> in its native and introduced ranges (where it experiences both hot and cold temperature extremes, more than it would in Ireland) indicates that this organism will be able to survive and establish in Ireland.
2.03	How likely is it that the organism will be able to establish in Ireland based on the similarity between other local <u>abiotic conditions</u> and the organism's current global distribution?	VERY LIKELY	VERY HIGH	Overall, abiotic conditions that could prevent the establishment of <i>Orconectes limosus</i> are not considered to be limiting in Ireland. The species is desiccation, saline (Souty-Grosset <i>et al.</i> 2006) and pollution tolerant (Pöckl 1995), and can be found living in a wide range of water types (refer to response to Question 2.04 below).
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?	VERY LIKELY	VERY HIGH	The species occurs in rivers, streams, canals, lakes, ponds and water-filled gravel pits in continental Europe and in the UK (GB Non-Native Species Secretariat 2011). It is also known to inhabit brackish waters in Poland (Souty-Grosset <i>et al.</i> 2006). It can occupy both soft (i.e. silty, muddy) and hard (i.e. stony) substrates in aquatic environments and can survive in cold, fast flowing waters, even though it displays a preference for deep, calm waters (reviewed in Holdich and Black 2007). <i>Orconectes limosus</i> has also been found in ponds and lakes which may be organically rich and polluted (reviewed in Holdich and Black 2007). There is an abundance of such habitats available for colonisation in Ireland.

**Stage 2 - Detailed assessment: Section B - Establishment**

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	VERY LIKELY	VERY HIGH	<p>Competition will occur from native Irish species but this is highly unlikely to prevent establishment - survival would depend on predation pressure and the availability of food, not so much on the quality of the water (GB Non-Native Species Secretariat 2011). Fish may provide competition for food resources, such as macroinvertebrates. It is highly likely that the native<sup>†</sup> White-clawed Crayfish would provide some direct competition for resources, where both occur. However, <i>Orconectes limosus</i> is very likely to out-compete the native White-clawed Crayfish as it has a more rapid growth rate and higher fecundity than the White-clawed crayfish (Holdich <i>et al.</i> 2004). In addition, <i>Orconectes limosus</i> is a carrier of the crayfish plague, which would have the potential to decimate native crayfish stocks (Souty-Grosset <i>et al.</i> 2006).</p> <p>(<sup>†</sup> It is uncertain whether the White-clawed Crayfish is indigenous or may have been introduced to Ireland in medieval times or later (reviewed in Reynolds 2010). However, being the only freshwater crayfish species found in the wild in Ireland, and of international conservation importance because of this, it is referred to as a native species in this risk assessment.</p>
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?	VERY LIKELY	VERY HIGH	<p>Predation is likely to occur from existing species such as perch, pike, heron (and some other waterfowl), otter, mink and eels, but is highly unlikely to prevent establishment (Haertel-Borer <i>et al.</i> 2005; Souty-Grosset <i>et al.</i> 2006; Holdich and Black 2007). <i>Orconectes limosus</i> is a vector of the crayfish plague <i>Aphanomyces astaci</i> (Souty-Grosset <i>et al.</i> 2006). This plague has extirpated populations of White-clawed Crayfish in the Irish midlands since the 1980s (reviewed in Matthews and Reynolds 1992) but no further outbreaks have been reported.</p>
2.07	How likely is it that establishment will occur despite existing management practices?	LIKELY	HIGH	<p>In general, the state management of waterways is undertaken in order to ensure that biosecurity measures are in place to mitigate for the spread of aquatic invasive species. An increase in awareness by some private stakeholders of the threat from aquatic invasive species has also reduced this risk. Nevertheless, it is considered likely that this species can establish despite existing management practices, which can only mitigate for aspects of the establishment risk. Importation of crayfish to Ireland was thought to be prohibited under the Live Fish (restriction of importation) Order 1972 of the Fisheries Acts. However, it was recently</p>

