Risk Assessment of *Astacus leptodactylus*

Name of Organism:	*Astacus leptodactylus* Eschscholtz 1823 – Turkish Crayfish
Objective:	Assess the risks associated with this species in Ireland
Version:	Final 15/09/2014
Author(s)	Michael Millane and Joe Caffrey
Expert reviewer	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 **N**on-native species **AP**plication based **R**isk **A**nalysis (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

Name of Document:	Risk Assessment of *Astacus leptodactylus*				
Author (s):	Dr Michael Millane and Dr Joe Caffrey				
Authorised Officer:	Dr Joe Caffrey				
Description of Content:	Non-native species risk assessment				
Approved by:	Dr Cathal Gallagher				
Date of Approval:	15/09/2014				
Assigned review period:	n/a				
Date of next review:	n/a				
Document Code	n/a				
This documents comprises	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		19/02/2014
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

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
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?	NO	*Astacus leptodactylus* Eschscholtz 1823, *Astacus leptodactylus* subspecies *kessleri (*Karaman,1963) *Astacus leptodactylus* subspecies *eichwaldi* (Karaman 1963); Danube Crayfish, Galician Crayfish, Long-clawed Crayfish, Narrow-clawed Crayfish, Pond Crayfish, Slender-clawed Crayfish, Swamp Crayfish, Turkish Crayfish (Gherardi and Souty-Grosset 2010); and Armenian crayfish (Declan MacGabhann pers. comm.) According to GB Non-Native Species Secretariat (2011), "*Astacus leptodactylus* is made up of several sub-species some of which have been elevated to specific level and as such it is referred to as a species complex (Souty-Grosset *et al.* 2006)." Further details on the evolution of the species complex classification can be found under "Taxonomic Notes" in Gherardi and Souty-Grosset (2010).
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)	YES	According to GB Non-Native Species Secretariat (2011), "*A. leptodactylus* can be defined as a species complex which shares some morphological traits. Various keys are available, including Pöckl *et al.* (2006) and Gledhill *et al.* (1993)."
4	Describe the organism.	-	*Astacus leptodactylus* is "characterized by long, narrow claws in adults; no prominent spur on inner medial margin of carpus or chela, but prominent spur may occur inner distal margin (this can cause confusion when trying to separate specimens from members of the Cambaridae, which have a prominent spur on the inner medial margin); carapace rough and spiny with two pairs of post-orbital ridges. Body colour variable from sandy yellow to dark green, usually with mottled background in paler specimens, occasionally blue; leg joints often orange." (Holdich and Sibley 2009). Total length is ≤ 15 cm, but can reach 20 cm (Souty-Grosset *et al.* 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 *et al.* 2013). It designated *Astacus leptodactylus* as a 'high risk' invasive species.
6	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	PARTIAL	
7	Where is the organism native?		Austria; Azerbaijan; Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Georgia; Greece; Hungary; Iran; Israel; Kazakhstan; Kyrgyzstan; Moldova; Romania; Russian Federation; Serbia; Slovakia; Turkey (Turkey-in-Asia, Turkey-in-Europe); Turkmenistan; and Ukraine (Gherardi and Souty-Grosset 2010).

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
8	What is the current global distribution of the organism (excluding Ireland)?		Armenia; Belgium; Czech Republic; Denmark; Finland; France; Germany; Great Britain; Italy; Latvia; Lithuania; Luxembourg; Netherlands; Poland; Switzerland; and Uzbekistan in addition to the countries listed in answer to Question 7 (Gherardi and Souty-Grosset 2010).
9	What is the current distribution of the organism in Ireland?	-	This species is not present in the wild in Ireland. However, it is regularly imported *via* the food trade for human consumption (Declan MacGabhann pers. comm.).
10	Is the organism known to be invasive anywhere in the world?		An extensive literature search has found limited specific information to comment on its invasiveness where it occurs, likely because of its large native or naturalised range in central and eastern Europe and its long-term establishment in much of western Europe. However, It is considered likely that *Astacus leptodactylus* could out-compete the indigenous white-clawed crayfish (*Austropotamobius pallipes* Lereboullet) in Britain, where their ranges overlap (Holdich and Sibley 2009). It can establish abundant populations after introduction, displacing other indigenous crayfish due to its large size and high fecundity (reviewed in Holdich 2002 and Souty-Grosset *et al*. 2006).

