Risk Assessment of *Leuciscus cephalus*

Name of Organism:	*Leuciscus cephalus* Linnaeus 1758 – Chub
Objective:	Assess the risks associated with this species in Ireland
Version:	Final 15/09/2014
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Expert reviewer	Rob Britton

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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

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Version Control Table

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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?	YES*	The most used scientific names for the organism are *Leuciscus cephalus* (Linnaeus 1758) and *Squalius cephalus* (Linnaeus 1758), with the latter name now more frequently in use in the scientific literature. A comprehensive list by CABI (2014) gives the following other scientific names: *Cyprinus albula* (Nardo 1827), *Cyprinus cephalus* (Linnaeus 1758), *Cyprinus chub* (Bonnaterre 1788), *Cyprinus kietaibeli* (Reisinger 1830), *Cyprinus kittaibeli* (Reisinger 1830), *Cyprinus lugdunensis* (Walbaum 1792), *Cyprinus orthonotus* (Hermann 1804), *Cyprinus rufus* (Vallot 1837), *Cyprinus salmoneus* (Gronow 1854), *Leucalburnus kosswigi* (Karaman 1972), *Leuciscus albiensis* (Valencienne 1844), *Leuciscus albus* (non Bonaparte 1838), *Leuciscus brutius* (Costa 1838), and *Leuciscus cabeda* (Risso 1827). Chub, European Chub, Round Chub, English Chub, Vardar Chub (CABI 2014), Fat Chub, Chevin and Pollard. * According to CABI (2014), "many populations in the Mediterranean basin have attracted little attention and they have been uncritically identified as *S. cephalus* or dumped into a "*S. cephalus* complex" or "*S. cephalus* species group. Several peri-Mediterranean populations are now considered morphologically and genetically distinct enough to be considered valid species or subspecies. Some morphological characters may be difficult to identify in live fish and, in particular, in juveniles: therefore, genetic analysis is recommended for correct identification. The recent description of new species and the previous wide range of *S. cephalus* make the identification of introduced populations in Europe difficult."
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	

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
4	Describe the organism.		*Leuciscus cephalus* is a slender-bodied member of the carp family that reaches an average length of 30-45 cm (1.0-1.5 kg), although fish of up to 80 cm (*c.*7.5 kg) are known from mainland Europe. Its colour varies from grey-brown tinged with green along the back to the lighter colour of the flanks, which often have a golden hue, blending into the white of the belly. The scales are bordered with black or grey, and there are 44-46 scales along the lateral line. The pectoral, dorsal and caudal fins are dark brown while the pelvic and anal fins are a rich red or reddish brown colour. The outer margins of the dorsal and caudal fins are convex in shape and the tail is forked. The mouth is wide and lacks barbels (Newdick 1979; Invasive Species Ireland 2010).
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	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 *Leuciscus cephalus* as a 'high risk' invasive species.
6	If there is an earlier risk assessment is it still entirely valid, or only partly valid?	PARTLY VALID	Only a preliminary risk assessment was previously conducted in Ireland (refer to Question 5).
7	Where is the organism native?		*Leuciscus cephalus* is native to and widespread throughout much of mainland Europe, England, Wales and southern Scotland, and native to some parts of Asia (Newdick 1979; Froese and Pauly 2011). Specifically, it is native to the following countries: Andorra; Armenia; Austria; Azerbaijan; Belarus; Belgium; Bosnia and Herzegovina; Bulgaria; Croatia; Czech Republic; Denmark; England; Estonia; Finland; France; Georgia; Germany; Hungary; Iran; Italy (disputed with Froese and Pauly (2011) but considered native to northern and central parts of the country by Bianco (1990)); Kazakhstan; Latvia; Liechtenstein; Lithuania; Luxembourg; Macedonia; Moldova; Montenegro; Netherlands; Norway; Poland; Romania; Russian Federation; Serbia; Slovakia; Slovenia; Spain; Scotland (Newdick 1979); Sweden; Switzerland; Turkey; Turkmenistan and Ukraine; and Wales (Freyhof and Kottelat 2008).
8	What is the current global distribution of the organism (excluding Ireland)?		As above.
9	What is the current distribution of the organism in Ireland?		*Leuciscus cephalus* was not officially recorded in Ireland until 2005 when live specimens caught by anglers in the lower River Inny in the Irish midlands were verified by the Central Fisheries Board (now Inland Fisheries Ireland) (Caffrey *et al*. 2008). Previous to this, in 2001 and 2004, there were anecdotal reports of