**Stage 2 - Detailed assessment: Section B - Establishment**

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				concluded that the definition given for “fish” did not apply to freshwater crayfish and, therefore, may not be enforceable (Reynolds 2010). Nevertheless, such measures have been successful to date in preventing the establishment of non-native crayfishes in the wild in this country (Reynolds 1998).
2.08	How likely is it that management practices in Ireland will facilitate the establishment of the organism?	UNLIKELY	HIGH	Refer to Question 2.07.
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?	VERY LIKELY	HIGH	The use of biocides (e.g. natural pyrethroids) is an option for a pond population but these are unlikely to work in a complex river catchment, or indeed in a canal or large lake (Cosgrove <i>et al.</i> 2008; GB Non-Native Species Secretariat 2011). Trapping is an ineffective eradication method due to behavioural traits, habitat complexity and the burrowing nature of the species (Holdich and Black 2007; Cosgrove <i>et al.</i> 2008; also reviewed in GB Non-Native Species Secretariat 2011).
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	VERY LIKELY	VERY HIGH	<i>Orconectes limosus</i> has rapid individual and population growth, early sexual maturity and high fecundity (Holdich and Sibley 2009) which confer it with a high capacity for establishment once introduced into a water.
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	VERY LIKELY	HIGH	The literature indicates that <i>Orconectes limosus</i> has a high capacity for spread once it is introduced to the wild. It has become one of the commonest non-native crayfish species in European inland waters since its original introduction in 1890 (Souty-Grosset <i>et al.</i> 2006). It is difficult to assess how much of the documented spread within Europe is solely <i>via</i> natural means as anthropogenic-mediated spread is often implicated. In the River Danube in Hungary, the colonisation speed of <i>Orconectes limosus</i> has been calculated to be more than 13 km yr <sup>-1</sup> (Puky and Schäd 2006). In Belarus, since 1997, <i>Orconectes limosus</i> spread 177 km upstream along the course of the Neman River from the Grodno region (Aklehnovich and Razlutskiy 2013). In Poland, populations of <i>Orconectes limosus</i> increased from 57 in 1959 to at least 1383 by 2004 and the species has established in 75% of the country. Anthropogenic-mediated spread is believed to be primarily responsible for this (reviewed in Souty-Grosset <i>et al.</i> 2006). In north-east Germany, out of 300 lakes recently examined, 214 were found to have <i>Orconectes limosus</i> (reviewed in

**Stage 2 - Detailed assessment: Section B - Establishment**

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N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				Souty-Grosset <i>et al.</i> 2006). It was first recorded in Italy in 1991, likely having been introduced with fish stocks, and is now common in northern parts of the country (Gherardi <i>et al.</i> 1999). Since its introduction in France in 1911, it has since expanded to occupy all suitable habitats in the country (reviewed in Souty-Grosset <i>et al.</i> 2006), where it is the most sought-after species for food and as bait (Changeux 2003). <i>Orconectes limosus</i> can travel over-land (D. Baldry, pers. comm. 2007 as cited in GB Non-Native Species Secretariat 2011).
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	VERY LIKELY	VERY HIGH	In general, crayfish are omnivorous, having the ability to act as herbivores, detritivores and predators. This non-specific, polytrophic character provides good adaptability to facilitate establishment in suitable habitats with varying food resources (reviewed in Souty-Grosset <i>et al.</i> 2006). The eurybiontic character of <i>Orconectes limosus</i> enables it to establish in a wide variety of aquatic habitats, under a range of environmental conditions (refer to responses to Questions 2.02, 2.03 and 2.04).
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	VERY LIKELY	HIGH	According to GB Non-Native Species Secretariat 2011, "There has only been one successful introduction of <i>O. limosus</i> into Europe from the USA and that was of 100 individuals in 1890 (Machino and 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."
2.14	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Ireland? If possible, specify the instances of invasion elsewhere in the justification box	VERY LIKELY	VERY HIGH	Based on a review of its biological character and ecological requirements in its native and introduced range, <i>Orconectes limosus</i> is very likely to establish in Ireland as climatic and abiotic conditions are considered suitable and there are a wide range of habitats available for colonisation. Its fast rate of spread after introduction to a number of European countries (refer to response to Question 2.11) further supports this.
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	UNLIKELY	HIGH	Transient populations are unlikely. It is considered from the documented history of establishment and spread of this species elsewhere in Europe (as outlined in this risk assessment) that reproducing populations would be very likely to establish after introduction.

**Stage 2 - Detailed assessment: Section B - Establishment**

*This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	VERY LIKELY	VERY HIGH	The information assembled in Section B suggests that it is very likely that <i>Orconectes limosus</i> can establish in the wild in Ireland. This is further supported by its documented establishment and spread elsewhere in Europe.