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 significant 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	VERY HIGH	There are two recent confirmed reports of this species being sold in Ireland *via* the aquarium trade (National Biodiversity Data Centre 2013). In general, a number 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). There is potential for the release of such 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	MEDIUM	There is no specific information available to assess this except that referred to in response to Question 1.03 above. Therefore, it is rated as moderately likely. However, potentially invasive, non-native crayfish are imported into Ireland for sale every year (Reynolds and O'Keeffe 2009). This species is considered to be less desirable for aquaria than some other crayfish species as it is not colourful, therefore, little movement *via* this pathway may occur (Declan MacGabhann pers. comm.).
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	Crayfish can survive an introduction at any time of year. The introduction of a single berried female could result in a population becoming established (summer to autumn period). Alternatively, it would take a minimum of two individuals (male and female) capable of breeding to establish a viable population. According to GB Non-Native Species Secretariat (2011), "*A. leptodactylus* is active throughout the year and has even been reported to be very active during winter."
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. This is a phenomenon observed in other countries (GB Non-Native Species Secretariat 2011). Alternatively, escape may be dependent on how securely live crayfish are stored and their proximity to a suitable water for survival.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	VERY LIKELY	VERY HIGH	There is only very limited information available to assess the extent of entry of this crayfish species to Ireland *via* this pathway. It is known that a variety of non-native crayfish species, including *Astacus leptodactylus*, are imported and available for sale in the country (Reynolds and O'Keeffe 2009; National Biodiversity Data Centre 2013). This species is considered to be less desirable for aquaria than some other crayfish species as it is not colourful, therefore, little movement *via* this pathway may occur (Declan MacGabhann pers. comm.).
1.10	Do other pathways need to be considered?	YES		

Pathway 2 – Food trade for humans or fish				
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	VERY HIGH	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). *Astacus leptodactylus* is regularly imported into Ireland *via* the food trade for human consumption (Declan MacGabhann pers. comm.).

Pathway 2 – Food trade for humans or fish				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
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?	VERY LIKELY	HIGH	*Astacus leptodactylus* for human consumption are principally imported to Ireland from Billingsgate Market in London, England (Declan MacGabhann pers. comm.). Although no specific information on the frequency of such imports is available, they do occur on a regular basis (Declan MacGabhann pers. comm.). Therefore, it is considered very likely that large numbers of *Astacus leptodactylus* will travel by this pathway into the country. 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 *via* these pathways to ensure their survival. They are imported in wooden crates in a damp environment and typically 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. There have been two such anecdotal reports in England which resulted in local populations establishing. The first involved escape from crates at a fish market into a nearby canal and the second was when the species was released into a watercourse so the animals would not die after a refrigerated lorry in which they were being transported broke down (GB Non-Native Species Secretariat 2011). Direct transfer is assured if stocked as a fish food source.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	HIGHLY LIKELY	VERY HIGH	As previously stated, *Astacus leptodactylus* are imported into Ireland *via* the food trade for human consumption (Declan MacGabhann pers. comm.). There are no known instances of non-native crayfish being stocked in Irish waters to provide a food source for fish (so in this case a rating is given as 'very unlikely' with 'high' confidence).

Pathway 2 – Food trade for humans or fish				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.10	Do other pathways need to be considered?	YES		

Pathway 3 – Fish stocking				
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)?	ACCIDENTAL	VERY HIGH	There is the potential for introduction as a containment 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 support populations of *Astacus leptodactylus* has the potential to inadvertently transfer the 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?	UNLIKLEY	MEDIUM	Although unlikely, there is some potential for introduction as a contaminant of fish stocking, 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		

Pathway 4 – Angling				
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)?	ACCIDENTAL	VERY HIGH	The movement of angling equipment (particularly landing or keep nets and stink bags) from a foreign water that support populations of non-native crayfish has the potential to inadvertently introduce these species to Ireland. In addition, if used as live bait for angling, there is potential for escape.
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.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	UNLIKLEY	MEDIUM	Although unlikely, there is some potential for entry *via* 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		

