RISK ASSESSMENT SUMMARY SHEET

Gibel carp (*Carassius gibelio*)

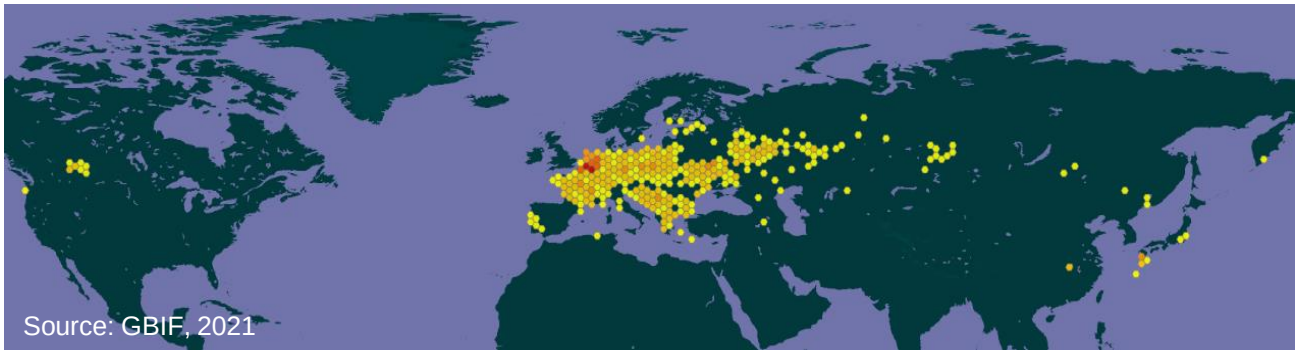
- A deep-bodied fish which grows to about 4-14 inches in length. Usually silver, sometimes with a faint golden tinge.
- Native to Siberia, East Asia and areas in Central Europe. There is no definite data on original distribution in Europe due to introduction, confusion with *Carassius auratus* and complex modes of reproduction.
- Invaded countries include Belgium, Turkey & Hungary. It is also present in North America.
- Not thought to be established in GB; however, there are unconfirmed reports that populations have been found in recent years.

Photograph: George Chernilevsky, Wikimedia

History in GB

Thought not to be established in GB, but recent reports from the angling community suggest populations may be present (yet to be publicly confirmed). It is established in Europe and considered invasive in at least Belgium, Czech Republic, Greece and Estonia.

Global Distribution



Impacts

Environmental (major, medium confidence)

- Can become dominant in some water bodies, outcompeting native fish.
- Has been recorded causing significant reductions in native fish populations in Europe, including to cyprinids, though no extirpations.
- Increases turbidity.
- Could threaten the status of other C*arassius* species via genetic introgression given that they are able to hybridise easily.

Economic (moderate, low confidence)

- Poorly quantified; however, it can be problematic in aquaculture where it competes with more valuable fish.
- Could impact on recreational fisheries in GB.

Societal (minimal, moderate)

- Limited evidence. There is speculation of impacts on the income of fishermen.

Introduction pathway

Intentional introduction is considered unlikely because it is illegal and there is little incentive to do so.

Contaminant of fish consignment is moderately likely.

Spread pathway

Natural: (moderate, medium confidence) - downstream dispersal (especially of drifting larvae and juveniles) if they are released into open waters - though introduction into a pond/lake for angling is more likely.

Human: (major, high confidence) – easily misidentified as *C. carassius* or *C. auratus* and moved between waters (as in Belgium).

Summary

	Response	Confidence
Entry	MODERATE	LOW
Establishment	LIKELY	HIGH
Spread	MODERATE	MEDIUM
Impact	MAJOR	MEDIUM
Overall risk	MEDIUM	MEDIUM

RISK ASSESSMENT COVERING PAGE - ABOUT THE PROCESS

It is important that policy decisions and action within Great Britain are underpinned by evidence. At the same time it is not always possible to have complete scientific certainty before taking action. To determine the evidence base and manage uncertainty a process of risk analysis is used.

Risk analysis comprises three component parts: risk assessment (determining the severity and likelihood of a hazard occurring); risk management (the practicalities of reducing the risk); and risk communication (interpreting the results of the analysis and explaining them clearly). This tool relates to risk assessment only. The Non-native Species Secretariat manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. During this process risk assessments are:

- Commissioned using a consistent template to ensure the full range of issues is addressed and maintain comparable quality of risk and confidence scoring supported by appropriate evidence.
- Drafted by an independent expert in the species and peer reviewed by a different expert.
- Approved by the NNRAF (an independent risk analysis panel) only when they are satisfied the assessment is fit-for-purpose.
- Approved by the Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAF and Programme Board if necessary.