**Stage 2 - Detailed assessment: Section C - Spread**

*This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.01	What area (given in % or 10km squares) in Ireland could the organism establish (0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%)?	68 – 90 % (of 10 km squares)	VERY HIGH	<i>Orconectes limosus</i> could colonise a range of habitat types that are abundant in Ireland (refer to response to Question 2.04).
3.02	How important is the expected spread of this organism in Ireland by <u>natural</u> means (minimal, minor, moderate, major or massive)?	MAJOR	HIGH	The rate of spread of <i>Orconectes limosus</i> after introduction to a number of European countries has been rapid, although it is not always clear if natural or anthropogenic-mediated spread, or a combination of both, is responsible (refer to response to Question 2.11). In the River Danube in Hungary, the colonisation speed of <i>Orconectes limosus</i> has been calculated to be more than 13 km yr <sup>-1</sup> (Puky and Schád 2006). In Belarus, since 1997, <i>Orconectes limosus</i> has spread 177 km upstream along the course of the Neman River from the Grodno region (Aklehnovich and Razlutskiy 2013). The ability of <i>Orconectes limosus</i> to traverse overland (D. Baldry, pers. comm. 2007 as cited in GB Non-Native Species Secretariat 2011) provides it with the potential to escape from confined locations.
3.03	How important is the expected spread of this organism in Ireland by <u>human assistance</u> (minimal, minor, moderate, major or massive)?	MAJOR	HIGH	Anthropogenic-mediated spread is more likely than natural spread to increase the rate of dispersal in Ireland, especially between catchments. Such inter-catchment transfers may be conducted to provide local food sources for humans or fish, or the species may be transferred by anglers for use as live fish bait (Souty-Grosset <i>et al.</i> 2006; Holdich and Black 2007). In addition, aquarium dumps (if the species is sold through the aquarium trade) also have a high potential to spread <i>Orconectes limosus</i> .
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MAJOR / MASSIVE	HIGH	This depends on the response time between an introduction occurring and the reaction enacted to contain it, and the nature of the water colonised. Containment would be feasible in a closed system, such as a pond, particularly if geographical isolated from other waters. It would be very difficult in an open water system (e.g. river catchment or lake) or semi-open system, such as a canal, because of its high ability to disperse by natural means. In general, the containment of other introduced invertebrates has been unsuccessful in Ireland.
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	NONE	VERY HIGH	This species has not been recorded in Ireland to date.



**Stage 2 - Detailed assessment: Section C - Spread**

*This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.*

<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
3.06	What proportion of the area in Ireland suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	N/A		The species is not present in the wild in Ireland.
3.07	What other timeframe would be appropriate to estimate any significant further spread of the organism (10, 20, 40, 80 or 160 years)? Please comment on why this timeframe is chosen.	N/A		The species is not present in the wild in Ireland.
3.08	In this timeframe, what proportion of the area (including any currently occupied areas) is likely to have been invaded by this organism?	N/A		The species is not present in the wild in Ireland.
3.09	Based on the answers to questions on the potential for establishment and spread in Ireland, define the area endangered by the organism. Be as specific as possible. If available, provide a map showing the area most likely to be endangered.	-		<i>Orconectes limosus</i> could colonise a range of habitat types which are abundant in Ireland, including soft-bottomed rivers and lakes (refer to response to Question 2.04).
3.10	Estimate the overall potential for future spread for this organism in Ireland (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues .			If introduced, the potential for subsequent spread is very high. This primarily depends on the number and density of introductions and the character and position of the waters they are introduced to.

**Stage 2 - Detailed assessment: Section D - Impact***This section evaluates the probability of impact of an organism within Ireland.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.01	How great is the economic loss caused by the organism within its global distribution (excluding Ireland), including the cost of any current management?	MODERATE	HIGH	According to GB Non-Native Species Secretariat (2011), "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 <i>O. limosus</i> . Also, since the 1960s other North American crayfish have been introduced into Europe that also carry crayfish plague. <i>O. limosus</i> 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 <i>et al.</i> 2006). It also has a lower meat yield than other introduced species. It has been implicated in the demise of some noble crayfish, <i>Astacus astacus</i> , populations in many countries, where noble crayfish were extensively harvested. Whilst the main catch in Hungary was <i>A. astacus</i> in the 1990s, it is now dominated by <i>O. limosus</i> (Souty-Grosset <i>et al.</i> 2006). It has also proved virtually impossible to restock native crayfish where <i>O. limosus</i> is present (Souty-Grosset <i>et al.</i> 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.
4.02	How great has the economic cost of the organism been in Ireland from the <u>time of introduction to the present</u> ? Exclude any costs associated with managing the organism from your answer.	N/A		This species has not been recorded in the wild in Ireland to date.
4.03	How great is the economic cost of the organism likely to be in the <u>future</u> in Ireland? Exclude any costs associated with managing the organism from your answer.	MODERATE	MEDIUM	The burrowing activity of <i>Orconectes limosus</i> has the potential to cause bankside erosion and collapse. However, burrowing in the species has only been recently documented and may be seasonal and not occur in all populations (Holdich and Black 2007). Commercial fisheries may be negatively impacted by the species damaging nets, preying on fish eggs, competing with fish for food resources or altering food-webs, which may affect fish stocks (Souty-Grosset <i>et al.</i> 2006; reviewed in Global Invasive Species Database 2011). Some of these activities may also negatively affect recreational fisheries.