Overall likelihood				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
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	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.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
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 Ireland in the wild to date.
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local climatic conditions and the organism's current global distribution?	VERY LIKELY	VERY HIGH	In general, the survival and establishment of *Astacus leptodactylus* populations in Ireland is very likely. The species has established populations throughout south-east England and at isolated locations in other regions of England, as well as Wales, since its introduction in the 1970s (Holdich 2002; GB Non-Native Species Secretariat 2011). This strongly suggests the suitability of the species to the Irish climate. Although, experience in an aquarium subject to ambient outdoor temperatures in Ireland, suggests that a sustained cold winter (which only occasionally occurs in Ireland) may hamper the ability of *Astacus leptodactylus* to successfully reproduce (Declan MacGabhann pers. comm.).
2.03	How likely is it that the organism will be able to establish in Ireland based on the similarity between other local abiotic conditions and the organism's current global distribution?	VERY LIKELY	VERY HIGH	Based on the organism's current global distribution where it is subject to a wide range of abiotic conditions, this is not considered to be limiting in Ireland. It is the most eurybiontic of the European *Astacus* species, being relatively more tolerant to changes in environmental conditions such as low oxygen concentrations, low water transparency, high salinity and high temperature than other related species (Souty-Grosset *et al*. 2006).
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	In its current range, *Astacus leptodactylus* is found in both freshwaters (lakes, reservoirs, canals, rivers, ponds and streams) and brackish waters (e.g. lagoons, estuaries) with a variety of substrate types (Holdich 2002; Souty-Grosset *et al*. 2006; Füreder *et al*. 2010). There is an abundance of such habitats available for the survival, development and proliferation of the organism in Ireland.
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	VERY LIKELY	VERY HIGH	Competition will occur from existing species but is highly unlikely to prevent establishment. Fish may also provide competition for food resources, such as macroinvertebrates (GB Non-Native Species Secretariat 2011). It is highly likely that the native† White-clawed Crayfish would provide some direct competition for resources where both occur. However, *Astacus leptodactylus* is likely to out-compete the native crayfish species (Holdich and Sibley 2009).

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
				(† 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.)
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?			Predation will occur from existing species such as perch, pike, heron, otter, mink and eels (Souty-Grosset *et al*. 2006), but is highly unlikely to prevent establishment (refer to Question 2.05). *Astacus leptodactylus* is susceptible to the crayfish plague *Aphanomyces astaci* (Schikora) and this has decimated some native and introduced populations of the species in parts of Europe (Holdich 2002; Harlıoğlu 2004). The same crayfish plague has extirpated populations of White-clawed Crayfish in Ireland since the 1980s (reviewed in Matthews and Reynolds 1992).
2.07	How likely is it that establishment will occur despite existing management practices?	UNLIKELY	HIGH	In general, the state management of waterways is undertaken 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. 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 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.

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
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?	MODERATELY LIKELY	HIGH	The organism is susceptible to crayfish plague, which has resulted in extinctions in Europe (Holdich 2002) but this would not be a feasible measure to employ in Ireland as the White-clawed Crayfish is also highly vulnerable to this. The use of biocides (e.g. natural pyrethroides) 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. Trapping is an ineffective eradication method due to habitat complexity (Cosgrove *et al.* 2008; GB Non-Native Species Secretariat 2011).
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	LIKELY	HIGH	It is likely that *Astacus leptodactylus* could establish in a range of Irish freshwaters due to its relatively large size and its faster growth rate when compared to the native White-clawed Crayfish (Reynolds 1998). Its eurybiontic character (Souty-Grosset *et al.* 2006) will also likely favour this.
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	MODERATELY LIKELY	LOW	This is uncertain and would depend on the extent of initial introduction(s). Once introduced into a catchment, the species is likely to spread naturally throughout it.
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	LIKELY	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. Further to this, *Astacus leptodactylus* is considered to have a eurybiontic character (Souty-Grosset *et al.* 2006), which should aid its establishment in a wide-range of habitats under varying abiotic conditions.
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	LIKELY	MEDIUM	There is no information available to comment on this.
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 knowledge of its biological character and ecological requirements in its native and introduced range, *Astacus leptodactylus* is very likely to establish in Ireland as climatic and abiotic conditions are suitable and there are a wide range of habitats available for colonisation. This species has established populations throughout south-east England and at isolated locations in other regions of England, as well as Wales, since its introduction in the 1970s (Holdich 2002; GB Non-Native Species Secretariat 2011) as well as in western Europe (Holdich 2002) which further indicates its ability to establish here.