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
			Leuciscus cephalus being caught by anglers in the same stretch of river (Caffrey *et al*. 2008). Extensive electrofishing and netting operations carried out on the River Inny and proximal area of Lough Ree (into which the River Inny discharges) by the Central Fisheries Board and Shannon Regional Fisheries Board (now amalgamated into Inland Fisheries Ireland) between 2006 and 2009 are believed to have removed most or all *Leuciscus cephalus* specimens from the river (Caffrey 2013). Since 2009, no *Leuciscus cephalus* specimens have been recorded in this river despite further intensive electrofishing operations, conducted annually (Caffrey 2013). Nor have any specimens been reported by anglers, who regularly fish the river for coarse fish. A single specimen of *Leuciscus cephalus* was captured in the Boyne Navigation in 2013 by an angler. This fish was presented to an IFI Fishery Officer, for identification. Photographs taken by the Officer confirmed that the fish was indeed *Leuciscus cephalus*. The area was surveyed by IFI research staff but no specimens were recorded. Nor have any further reports of *Leuciscus cephalus* being caught in this river been received by IFI. Previous to this, there were occasional unsubstantiated reports of *Leuciscus cephalus* being caught by anglers in the River Boyne (Gough 1989) where it was suspected that 30-40 specimens had been illegally introduced for angling purposes in the late 1970s (P. Bourke pers. comm.). There was a subsequent unconfirmed report of a specimen being caught in the 1980s by an angler but until 2013 (mentioned above), numerous surveys undertaken by the fisheries authorities in the river and the numerous angling events and fishing excursions that have taken place did not, to the knowledge of the authors, record any *Leuciscus cephalus* (P. Bourke pers. comm.; J. Caffrey pers. comm.).
10	Is the organism known to be invasive anywhere in the world?	NO	There are no reported incidences of *Leuciscus cephalus* introductions to waters outside of their natural range other than to Ireland (Invasive Species Ireland 2010), potentially to Italy (Bianco 1990; Kottelat and Freyhof 2007; CABI 2014) and to Loch Lomond in Scotland (Adams *et al*. 1990). However, invasiveness has not been documented in these populations. In Ireland, low propagule pressure was likely to have limited the probability of populations establishing and becoming invasive (Caffrey *et al*. 2008; Caffrey 2013).

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)?	FEW	VERY HIGH	Illegal stocking for angling, and use of live bait for pike angling. *Leuciscus cephalus* occasionally appear in England in cold water aquarium fish shops, but it is rare (R. Britton pers. comm.), so this potential pathway is not considered further in the present risk assessment.
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. Illegal stocking for angling; 2. Live bait for pike angling.		

Pathway 1 - Illegal stocking for 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)?	INTENTIONAL	VERY HIGH	It is suspected that *Leuciscus cephalus* was illegally introduced to the River Inny by anglers in an effort to increase the diversity of coarse angling species available in Ireland and make an unauthorised attempt to establish a local population for angling (Caffrey *et al*. 2008). The specimen confirmed in the Boyne Navigation is also likely to have been introduced for angling.
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	The presence of *Leuciscus cephalus* has only been confirmed at two locations in Ireland, suggesting a low frequency of deliberate introductions to date.