**Stage 2 - Detailed assessment: Section D - Impact**

*This section evaluates the probability of impact of an organism within Ireland.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.04	How great have the economic costs of managing this organism been in Ireland from the <u>time of introduction to the present</u> ?	N/A		This species has not been recorded in the wild in Ireland to date.
4.05	How great is the economic cost of managing this organism likely to be in the <u>future</u> in Ireland?	MODERATE	MEDIUM	This would depend of the level of establishment and spread, if introduced. It would be vitally important to minimise any impact to the native White-clawed Crayfish that could be caused, either directly or indirectly, by <i>Orconectes limosus</i> . This mitigation could perhaps be achieved by eradication, containment and control.
4.06	How important is environmental harm caused by the organism within its global distribution?	MAJOR	MEDIUM	<p>This species will reduce certain macrophytes, thus altering the habitat for other organisms. According to GB Non-Native Species Secretariat (2011), <i>Orconectes limosus</i> "has not been recorded as causing much environmental harm in North America, unlike some of its congeners (Olsen <i>et al.</i> 1991; Lodge <i>et al.</i> 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."</p> <p>There is a lack of studies in the literature to assess environmental harm to invaded ecosystems in more detail as most studies to date, in Europe at least, have focused on the population biology of the species (Souty-Grosset <i>et al.</i> 2006).</p>
4.07	How important has the impact of the organism on biodiversity* been in Ireland from the time of introduction to the present? *e.g. decline in native species, changes in community structure, hybridisation	N/A		This species has not been recorded in the wild in Ireland to date.
4.08	How important is the impact of the organism on biodiversity likely to be in the <u>future</u> in Ireland?	MAJOR	HIGH	The establishment of <i>Orconectes limosus</i> populations would represent a serious threat to the continued conservation of the indigenous White-clawed Crayfish in Ireland (Reynolds 1998; Souty-Grosset <i>et al.</i> 2006). The White-clawed Crayfish is an EU Habitat's Directive protected Annex 2 listed species and classified as vulnerable and rare in the IUCN Red List of threatened animals. It is also recognised to be of national importance, with legislation enacted to protect it under the Wildlife Act

**Stage 2 - Detailed assessment: Section D - Impact**

*This section evaluates the probability of impact of an organism within Ireland.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				1976 in Ireland. It is likely that both crayfish species would occupy similar ecological niches and habitats and it is considered that <i>Orconectes limosus</i> would displace the native crayfish due to its carrying plague, its relatively large size, faster growing nature and enhanced reproduction capability ( Reynolds 1998; Holdich and Sibley 2009).
4.09	How important has alteration of ecosystem function* caused by the organism been in Ireland from the time of introduction to the present? *e.g. habitat change, nutrient cycling, trophic interactions	N/A		This species has not been recorded in the wild in Ireland to date.
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the <u>future</u> ?	MAJOR	HIGH	As 'ecosystem engineers', crayfish in general have the ability to alter ecosystem function through food-web or habitat modification (Jones <i>et al.</i> 1997). The degree of change would likely depend on the extent of colonisation. High population densities in invaded ecosystems may increase the potential for ecosystem function to be altered or alternatively the species would fill the niche occupied by extirpated native crayfish. Population density appears much higher than for the White-clawed Crayfish, e.g. equivalent to much or most of the biomass of macroinvertebrates and fish (Haertel-Borer <i>et al.</i> 2005).
4.11	How important has decline in conservation status* caused by the organism been in Ireland from the time of introduction to the present? *e.g. sites of nature conservation value, WFD classification, etc.	N/A		This species has not been recorded in the wild in Ireland to date.
4.12	How important is decline in conservation status caused by the organism likely to be in the <u>future</u> in Ireland?	MAJOR	HIGH	The establishment of <i>Orconectes limosus</i> would have detrimental impacts to native White-clawed Crayfish populations in Ireland (refer to response to Question 4.08). This may have implications for the classification of ecological status under the EU Water Framework Directive and conservation status under the EU Habitats Directive.
4.13	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within its global distribution?	MODERATE	MEDIUM	According to GB Non-Native Species Secretariat (2011), <i>Orconectes limosus</i> "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-Grosset <i>et al.</i> 2006), but this has never been quantified, even though <i>O. limosus</i> has