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
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	UNLIKELY	VERY HIGH	Transient populations are unlikely as it is considered very likely that reproducing populations would establish after introduction.
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 *Astacus leptodactylus* can establish in Ireland if introduced.

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)	HIGH	There is an abundance of freshwaters and brackish waters in Ireland where *Astacus leptodactylus* could establish (refer to response to Question 2.04). The species is likely to be limited by waters with low calcium (specific values for calcium tolerance cannot be found in the literature).
3.02	How important is the expected spread of this organism in Ireland by natural means (minimal, minor, moderate, major or massive)?	MODERATE	MEDIUM	Natural spread will occur within catchments but the rate of spread is uncertain. Between catchments, any spread would principally be human-mediated.
3.03	How important is the expected spread of this organism in Ireland by human assistance (minimal, minor, moderate, major or massive)?	MODERATE	HIGH	Experience from Britain suggests that anthropogenic-mediated spread would be principally responsible for an increase in the distribution of this species in Ireland (GB Non-Native Species Secretariat 2011).
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MODERATE / MAJOR	HIGH	This depends on the response time between an introduction occurring and the reaction enacted to contain it. It also depends on the nature of the water that is stocked or colonised. Containment would be moderately difficult but feasible in a closed or semi-closed system (i.e. pond, land-locked water or locked canal) but more difficult in an open water system (e.g. river catchment).
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 the wild in Ireland to date.
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		This species has not been recorded in the wild in Ireland to date.
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		This species has not been recorded in the wild 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.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
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		This species has not been recorded in the wild in Ireland to date.
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.	-		Refer to Question 3.01.
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, although the rate at which the species could spread is uncertain. This primarily depends on the number and quantity of introductions and the character 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?	MINOR	LOW	There is a paucity of information in this regard. *Astacus leptodactylus* is likely to be more of a nuisance than cause economic loss and it has the potential to impact on fisheries by reducing the value of the angling resource e.g. by interfering with bait and reducing macrophyte growth in some areas (GB Non-Native Species Secretariat 2011).
4.02	How great has the economic cost of the organism been in Ireland from the time of introduction to the present? 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 future in Ireland? Exclude any costs associated with managing the organism from your answer.	MINOR	LOW	Economic costs excluding managing the organism are likely to be low.
4.04	How great have the economic costs of managing this organism been in Ireland from the time of introduction to the present?	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 future in Ireland?	MODERATE	MEDIUM	As potential impacts are uncertain, 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 *Astacus leptodactylus*. This mitigation could be achieved by eradication, containment or control.
4.06	How important is environmental harm caused by the organism within its global distribution?	MINOR	MEDIUM	*Astacus leptodactylus* is not noted for causing significant environmental harm within its global range (GB Non-Native Species Secretariat 2011). However, it can threaten the status of conservationally important indigenous crayfish, such as the White-clawed Crayfish, where both occur in the same habitat (Holdich and Sibley 2009). Unlike some other crayfish species, it is not known to burrow and thus interfere with river bank stability (GB Non-Native Species Secretariat 2011).
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.