Pathway 1 - Illegal stocking for angling				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	It is very likely that consignments of *Leuciscus cephalus* can enter Ireland without the knowledge of the relevant competent authorities as knowledge to correctly identify such fish species at points of entry to the country is low (Invasive Species Ireland 2010). By its nature, the transport of such fish from abroad *via* a road vehicle and ferry crossing could easily be concealed from the authorities. IFI is aware of many instances of live fish being introduced illegally by anglers travelling from the UK.
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	VERY HIGH	As the organism would be deliberately transported in an aquatic environment to keep the fish alive, survival is very likely.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY HIGH	There is no known seasonal restriction to inhibit the establishment of *Leuciscus cephalus* after introduction to a water. This is evident from their survival over a number of years in the River Inny (Caffrey *et al*. 2008; Caffrey 2013).
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	In Ireland there is an abundance of suitable waters in which *Leuciscus cephalus* could establish (Caffrey *et al*. 2008). The species typically inhabits rivers with a moderate flow, but can also be found in streams, reservoirs and lakes (where they can migrate to inflowing streams to spawn) (Kottelat and Freyhof 2007; CABI 2014). Juvenile fish form shoals in shallow water whereas larger fish tend to be solitary (reviewed in Caffrey *et al*. 2008). They tend to spawn in moderate to fast flowing sections of shallow rivers or streams with coarse gravels (Kottelat and Freyhof 2007; reviewed in Caffrey *et al*. 2008).
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	VERY LIKELY	VERY HIGH	It has already been deliberately introduced to Ireland *via* this pathway (Caffrey *et al*. 2008).
1.10	Do other pathways need to be considered?	YES		

Pathway 2 – Live bait for pike 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)?	INTENTIONAL	VERY HIGH	There have been no confirmed cases of the use of *Leuciscus cephalus* as live bait for pike angling in Ireland.
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	See above.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	It is very likely that consignments of *Leuciscus cephalus* can enter Ireland without the knowledge of the relevant competent authorities as knowledge to correctly identify such fish species at points of entry to the country is low (Invasive Species Ireland 2010). By its nature, the transport of such fish from abroad *via* a road vehicle and ferry crossing could easily be concealed from the authorities.
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	HIGH	The intention would be to keep the fish alive during transit for subsequent use as live bait for angling.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	HIGH	Refer to Question 1.07 (Pathway 1).
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	Refer to Question 1.08 (Pathway 1). In addition, there is the potential for escape of live (and relatively unharmed) fish from the hook while being used as live bait. More probable is the dumping of unused live bait into a recipient water after the conclusion of an angling excursion.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	MODERATELY LIKELY	HIGH	This pathway depends on the illicit movement of *Leuciscus cephalus* for use as live bait into the region from abroad. There are no confirmed cases of the use of *Leuciscus cephalus* as live bait for angling to date in Ireland.
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).	VERY LIKELY	VERY HIGH	The primary pathway of entry into Ireland is through deliberate illegal stocking of *Leuciscus cephalus* by anglers to establish a population to exploit for angling and increase the diversity of fish species available for fishing in the country.

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	*Leuciscus cephalus* is considered to be eradicated or its numbers very significantly depleted in the River Inny (Caffrey 2013) and their status in the River Boyne remains uncertain (see response to Question 9 for further information). Inland Fisheries Ireland will continue to monitor both the Rivers Inny and Boyne for *Leuciscus cephalus* over the next number of years (J. Caffrey pers. comm.).
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	*Leuciscus cephalus* encounters a wide variety of climatic conditions throughout its global range and populations are present in England, Scotland and Wales (Adams *et al*. 1990; Froese and Pauly 2011). In Britain, a minimum water temperature of 15^{o}C is required to induce spawning activity (Cowx 2001), which indicates Irish waters are suitable for reproduction (Caffrey *et al*. 2008). The growth rate of *Leuciscus cephalus* in the River Inny was demonstrated to be comparable to that recorded for English populations and was fast when compared to established *Leuciscus cephalus* populations in rivers in mainland Europe (Caffrey *et al*. 2008). These factors suggests that Irish climatic conditions will not inhibit the establishment of *Leuciscus cephalus* in suitable freshwaters throughout Ireland and their demonstrated survival over a number of years in the River Inny (Caffrey *et al*. 2008; Caffrey 2013) further supports this.
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	There are no significant overriding abiotic factors present in Ireland to limit the establishment of this species. There is an abundance of freshwater habitats considered suitable for establishment in Ireland (refer to response to Question 1.08 (Pathway 1)).
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 Ireland, there is an abundance of freshwater habitats suitable for the survival and development of *Leuciscus cephalus* (refer to response to Question 1.08 (Pathway 1)). Conditions are generally considered suitable for reproduction in Ireland (Caffrey *et al.* 2008). Local reproductive capacity will depend on the availability of suitable spawning habitat but the species can migrate long distances to spawning areas (R. Britton pers. comm.). Their presence in the River Inny could have facilitated eventual natural spread throughout the Irish midlands, mid-west and north-west as the Inny system is a sub-catchment of the River Shannon system. Further spread to the south-east and south *via* the Grand Canal and Barrow Navigation was also a possibility.