Common misconceptions about risk assessments

The risk assessments:

- Consider only the risks (i.e. the chance and severity of a hazard occurring) posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They also only consider only the negative impacts of the species, they do not consider any positive effects. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Are advisory and therefore part of the suite of information on which policy decisions are based.
- Are not final and absolute. They are an assessment based on the evidence available at that time. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

Period for comment

Once placed on the NNSS website, risk assessments are open for stakeholders to provide comment on the scientific evidence which underpins them for three months. Relevant comments are collated by the NNSS and sent to the risk assessor for them to consider and, if necessary, amend the risk assessment. Where significant comments are received the NNRAF will determine whether the final risk assessment suitably takes into account the comments provided.

To find out more: published risk assessments and more information can be found at http://www.nonnativespecies.org/index.cfm?pageid=143

GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Name of organism: Gibel carp, *Carassius gibelio* (Bloch, 1782)
Author: Robert Britton, Bournemouth University
Risk Assessment Area: Great Britain (England, Scotland, Wales and their islands)
Version: Draft 1 (January 2021), Peer reviews (Feb and Apr 2021), NNRAP 1 (Apr 2021), Draft 2 (Jul 2021), NNRAF 2 (Jul 2021), Draft 3 (Sep 2021), NNRAF (Nov 2021), Draft 4 (Dec 2021)
Signed off by NNRAF: November 2021
Approved by Programme Board: January 2023
Placed on NNSS website: January 2024

What is the principal reason for performing the Risk Assessment?

This species has spread across Europe in recent years, where negative impacts on native fish species have been reported. There is concern that this could also happen in GB, especially with suggestions that the species is likely to be present already.

SECTION A – Organism Information		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**COMMENT**
1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	Gibel carp (*Carassius gibelio*) (Bloch, 1782). Yes (*cf*. Kottelat 1997; Rylková et al. 2013). Gibel carp is also known as Prussian carp. Yes, but note there have been concerns over their identification with other species of the *Carassius* genus, crucian carp *Carassius carassius* and goldfish *Carassius auratus,* including the possibility of hybridisation. It has also been posited that *Carassius auratus* represents a complex comprising a number of forms of different taxonomic status, including *Carassius auratus gibelio* (wild form) and *Carassius auratus auratus* (ornamental form that can occur in the wild) (Lusková et al. 2010). Thus, there has been debate over whether gibel carp is a species in its own right, a subspecies of goldfish or whether it may be of hybrid origin (Hänfling et al. 2005). Genetic analyses by Hänfling et al. (2005) concluded that it was impossible to verify whether pure gibel carp existed across three populations sampled from European waters or whether the term 'gibel' carp relates to an assemblage of lineages of different origins. Notwithstanding, Kottelat & Freyhoff (2007) treated goldfish (*C. auratus*) and gibel carp (*C. gibelio*) as two separate species. Gibel carp is also listed on www.Fishbase.de as *Carassius gibelio*, with *Carassius auratus gibelio* being a synonym (Froese & Pauly, 2019). Kalous et al. (2012) suggest that *C. gibelio* is made up of two clades so is not monophyletic. Therefore, for the purposes of this risk assessment, gibel carp *Carassius gibelio* is being considered as a single taxonomic entity that differs from *Carassius carassius* and *Carassius auratus*. It is acknowledged that within this risk assessment, some of the literature used could actually be referring to *Carassius* hybrid forms or *C. auratus* (Rylková et al. 2010). However, as these fish have high morphological and functional similarity with *C. gibelio*, then this is not considered to be a major issue in the context of describing their environmental impacts.	