Stage 2 - Detailed assessment: Section D - Impact

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.08	How important is the impact of the organism on biodiversity likely to be in the future in Ireland?	MAJOR	HIGH	The establishment of *Astacus leptodactylus* populations would represent a serious threat to the continued conservation of the indigenous White-clawed Crayfish in Ireland. 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 under it the Wildlife Act 1976 in Ireland. It is likely that both *Astacus leptodactylus* and our native crayfish species would occupy similar ecological niches and habitats and it is considered that *Astacus leptodactylus* will out-compete and displace the native crayfish due to its relatively large size and faster growing character (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 future?	MODERATE	LOW	As 'ecosystem engineers', crayfish species have the ability to alter ecosystem function through food-web or habitat modification (Jones *et al*. 1997). The degree of change would likely depend on the extent of colonisation.
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 future in Ireland?	MAJOR	HIGH	The establishment of *Astacus leptodactylus* may have detrimental impacts on our 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 the conservation status under the EU Habitats Directive.

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.13	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within its global distribution?	MINOR	LOW	According to GB Non-Native Species Secretariat (2011), "Only impact would be on angling and aquatic macrophytes. Non-native crayfish species are prolific and do attain high population densities. This can affect angling in two ways; firstly by competing with the fish for available food and secondly by taking bait directly from anglers hooks (Holdich 2000). High population densities would also remove aquatic macrophytes resulting in a loss of fish spawning sites, habitat deterioration and an aesthetic impact."
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 successfully interbreed with the White-clawed Crayfish (Holdich *et al*. 1995).
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)?			Like all non-American Astacidae, *Astacus leptodactylus* is susceptible to crayfish plague (Souty-Grosset *et al*. 2006). Infected susceptible crayfish generally die in about 2-3 weeks, but up to death they can spread the zoospores of the plague (J. Reynolds pers. comm.). *Astacus leptodactylus* is believed to show some resistance to the plague, as mortalities are sometimes less severe (Kokko *et al*. 2012; Schrimpf *et al*. 2012). Therefore some plague-infected *Astacus leptodactylus* may not die, but remain infective vectors (Schrimpf *et al*. 2012). This could pose an added threat to the White-clawed Crayfish. *Astacus leptodactylus* is known as a non-specific prey item of the invasive North American Mink (reviewed in GB Non-Native Species Secretariat 2011), which is already established in the wild in Ireland.
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	

Stage 2 - Detailed assessment: Section D - Impact

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.18	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?	MODERATE	HIGH	Natural control by other organisms (bar the crayfish plague) is unlikely to influence expected impacts (i.e. displacement of the native White-clawed Crayfish).
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 *Astacus leptodactylus* could establish (i.e. non-acidic freshwaters such as lakes, reservoirs, canals, rivers, ponds and streams) and brackish waters such as lagoons, estuaries). There are an abundance of such waters in Ireland. The conservation 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 *Astacus leptodactylus* in Ireland is the threat it poses to the native White-clawed crayfish.

Stage 2 - Detailed assessment: Section E - Conclusion

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.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
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.

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.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
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 *et al*. 2008). *Astacus leptodactylus* is subject to a range of climatic condition throughout its global distribution. As it originates in the Caspian-Black Sea area, and occurs mostly in southern parts of Europe increases in water temperature would probably favour its spread.
6.02	What is the likely timeframe for such changes (5, 10, 15 , 20, 50 or 100 years)?	UNKNOWN	LOW	
6.03	What aspects of the risk assessment are most likely to change as a result of climate change			Refer to response to Question 6.01 above.
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.			As *Astacus leptodactylus* is not present in the wild in Ireland, it is difficult to comprehensively evaluate the socio-economic, economic and environmental impacts that this species may have. There is a paucity of information available on its impacts where it was recently introduced. Further analyses in this regard would be useful. There is also a lack of published studies on its ecology and much of this is in the Russian or Ukrainian languages (Souty-Grosset *et al*. 2006).

References

Cosgrove, P.J., Maguire, C.M. and Kelly, J. (2008). Non-native crayfish exclusion strategy and contingency plan. Prepared for NIEA and NPWS as part of Invasive Species Ireland pp. 10.

Desmond, M., O'Brien, P. and McGovern, F. (2008). A Summary of the State of Knowledge on Climate Change Impacts for Ireland. EPA Climate Change Research Programme 2007-2013. Environmental Protection Agency, Wexford pp. 20.

Füreder, L., Gherardi, F., Holdich, D., Reynolds, J., Sibley, P. and Souty-Grosset, C. (2010). *Austropotamobius pallipes*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. (accessed 12/02/2014).