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
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	LIKELY	VERY HIGH	In general, competition from native and naturalised fish species is considered unlikely to inhibit establishment. Having said that, it is feasible to assume that in waters supporting healthy pike populations, the establishment or spread of introduced *Leuciscus cephalus* may be severely curtailed by pike predation (and this may have been a factor in the low abundance of *Leuciscus cephalus* recorded in the River Inny). In the River Inny, roach, perch, pike, brown trout, roach x bream hybrids, rudd x bream hybrids, gudgeon, bream, minnow and stone loach are resident (Caffrey *et al*. 2008). Brown trout primarily occupy the habitat where *Leuciscus cephalus* was resident - an 0.8 km section of the river which was wide, shallow, moderately fast flowing, sparsely vegetated and had a substrate of coarse gravel (Caffrey *et al*. 2008).
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?	MODERATELY LIKELY	MEDIUM	It is considered likely that parasites or pathogens of *Leuciscus cephalus* present in Ireland will not have an effect on their establishment. Pike and mink are likely to prey on *Leuciscus cephalus* in Ireland as it is known to do so elsewhere (e.g. Alp *et al*. 2008 and Bartoszewicz and Zalewski 2003, respectively) as are some piscivorous waterfowl (CABI 2014). As stated above, it is feasible to assume that in waters supporting healthy pike populations, the establishment or spread of introduced *Leuciscus cephalus* may be severely curtailed by pike predation (and this may have been a factor in the low abundance of *Leuciscus cephalus* found in the River Inny).
2.07	How likely is it that establishment will occur despite existing management practices?	MODERATELY LIKELY	VERY HIGH	The standard policy within Inland Fisheries Ireland (IFI) is to develop, manage and protect native and naturalised fish species and to actively monitor and control the introduction and spread of non-native species (Caffrey *et al*. 2008). IFI and its predecessors have actively sought to eradicate *Leuciscus cephalus* where it has occurred in Ireland and will continue to do so to prevent any establishment, in addition to creating awareness among anglers and other stakeholders of the threat from potentially invasive, non-native aquatic species (Caffrey 2013). Nevertheless, illegal introductions for angling purposes may undermine this management policy.