2. If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	Please see comments above. While it is acknowledged that there has been taxonomic ambiguity, it is not considered that a re-definition is required at this stage.
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	Yes - there are risk screening scores for the species within Copp et al. (2009), Britton et al. (2010), Almeida et al. (2013), Matthews et al. (2017) and Vilizzi et al. (2019). These are all nested within larger peer-reviewed journal articles. All suggest high risk.
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Yes
5. Where is the organism native?	The native range includes Siberia and East Asia (including China), and areas in Central Europe. In Fishbase.org (https://www.fishbase.de/Country/CountryList.php?ID=6376&GenusName=Carassius&SpeciesName=gibelio), countries where the species has been listed as native include Armenia, Austria, Bulgaria, Bosnia, China, Estonia, Georgia, Greece, Croatia, Hungary, Kazakhstan, Lithuania, Latvia, Modova, Russia, Romania, Serbia, Slovakia, Ukraine and Turkmenistan. However, their native range in Central Europe is more ambiguous, as Grabowska et al. (2010) suggest they are non-native to Poland, despite earlier reports that they are native. In Hungary, Tóth (1975) suggest they are introduced. As such, there is some ambiguity/ uncertainty on the western extent of their native range.
6. What is the global distribution of the organism (excluding the risk assessment area)?	*C. gibelio* is distributed in Europe and Asia: it is usually considered as native from central Europe to Siberia, or introduced to European waters from eastern Asia. Clear and definite data on original distribution in Europe are not available due to introductions, confusion with *Carassius auratus*, and complex modes of reproduction (e.g. Verreycken et al. 2007; also see Q5). At present, it is widely distributed and commonly stocked together with *Cyprinus carpio* which is transported throughout Europe. *Carassius gibelio* is also present in North America (e.g. Elgin et al. 2014; Docherty et al. 2017). Invaded countries include Belgium, Turkey and Hungary.

7. What is the distribution of the organism in the risk assessment area?	It has not been considered as present in the past. However, it has been indicated recently that the organism is present in the risk assessment area by the crucian carp angling community, where there is the suggestion of an isolated community present in Southern England (Copp & Sayer 2020). This still requires confirmation (e.g. by genetics with an accompanying peer-reviewed article). Correspondingly, for the purposes of this risk assessment, the species is considered as not present. This confirmation remains important, given there remains some ambiguity in the taxonomy and identification of species the *Carassius* genus (e.g. Jakovlić & Gui, 2011).
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes. Gibel carp has been listed in the top 27 alien species introduced into Europe for aquaculture and fisheries, where negative ecological impacts have been recorded in every country where it has been introduced (Savini et al. 2010). It is considered invasive in countries including Turkey (Tarkan et al. 2012a,b; Karakuş et al. 2013; Yerli et al. 2014), Sweden (Wouters et al. 2012), Belgium (Verreycken et al. 2007), the Czech Republic (Lusková et al. 2010), Greece (Perdikaris et al. 2012) and Estonia (Vetemaa et al. 2005).
9. Describe any known socio-economic benefits of the organism in the risk assessment area.	There are no known socio-economic benefits of the organism in the risk assessment area. There is potential for benefits from the organism in aquaculture and recreational fisheries. However, where the species is present in aquaculture elsewhere in the world, it tends to be of low value and can also can reduce yields of other species (Halačka et al. 2003; Luscová et al. 2010). It has nevertheless been imported into some countries for aquaculture (e.g., to Hungary; Tóth 1975) and the Baltic States (Bonow et al. 2016), with introductions into Turkey by fishers, which subsequently led to the species becoming the most important species in the commercial catch (Özuluğ et al. 2005). Note that these aquaculture activities based on cyprinid species are rarely practised in the risk assessment area. Some recreational fisheries in the risk assessment area are heavily based on providing high stock densities of cyprinid species for exploitation, often including species and hybrids of the *Carassius* genus (including crucian carp and goldfish). These species have yet to include gibel carp and there is no known desire of anglers in the risk assessment to capture gibel carp. However, it is noted that other species of the *Carassius* genus are used to enhance pond and lake fisheries (*Carassius carassius*, *Carassius auratus*).

	Consequently, the socio-economic benefits of the organism in the risk assessment area are considered as low.

SECTION B – Detailed assessment

PROBABILITY OF ENTRY

Important instructions:

- Entry is the introduction of an organism into the risk assessment area. Not to be confused with spread, the movement of an organism within the risk assessment area.
- For organisms which are already present in the risk assessment area, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms which have entered in the past and have no current pathways of entry.