GB Non-Native Species Secretariat (2011). GB non-native risk assessment scheme: *Astacus leptodactylus*. Food and Environment Research Agency, UK. https://secure.fera.defra.gov.uk/nonnativespecies/ (accessed 12/02/2014).

Gherardi, F. and Souty-Grosset, C. (2010). *Astacus leptodactylus*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. (accessed 12/02/2014).

Gledhill, T., Sutcliffe, D.W. and Williams, W.D. (1993). British Freshwater Crustacea Malacostraca: A key with Ecological Notes. Freshwater Biological Association Scientific Publication Number 52.

Harlıoğlu, M.M. (2004). The present situation of freshwater crayfish, *Astacus leptodactylus* (Eschscholtz, 1823) in Turkey. *Aquaculture* 230:181–187.

Holdich, D.M., (1995). Interactions between three species of crayfish (*Austropotamobius pallipes*, *Astacus leptodactylus* and *Pacifastacus leniusculus*) *Freshwater Crayfish* 10:46-56.

Holdich D.M. (2000). The introduction of alien crayfish species into Britain for commercial exploitation – an own goal? *Crustacean Issues* 12:85–97.

Holdich, D.M. and Sibley, P.J. (2009). ICS and NICS in Britain in the 2000s. Crayfish Conservation in the British Isles. pp. 13-33.

Holdich, D.M., Reader, J.P., Rodgers, W.D. and Harlıoğlu, M.M. (2002). Distribution of crayfish in Europe and some adjoining countries. *Bulletin Francais de la Peche et de la Pisciculture* 367:611-65.

Jones, C.G., Lawton, J.H. and Shachak, M. (1997). Positive and negative effects of organisms as physical ecosystem engineers. *Ecology* 78:1946-1957.

Kelly, J., O'Flynn, C. and Maguire, C. (2013). Risk analysis and prioritisation for invasive and non-native species in Ireland and Northern Ireland. A report prepared for the Northern Ireland Environment Agency and National Parks and Wildlife Service as part of Invasive Species Ireland. 59 pp.

Kokko, H., Koistinen, L., Harlioğlu, M.M., Makkonen, J., Aydın, H. and Jussila, J. (2012). Recovering Turkish narrow clawed crayfish (Astacus leptodactylus) populations carry Aphanomyces astaci. *Knowledge and Management of Aquatic Ecosystems* 404(12):1-7.

Matthews, M.A. and Reynolds, J.D. (1992) Ecological impact of crayfish plague in Ireland. *Hydrobiologia* 234:1-6.

National Biodiversity Data Centre (2013). Concern as potentially invasive Turkish crayfish continues to be for sale in Ireland http://invasives.biodiversityireland.ie/invasive-turkish-crayfish/ (accessed 14/02/2014).

Reynolds, J.D. (1998). Conservation management of the white-clawed crayfish, *Austropotamobius pallipes.* Part 1. Irish Wildlife Manuals, No. 1. 33 pp.

Reynolds, J. (2010). White-clawed Crayfish in Ireland - under increasing threat In: Rees M, Nightingale J, Holdich DM (eds.) (2011). Species Survival: Securing white-clawed crayfish in a changing environment. Proceedings of a conference held on 16th and 17th November 2010 in Bristol, UK.

Reynolds, J.D. and O'Keeffe, C. (2009). Protect Ireland Crayfish. National Parks and Wildlife Service, Dublin 2. 2 pp.

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

Schrimpf, A., Pârvulescu, L., Copilaş-Ciocianu, D., Petrusek, A. and Schul, R. (2012). Crayfish plague pathogen detected in the Danube Delta – a potential threat to freshwater biodiversity in south-eastern Europe. *Aquatic Invasions* 7(4):503–510.

Souty-Grosset, C., Holdich, D.M., Noël, P.Y., Reynolds, J.D. and Haffner, P. (eds) (2006). Atlas of Crayfish in Europe. Muséum National d'Histoire Naturelle, Paris, 187 pp. (Patrimoines naturels, 64).