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
2.08	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?	MODERATELY LIKELY	MEDIUM	The success of the control/eradication operations in the River Inny demonstrated that a targeted, comprehensive and sustained fish removal programme can prevent the successful establishment of *Leuciscus cephalus,* particularly where this is implemented before the fish become widely distributed in a catchment (Caffrey 2013). However, if the species become widely distributed over time and reproduces successfully, eradication campaigns are highly unlikely to be successful. There is some evidence to suggest that *Leuciscus cephalus* may not disperse widely following an introduction (Bollard *et al*. 2008). However, migrations of more than 100 km can occur during the spawning season (Riede 2004 as cited in CABI 2014).
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	LIKELY	VERY HIGH	*Leuciscus cephalus* has already demonstrated its capacity to survive and establish in the River Inny in Ireland (Caffrey *et al*. 2008; Caffrey 2013). According to CABI, *Leuciscus cephalus* "has ecological characteristics associated with invasiveness. It is omnivorous and its food sources range from small (i.e. detritus, plants, invertebrates) to large (i.e. tadpoles, small fish) items. In addition it has high fecundity, fast growth rate, and is considered tolerant of anthropogenic pressures."
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	LIKELY	VERY HIGH	Although there is some evidence to suggest that *Leuciscus cephalus* may not disperse widely following an introduction (Bollard *et al*. 2008), once a founder population establishes, natural spread is considered inevitable over time. Migrations of more than 100 km can occur during the spawning season (Riede 2004 as cited in CABI 2014).
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	VERY LIKELY	VERY HIGH	*Leuciscus cephalus* can inhabit a range of freshwater environments in Ireland (Caffrey *et al*. 2008), which increases its potential for establishment.
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	UNKNOWN	LOW	There is no information available to assess this.

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
2.14	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	It has already demonstrated this capacity in Ireland.
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	VERY LIKELY	VERY HIGH	There is some potential for transient populations to occur if reproduction capacity is low in Ireland. The apparent introduction of 30-40 *Leuciscus cephalus* specimens to the River Boyne in the 1970s (P. Bourke pers. comm.) could, in theory, suggest a low potential for establishment as no discernable population appears to have developed and, to date, only a single specimen has been officially documented in this river.
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	VERY LIKELY	VERY HIGH	Overall, it is considered very likely that *Leuciscus cephalus* can establish in Ireland (Caffrey 2013). The survival of this species prior to control/eradication in the River Inny and its prevalence in England, Scotland and Wales supports this assertion (Newdick 1979; Adams *et al.* 1990).