QUESTION	**RESPONSE** **[chose one entry, delete all others]**	**CONFIDENCE** **[chose one entry, delete all others]**	**COMMENT**
1.1. How many active pathways are relevant to the potential entry of this organism? (If there are no active pathways or potential future pathways respond N/A and move to the Establishment section)	Very few	medium	In general, due to extant legislation, the intentional transfer and introduction of gibel carp into the risk assessment area is sufficiently unlikely that the only pathways by which the species could enter are those that are contrary to extant legislation and policy. There are two pathways that potentially exist for this: 1) Illegal transfer and introduction by humans (e.g. release of aquarium, garden or live bait specimens); and 2) Contaminant of fish consignments (i.e. the unintentional presence of the species in consignments of fish moved from one location to another).
1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific	contaminant of fish consignments		The fish would enter the pathway when they were removed from the source water in the country of origin and are misidentified as either *Carassius carassius* or *Carassius auratus*. This would most likely be a country in NW Europe, such as Belgium (Verrycken et al. 2007) The fish would be

origins and end points of the pathways. For each pathway answer questions 1.3 to 1.10 (copy and paste additional rows at the end of this section as necessary).	Intentional (illegal) transfer and introduction		transported/ imported into the risk assessment area and released into their new location, most likely to be either an aquaculture facility or ornamental fish facility. It is considered unlikely these fish would be released directly into the wild. The release of the fish into a wild pond used as a fishery is the endpoint of the pathway. Gibel carp could also be used intentionally (albeit illegally) by fishery managers as a new species to attract anglers to pond fisheries, with intentional transfer and introduction of individuals from NW Europe. The fish enter the pathway when they are removed from their source water, are imported into the risk assessment area and released into the pond fishery.
Pathway name:	i. Intentional, illegal transfer and introduction by humans		
i.1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)? (If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)	intentional	medium	The species has some potential for enhancing angling, with their potential for use in European aquaculture more limited. With invasive populations present in NW Europe (e.g. Belgium; Verreycken et al. 2007), there is the possibility that some will be imported with a view to their release into an angling pond. However, due to extant import and post import legislation and policies, requests to import/farm/ keep/ release are unlikely to be consented and so any intentional transfers would be completed outside of this legal framework.
i.1.4. How likely is it that large numbers of the organism will travel along this pathway from the	Unlikely	medium	There is some likelihood that the species could enter the pathway from their point of origin as the species is present in open waters in countries such as Belgium. However, the

point(s) of origin over the course of one year? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.			likelihood of intentional movements of gibel carp are considered to be unlikely - but with this of only medium confidence.
i.1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	high	Fish entering via this pathway would be released intentionally into a water body for the purposes of angling/ aquaculture enhancement (high confidence). However, given the controls outlined above, the only way in which this would be possible is through an illegal process.
i.1.10. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	unlikely	medium	There is a possibility that gibel carp would be used for recreational angling in the risk assessment area, but with other species of the *Carassius* genus already present in the risk assessment area, then it is considered that the demand would be low and thus the species unlikely to enter via this pathway.
End of pathway assessment, repeat as necessary.			
Pathway name:	ii. Contaminant of fish consignments		
ii.1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)?	accidental	very high	The species can potentially enter as a contaminant of imported *Carassius auratus*, as the two species are difficult to tell apart (see detail provided in Section A). The potential for this to occur is also evidenced by other species being reported as contaminants of fish imported from USA (Copp et al. 1993, 2006).

(If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)			
ii.1.4. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	Unlikely	medium	There is the potential of some likelihood that the species could enter the pathway from their point of origin as the species is present in open waters in countries such as Belgium (Verreycken et al. 2007). However, the likelihood of movements of goldfish from open waters in NW Europe that are contaminated by gibel carp into the risk assessment area is considered unlikely, but of medium confidence.
ii.1.5. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	Very likely	High	The species would be likely to survive given their capability to survive in relatively degraded conditions in the wild (e.g. shallow, eutrophic waters; Vetemaa et al. 2005). However, the organism would be considered as highly unlikely to multiply along the pathway. High confidence.
ii.1.6. How likely is the organism to survive existing management practices during passage along the pathway?	likely	medium	This has been given as likely but of medium confidence, as it is dependent upon the management practice utilised. Management practices applied within the pathway cover the authorisation of importers, health certification of consignment for import, border checks, applications to keep/ use non-native species in GB, and