**Stage 2 - Detailed assessment: Section D - Impact**

*This section evaluates the probability of impact of an organism within Ireland.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				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-Grosset <i>et al.</i> 2006)."
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	N/A		This species has not been recorded in the wild in Ireland to date.
4.15	How important is it that genetic traits of the organism could be carried to other organisms / species, modifying their genetic nature and making their economic, environmental or social effects more serious?	MINIMAL	HIGH	This species is not known to interbreed with the White-clawed Crayfish or other species.
4.16	How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?			<i>Orconectes limosus</i> is a chronic carrier of and vector for the crayfish plague (Souty-Grosset <i>et al.</i> 2006) and could spread it to the native White-clawed Crayfish. It is known as a non-specific prey item of the invasive North American Mink (Alekhnovich <i>et al.</i> 1999), which is already widespread in the wild in Ireland. <i>Orconectes limosus</i> can also harbour the invasive zebra mussel (Souty-Grosset <i>et al.</i> 2006).
4.17	How important might other impacts not already covered by previous questions be resulting from introduction of the organism? Specify in the justification box.	MINIMAL	HIGH	
4.18	How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Ireland?	MAJOR	HIGH	Natural control by other organisms is unlikely to affect expected impacts (i.e. displacement of the native White-clawed Crayfish).

<b>Stage 2 - Detailed assessment: Section D - Impact</b>				
<i>This section evaluates the probability of impact of an organism within Ireland.</i>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
4.19	Indicate any parts of where economic, environmental and social impacts are particularly likely to occur. Provide as much detail as possible, where possible include a map showing vulnerable areas.	-		Potential economic, environmental and social impacts are possible wherever <i>Orconectes limosus</i> could establish. There are an abundance of such waters in Ireland. The conservations status of waters which hold native White-clawed crayfish stock would be directly threatened.
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MAJOR	VERY HIGH	The primary potential impact of <i>Orconectes limosus</i> in Ireland is the threat it poses to the native White-clawed Crayfish. In addition, native biodiversity and ecosystem function are also likely to be threatened if abundant populations establish in the wild in Ireland. Furthermore, this non-native crayfish species could interfere with bank stability, and reduce the value of commercial and recreational fisheries.

<b>Stage 2 - Detailed assessment: Section E - Conclusion</b>				
<i>This section requires the assessor to provide a score for the overall risk posed by an organism, taking into account previous answers to entry, establishment, spread and impact questions.</i>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
5.01	Estimate the overall risk of this organism in Ireland (noting answers given in 1.11, 2.16, 3.10 & 4.20).	MAJOR	VERY HIGH	This crayfish species has the potential to seriously threaten the conservation of the native White-clawed Crayfish populations in Ireland. In addition, native biodiversity and ecosystem function are likely to be threatened if abundant populations establish in the wild in Ireland. Furthermore, this non-native crayfish species could interfere with bank stability, and reduce the value of commercial and recreational fisheries.

**Stage 2 - Detailed assessment: Section F – Additional questions**

*This section is used to gather information about the potential effects of climate change on the risk posed by an organism. It is also an opportunity for the risk assessor to highlight high priority research that could help improve the risk assessment.*

<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
6.01	What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	-	MEDIUM	Climate change is expected to increase water temperatures over time in Ireland, with increased periods of drought in summer and higher rainfall in winter leading to more flooding events (Desmond <i>et al.</i> 2008). The species is tolerant of habitat drying for a number of weeks, which increases its ability to withstand any prolonged periods of drought that may occur (Souty-Grosset <i>et al.</i> 2006). Increased flooding events may help to naturally spread this species by facilitating escape from confined waters, which are adjacent to open systems.
6.02	What is the likely timeframe for such changes (5, 10, 15, 20, 50 or 100 years)?	UNKNOWN		
6.03	What aspects of the risk assessment are most likely to change as a result of climate change	NONE	MEDIUM	
6.04	If there is any research that would significantly strengthen confidence in the risk assessment, please note this here. If more than one research area is provided, please list in order of priority.	YES	HIGH	Information is required to ascertain whether <i>Orconectes limosus</i> is imported to Ireland for the food or aquarium trades. There are few studies available to review the impact of this species on native species (bar indigenous crayfish) and ecosystems in Europe (Souty-Grosset <i>et al.</i> 2006). However, such work is ongoing in the Czech Republic (J. Reynolds pers. comm.). Further research in this regard would be useful to strengthen the risk assessment analysis.

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