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%)?	34% - 67% (of 10 km squares)	VERY HIGH	*Leuciscus cephalus* has the potential to establish populations in many rivers, streams , canals, reservoirs and lakes in Ireland. In some of these waters, reproduction may be limited by the availability of suitable spawning habitat unless the fish can migrate to suitable areas for spawning (R. Britton pers. comm.) (refer to responses to Question 1.08 (Pathway 1) and Question 2.04).
3.02	How important is the expected spread of this organism in Ireland by natural means (minimal, minor, moderate, major or massive)?	MODERATE TO MAJOR	HIGH	Within catchments, dispersal by natural movements is considered inevitable. Spread to interconnected catchments is also possible (e.g. from Shannon to Barrow *via* the Grand Canal). As mentioned previously, migrations of more than 100 km can occur during the spawning season (Riede 2004 as cited in CABI 2014).
3.03	How important is the expected spread of this organism in Ireland by human assistance (minimal, minor, moderate, major or massive)?	MAJOR	VERY HIGH	Illegal introductions have occurred in Ireland (Caffrey *et al*. 2008) and are likely to be the principal mechanism responsible for inter-catchment spread in future.
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MODERATE to MAJOR	MEDIUM	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. In general, containment would be moderately difficult but feasible in a closed or semi-closed system (i.e. land-locked water or locked canal) but much more difficult in an open water system (e.g. river catchment or large lake). Despite being an open system, the species is believed to have been significantly controlled or eradicated from the River Inny after a sustained programme of control and monitoring measures were undertaken (Caffrey 2013).
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	0% -10%	VERY HIGH	Refer to Question 9.
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)?	0% -10%	HIGH	This is solely dependent on the frequency of future illegal introductions, which have been uncommon 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
3.07	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.	10 years	HIGH	This is solely dependent on the frequency of future illegal introductions which have been uncommon to date.
3.08	In this timeframe, what proportion of the endangered area (including any currently occupied areas) is likely to have been invaded by this organism?	0% - 10%		Refer to Question 3.07.
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.	-	-	In Ireland, there is an abundance of suitable waters for *Leuciscus cephalus* to establish in (refer to response to Question 1.08 (Pathway 1)). In some of these waters, reproduction may be limited by the availability of suitable spawning habitat unless the fish can migrate to suitable areas for spawning (R. Britton pers. comm.)
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 .	MODERATELY	MEDIUM	This is solely dependent on the frequency of future illegal introductions which have been uncommon 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
4.01	How great is the economic loss caused by the organism within its global distribution (excluding Ireland), including the cost of any current management?	MINIMAL	HIGH	Globally, costs are minimal as this species is native to the majority of its range.
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.	NONE	VERY HIGH	In Ireland, the species was significantly controlled or eradicated from the River Inny before it had the potential to become invasive and cause any economic impacts (Caffrey 2013). No such impacts have been reported from the River Boyne where only a single specimen has been confirmed 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.	MODERATE	MEDIUM	The potential impacts of *Leuciscus cephalus* on the Irish economy are those associated with the introduction of fish diseases and parasites, a reduction in the quality of Irish game and potentially coarse fisheries and impacts arising from the decline of Irish salmonid fisheries (Caffrey *et al*. 2008; Invasive Species Ireland 2013; Caffrey 2013).
4.04	How great have the economic costs of managing this organism been in Ireland from the time of introduction to the present?	MINOR	VERY HIGH	Specific information is not available. Routine economic costs have been incurred as a result of eradication and monitoring programmes conducted, principally on the River Inny catchment (Caffrey *et al*. 2008; Caffrey *et al*. 2013) and the River Boyne.
4.05	How great is the economic cost of managing this organism likely to be in the future in Ireland?	MODERATE / MAJOR	MEDIUM	Further to Question 4.03, this is dependent on amount of future introductions, spread and population densities attained in Ireland. Costs are likely to be incurred through eradication, control and monitoring programmes.
4.06	How important is environmental harm caused by the organism within its global distribution?	MINIMAL	HIGH	According to CABI (2014), "The introduction of exotic species may cause hybridization with native species, predation, resource competition and antagonistic behaviour with native species and/or the introduction of diseases. Chub does not represent a risk for humans but it may cause changes to ecosystems (i.e. altering food web structures) and it may predate on native species. Studies on the effects of chub on native fish species are lacking." The primary reason for a paucity of information on the impacts of *Leuciscus cephalus* globally is likely to be because they are native throughout the majority of their global range. No negative impacts have been reported for *Leuciscus cephalus* in Ireland, likely as a result of their low abundance, eradication and restricted occurrence to date (Caffrey 2013).

Stage 2 - Detailed assessment: Section D - Impact

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.07	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	MINIMAL	HIGH	The low numbers of *Leuciscus cephalus* in the River Inny prior to eradication were unlikely to cause impacts to biodiversity.
4.08	How important is the impact of the organism on biodiversity likely to be in the future in Ireland?	MODERATE	MEDIUM	This is dependent on level of future introductions, spread and population densities attained in Ireland. The absence of suitable controls on the origins and health status of illegally imported *Leuciscus cephalus* gives a risk of associated diseases and parasites being introduced into Ireland. These have the potential to infect cyprinid and other fish populations in Irish waters. There is also the potential for *Leuciscus cephalus* to hybridise with some coarse fish species, notably roach, rudd and dace. Salmon and Brown Trout are considered to be at risk from direct competition with *Leuciscus cephalus* (Caffrey *et al*. 2008; Invasive Species Ireland 2010; Caffrey 2013). Brown Trout and juvenile Salmon occupy habitats utilised by *Leuciscus cephalus* and their dietary range overlaps (Caffrey *et al*. 2008; Invasive Species Ireland 2010; Caffrey 2013). Other conservationally important native fish such as rare strains of Brown Trout (e.g. in Lough Melvin), Pollan and Arctic Char may also be threatened by the introduction of *Leuciscus cephalus* (Caffrey *et al*. 2008; Invasive Species Ireland 2010; Caffrey 2013). The wide range of food items consumed by *Leuciscus cephalus* at different stages of its life cycle means that there is also the potential for direct competition with other fish species and for unpredictable and potentially significant ecological changes to occur (Invasive Species Ireland 2010; Caffrey 2013). Overall, these impacts have the potential to undermine recreational coarse and salmonid fisheries in Ireland and, ultimately, the economic activities that are supported by them (Caffrey *et al*. 2008; Invasive Species Ireland 2010; Caffrey 2013).
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	MINIMAL	HIGH	The low numbers of *Leuciscus cephalus* in the River Inny prior to control/eradication were unlikely to affect ecosystem function.