			then applications to release the species within GB. Monitoring and enforcement of these activities are by the competent authority (currently Fish Health Inspectorate and Environment Agency).
ii.1.7. How likely is the organism to enter the risk assessment area undetected?	very likely	high	The species can easily be misidentified for other species of the *Carassius* genus that are already present in the risk assessment area and that are used in fisheries and ornamentally, including goldfish *Carassius auratus.* Thus, their chance to enter the risk assessment area without being detected is considered as very likely and of high confidence. The organism was spread through Belgian waters after misidentification of fish being stocked out as *Carassius carassius* (Verrycken et al. 2007).
ii.1.8. How likely is the organism to arrive during the months of the year most appropriate for establishment?	likely	high	Most inland fish transfers are conducted in periods of relatively low water temperatures. The species will reproduce in late spring and summer (Şaşı, 2008). However, the release of these fish in periods of low temperature are unlikely to affect their long-term survival (the organism experiences cold winter temperatures in areas of their native range, such as in central and northern China; Ford & Beitinger (2005)). As such, this aspect of the risk assessment is not considered important, as the released individuals would survive and reproduce/ establish in future.
ii.1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	high	If gibel carp arrived in the risk assessment area via this pathway then there is a reasonable likelihood they would be released into inland waters that provide suitable habitats, given the pathway end point is the release of the fish into the wild.

ii.1.10. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	moderate	medium	Overall, it is still considered of moderate likelihood that the organism will enter via this pathway, but is of medium confidence as there some uncertainties in the pathways.
1.11. Estimate the overall likelihood of entry into the risk assessment area based on all pathways (comment on the key issues that lead to this conclusion).	moderate	low	The demand for the species in the risk assessment area is considered as relatively low and, as such, it is not considered as likely as entering. A moderate likelihood is given. A low confidence is given on this due to the difficulty of identifying gibel carp from its congeners crucian carp and goldfish, with these species already present in the risk assessment area, with goldfish also imported (although generally in their ornamental form). Note there is also the unconfirmed report of the species actually being present in the risk assessment area (see earlier responses).

PROBABILITY OF ESTABLISHMENT

Important instructions:

- For organisms which are already well established in the risk assessment area, only complete questions 1.15, 1.21 and 1.28 then move onto the spread section. If uncertain, check with the Non-native Species Secretariat.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.12. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between climatic conditions in the risk assessment area and the organism's current distribution?	Very likely	High	While there are established populations in many European countries, many of these have climate conditions quite different to the risk assessment area (e.g. Iberia; Ribeiro et al. 2015). However, with established populations in Belgium that are also spreading (Verreycken et al. 2007), a country with relatively similar climate conditions to many regions of the risk assessment area, then it is considered likely that the species would establish (high confidence). Its congener *Carassius carassius* is able to produce highly abundant populations in appropriate habitats within the risk assessment area, with *Carassius auratus* also able to produce sustainable populations (Tarkan et al. 2010). It is thus considered very likely with high confidence.
1.13. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity between other abiotic conditions in the risk assessment area and the organism's current distribution?	Very likely	very high	Invasive populations in the Czech Republic have been reported from river branches, pools, small lakes, gravel pits and canals (Lusková et al. 2010). They also inhabit a wide variety of still water bodies and lowland rivers, usually associated with submerged vegetation or regular flooding (Kottelat & Freyhof 2007), and prefer shallow, eutrophic waters with dense vegetation with large adult specimens, and is only occasionally captured in the open deeper and colder waters (Vetemaa et al. 2005).

			Thus, there are abundant waterbodies in the risk assessment area providing suitable abiotic conditions for establishment and so the response is very likely with very high confidence.
1.14. How likely is it that the organism will become established in protected conditions (in which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in the risk assessment area? Subnote: gardens are not considered protected conditions	Very likely	high	Invaders of the species has already been reported in aquaculture systems elsewhere in the world where they are reported as decreasing yields (Luscová et al. 2010). Given the conditions encountered in pond aquaculture systems (supplementary feeding etc.), these conditions are potentially favourable.
1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area?	widespread	very high	The typical waterbodies invaded by gibel carp elsewhere in Europe (river branches, pools, small lakes, gravel pits and canals; Vetemaa et al. 2005; Verreycken et al. 2007; Lusková et al. 2010) are considered as relatively widespread in lowland areas of the risk assessment area. This has very high confidence.
1.16. If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the risk assessment area?	NA		Whilst NA is given, note that through their gynogenetic reproduction, female, triploid gibel carp (which often comprise large proportions of invasive populations) utilise the sperm of other species to activate - but not fertilise - their own eggs (Vetemaa et al. 2005; Kalous et al. 2004). So, the organism can require other species for reproduction - but this is not specific to a particular species (e.g. Paschos et al. 2004). When females are diploid then other species are not required (only male gibel carp).

			As triploid females do not require males of specific species for reproduction and diploid females reproducing in a more regular manner, then the response given is NA. Note that in experimental conditions, triploids are also capable of sexual reproduction (Šimková et al. 2015).
1.17. How likely is it that establishment will occur despite competition from existing species in the risk assessment area?	very likely	very high	Although other *Carassius* species are present in the risk assessment area (e.g. Busst & Britton 2017), it is considered unlikely that competition between these species will affect establishment. Studies in pond populations in Belgium found established populations in ponds with up to 10 other species present, including other invasive fish species (e.g. Tran et al. 2015). There is no direct evidence available that suggests competition from native species will prevent their establishment, indeed, *C. gibelio* have been documented to outcompete native species and flourish (Tarkan et al. 2012a). Therefore, a response of very likely is given of very high confidence.
1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?	very likely	very high	Although gibel carp might be vulnerable to some parasites that also infect crucian carp, such as *Philometroides sanguineus* (Pegg et al. 2011), it is unlikely that these parasites will inhibit their establishment. Native parasites will potentially infect gibel carp, with native parasites often being recorded in non-native fish in the risk assessment area (e.g. Sheath et al. 2015). However, these infections are again considered as very unlikely to prevent establishment. The species could be vulnerable to predation, although *Carassius carassius* alter their body shape when present with northern pike *Esox lucius* (as an anti-predator response' e.g. Brönmark & Miner 1992). *Carassius carassius* might also use alarm-substance related and predator-related cues to identify predators, can discriminate between large and small predators, and individuals from populations that coexist with predators exhibit

			less pronounced fright responses due to their induced morphological defences, i.e. a deeper body (Petterson et al. 2000). If similar traits were evident in *Carassius gibelio* then these would decrease the chance that predation would inhibit their establishment. Correspondingly, it is very likely that establishment would occur despite predator presence and of very high confidence.
1.19. How likely is the organism to establish despite existing management practices in the risk assessment area?	very likely	high	Management options to deal with gibel carp are relatively limited and once introduced, the organism might not be actively managed. In England, the Environment Agency have taken steps to eradicate, using rotenone, isolated populations of non-native fish, including *Ameiurus melas* (Ruiz Navarro et al. 2015) and fathead minnow *Pimephales promelas* (Britton et al. 2011a). However, whether such as step would be taken against a newly detected population of gibel carp prior to its dispersal and wider establishment is uncertain. Correspondingly, it is considered as very likely that the organism would establish despite management practices in the risk assessment area, with high confidence.
1.20. How likely are management practices in the risk assessment area to facilitate establishment?	likely	moderate	In Belgium, gibel carp were mistakenly released as being misidentified as crucian carp *Carassius carassius* in planned stocking events (Verreycken et al. 2007). There is potential for this to happen in the risk assessment area if gibel carp were introduced, with management practices of enhancing pond fisheries with *Carassius* spp. used in the risk assessment area (Pegg et al. 2011). As such, through increased propagule pressure, this management practice could facilitate establishment.

			However, there is some uncertainty in this and so it is considered likely with moderate confidence.
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?	unlikely	high	If eradication campaigns utilised chemical based methods, such as rotenone (Britton et al. 2008, 2011b), then it is considered as unlikely the organism would survive. A drain-down and disinfectant exercise was also successful in eradicating *Carassius carassius* - as a non-target species - in two ponds in western England, where topmouth gudgeon *Pseudorasbora parva* was the target species (Britton et al. 2008). Thus, it is considered unlikely gibel carp could survive such eradication methods, with high confidence. Should chemical based methods be unable to be used then a different response is required (likely/ high) as Card et al. (2020) revealed a three-pass electric fishing removal strategy was not sufficient to eradicate the species from a stream network.
1.22. How likely are the biological characteristics of the organism to facilitate its establishment?	Very likely	very high	Female triploid gibel carp utilise gynogenetic reproduction, whereby they can utilise the sperm of other species within the reproduction process, with a study in Greece demonstrating that in a wild population, females comprised over 97% of the population and utilised male *Rutilus ylikiensis* in their reproduction (Paschos et al. 2004). This manner of reproduction means that the release into the wild of only female triploid gibel carp could still result in establishment. Allied with their relatively high fecundity (e.g. >100,000 eggs in individual, large females; Balik et al. 2004) then this provides considerable advantages in their ability to establish. The assessment is thus very likely of very high confidence.