Stage 2 - Detailed assessment: Section D - Impact

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the future?	MODERATE / MAJOR	HIGH	Refer to response to Question 4.08.
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.	MINIMAL	HIGH	There has been no decline in conservation status caused by *Leuciscus cephalus* in Ireland to date, specifically due to its limited occurrence and low population density.
4.12	How important is decline in conservation status caused by the organism likely to be in the future in Ireland?	MODERATE / MAJOR	HIGH	Refer to response to Question 4.08.
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?	MINIMAL	VERY HIGH	No such impacts have been reported (CABI 2004), principally as it is native throughout the majority of its global range.
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	MINIMAL	VERY HIGH	No such impacts have been reported, specifically due to its limited occurrence and low population density.
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	VERY HIGH	Highly unlikely - there is no evidence for this.
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)?	MINIMAL	HIGH	Refer to response to Question 4.08.

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.17	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	All known or potential impacts have been covered elsewhere in this document.
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?	MINIMAL	HIGH	It is likely that *Leuciscus cephalus* is not naturally controlled by any parasite or pathogen in Ireland. Although, it is possible some predation by pike could occur where both species overlap, which in theory, has the potential to limit establishment or population density (refer to response to Question 2.06).
4.19	Indicate any parts of Ireland 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.		MEDIUM	In Ireland, there is an abundance of freshwaters in Ireland suitable for *Leuciscus cephalus*. The potential for the species to disperse naturally within catchments and into linked catchments, if it was to become established, is high and this may be exacerbated by anthropogenic-mediated transfers for angling purposes. Juvenile Salmon and Brown Trout populations are considered particularly vulnerable to the establishment of *Leuciscus cephalus* populations for the reasons outlined in response to Question 4.08 (Caffrey *et al*. 2008; Invasive Species Ireland 2010; Caffrey 2013).
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MODERATE	MEDIUM	This is dependent on amount of future introductions, spread and population densities attained in Ireland. Juvenile Salmon and Brown Trout populations are considered particularly vulnerable to the establishment of *Leuciscus cephalus*. A 'moderate' response and 'medium confidence' are given in this risk assessment as there is some uncertainty on the actual impacts that could occur due to a paucity of invasion information to review in the literature.

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).	MODERATE	MEDIUM	This is dependent on amount of future introductions, spread and population densities attained in Ireland. Juvenile Salmon and Brown Trout populations are considered particularly vulnerable to the establishment of *Leuciscus cephalus*. A 'moderate' response and 'medium confidence' are given in this risk assessment as there is some uncertainty on the actual impacts that could occur due to a paucity of invasion information to review in the literature.

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?		LOW	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). It is uncertain how this may affect the establishment, spread or impacts of *Leuciscus cephalus* in Ireland. It is possible that warmer water temperatures in the summer may increase the growth and survival of *Leuciscus cephalus* (Nunn *et al*. 2003; Nunn *et al*. 2007). A reduction in the frequency of high water discharge) in nursery areas in summer may also positively affect recruitment by reducing related mortality or stress (Nunn *et al*. 2003; Nunn *et al*. 2007).
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	UNKNOWN	HIGH	Refer to Question 6.01.
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.			The primary reason for a paucity of information on the impacts of *Leuciscus cephalus* globally is likely to be because they are native throughout the majority of their global range. The status of *Leuciscus cephalus* in the River Boyne will be ascertained by IFI. Further electrofishing and netting surveys on the River Inny will also be conducted. Any other anecdotal reports by anglers of its presence in other catchments in Ireland should be explored further.

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