1.23. How likely is the capacity to spread of the organism to facilitate its establishment?	Very likely	medium	The species is able to spread successfully throughout river basins. For example, they dispersed into the river networks of the Czech Republic from the River Danube via the River Morava; initial recordings, around the confluence of the Morava and Dyje Rivers, date from 1976. Subsequently, they invaded streams within drainage areas through natural dispersal, overcoming boundaries due to both the intentional and unintentional help of man, predominantly as an admixture to carp (*Cyprinus carpio*) stockings. Within 15 years, they had occupied all suitable habitats in the Czech Republic (Lusková et al. 2010). While the species is not considered to have traits that facilitate rapid spread, evidence suggests that its ability to establish could be facilitated by some inherent capacity to spread. So an assessment of very likely is given but only of medium confidence as there is some uncertainty, given the evidence for spread is from outside the risk assessment area. Where introductions are into enclosed lentic waters then the ability of the species to spread will be limited.
1.24. How likely is the adaptability of the organism to facilitate its establishment?	Very likely	medium	The literature base for the species suggests their wide tolerances and biological traits (see other sections) means the species is able to adapt to a wide range of conditions (e.g. its invasiveness in varied waterbodies in Iberia, Turkey and Belgium, countries of quite different climate conditions; (Keskin et al, 2013; Ribeiro et al. 2015; Verreycken et al. 2007). As such, an assessment of very likely of medium confidence is given.
1.25. How likely is it that the organism could establish despite low genetic diversity in the founder population?	likely	high	Given the ability of females to reproduce gynogenetically, then genetic diversity might not be high anyway (Paschos et al. 2004). Invasive populations in Turkey have been reported as having low genetic diversity (Keskin et al. 2013). Thus, low genetic diversity

			does not appear to be a major constraint on their establishment from the evidence available. An assessment of likely is given of high confidence.
1.26. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in the risk assessment area? (If possible, specify the instances in the comments box.)	Very likely	high	The risk assessment area is climatically suited, the species has biological traits (highly fecund, use of gynogenetic reproduction by triploid females, tolerance of poor water chemistry, use of a wide range of water bodies etc.) suggest that it is very likely that gibel carp would establish if introduced into the risk assessment area (high confidence).
1.27. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in the risk assessment area but is established because of continual release, is an example of a transient species.	Very likely	medium	Note it is not considered that a transient population would exist as establishment is considered likely unless there is a successful eradication programme. If, however, the species does not establish, then the pathways by which the species was introduced are likely to remain open and thus it is considered very likely that transient populations will form. The response is given as very likely but with only medium confidence.
1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box).	Very likely	high	If gibel carp are introduced into the risk assessment area (noting that Copp & Sayer (2020) suggest they have been introduced already), then evidence from elsewhere in their range suggest establishment is at least likely, with high confidence.

PROBABILITY OF SPREAD

Important notes:

- Spread is defined as the expansion of the geographical distribution of a pest within an area.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.1. How important is the expected spread of this organism in the risk assessment area by natural means? (Please list and comment on the mechanisms for natural spread.)	moderate	medium	The spread of gibel carp would be a combination of human-assisted means (satellite) especially in relation to their potential to be misidentified with crucian carp and other *Carassius species* during fish stocking events (Verrycken et al. 2007) and natural dispersal (linear, given this will occur in rivers). The extent to which they will be able to disperse naturally will be dependent on the local situation; evidence from invasive populations in Europe suggest they are able to achieve wide distributions via natural dispersal if they are released into open waters (Lusková et al. 2010), with downstream dispersal (especially of drifting larval and juvenile stages) being important (e.g. Reichard & Jurajda 2007). Other non-native fish have been recorded as moving out of invaded pond systems into river systems, mainly as juvenile lifestages, within the risk assessment area (Davies and Britton 2016). Nevertheless, if the species is to achieve a wide distribution within a 10 year period then natural dispersal (achieved by both downstream drift in flowing waters and upstream movement following dispersal from ponds) would be important. Note that Ruppert et al. (2017) reported that the species doubled their distribution in North America every 5 years, so their natural dispersal can be more rapid.

			Also note it is considered unlikely the species would be introduced directly into a river and is more likely to be released into a pond/ lake for angling. If introduced as misidentified *Carassius auratus*, then, legally, these fish should only be stocked into ponds outside of the floodplain and without an outflow (i.e. they should be fully enclosed) (Hickley & Chare 2004). As such, only medium confidence is given in the response due these uncertainties around speed of spread.
2.2. How important is the expected spread of this organism in the risk assessment area by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	major	high	The dispersal of gibel carp in Belgium was strongly assisted by human assistance via being moved between waters (due to misidentification with their congener, crucian carp) (Verreycken et al. 2007). As such this is considered of major importance and of high confidence.
2.3. Within the risk assessment area, how difficult would it be to contain the organism?	difficult	moderate	As the species can tolerate relatively poor water quality and can be easily misidentified as its congeners *Carassius carassius* and *Carassius auratus* (and their hybrids) that are used as species to enhance recreational pond and lake fisheries, then should the species be introduced into the risk assessment area then it would be difficult to contain. However, the numbers of crucian carp and goldfish being moved into inland waters on an annual basis is relatively low compared with species such as common carp and so there is only moderate confidence in this.
2.4. Based on the answers to questions on the potential for establishment and spread in the risk assessment area, define the	freshwaters in lowland areas	high	All freshwaters in lowland areas of the risk assessment area could be endangered by gibel carp. However, waters most at risk are considered to be lentic environments (ponds, lakes) and those that have been anthropogenically modified (impounded rivers, reservoirs).

area endangered by the organism.			
2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of the risk assessment area were the species could establish), if any, has already been colonised by the organism?	0-10	medium	There are no confirmed populations of gibel carp in the risk assessment area. However, Copp & Sayer (2020) suggest at least one population, although evidence in the public domain remains limited. Indeed, there is potential for them to be present elsewhere in GB via misidentification with their congeners crucian carp *Carassius carassius* and brown goldfish *Carassius auratus*.
2.6. What proportion (%) of the area/habitat suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	10-33%	medium	If the species was introduced in the near future (or confirmed as present in the peer-review literature), it is considered unlikely that there would be rapid dispersal; however, this is only of medium confidence due to some uncertainties, including the likelihood of introduction, introduction and further releases occurring into fully enclosed ponds rather than open waters. Moreover, their spread has been relatively fast elsewhere, both through natural (Lusková et al. 2010) and anthropogenic means (Verrycken et al. 2007).
2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in the risk assessment area? (Please comment on why this timeframe is chosen.)	5	high	As the species has the ability to reproduce relatively quickly and evidence from Europe suggests that they can achieve wide dispersal relatively quickly (e.g. occupying all suitable habitats in the Czech Republic in 15 years; Lusková et al. 2010) then 10 years would be an appropriate timeframe to assess their spread. In addition, Ruppert et al. (2017) noted that the species doubled their distribution in North America every 5 years. However, note that Slavík & Bartoš (2004) noted that on the Elbe River, Czech Republic, the spread of the species was mainly through aquaculture activities rather than through upstream fish movements or their reproduction.

2.8. In this timeframe what proportion (%) of the endangered area/habitat (including any currently occupied areas/habitats) is likely to have been invaded by this organism?	10-33	low	There are many variables that would influence the proportion of the endangered habitat that is likely to have been invaded. Assuming an introduction in the near future, then the extent to which the species would spread is dependent on whether it is introduced into a pond/ lake with connection to a river catchment and then whether this system has connection with other catchments (e.g. via the canal network), allied with the frequency of human assisted movements. As such, low confidence is given on this.
2.9. Estimate the overall potential for future spread for this organism in the risk assessment area (using the comment box to indicate any key issues).	moderate	medium	Although this is rather contrary to Lusková et al. (2010), where all suitable habitats in the Czech Republic were occupied within 15 years, there are many factors that would affecting gibel carp spread in the risk assessment area. These factors include the connectivity of invaded waters and the frequency of angling related movements of their congeners. As such, while future spread would be expected, this rate of spread is uncertain due its dependence on the species reaching open waters and so confidence is given as medium.

PROBABILITY OF IMPACT

Important instructions:

- When assessing potential future impacts, climate change should not be taken into account. This is done in later questions at the end of the assessment.
- Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).
- Note questions 2.10-2.14 relate to economic impact and 2.15-2.21 to environmental impact. Each set of questions starts with the impact elsewhere in the world, then considers impacts in the risk assessment area separating known impacts to date (i.e. past and current impacts) from potential future impacts. Key words are in bold for emphasis.

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.10. How great is the economic loss caused by the organism within its existing geographic range **excluding the risk assessment area**, including the cost of any current management?	major	medium	Economic losses from the species have been poorly quantified in the existing geographic range. Lusková et al. (2010) suggested that in aquaculture systems in the Czech Republic, *C. gibelio* was an unwelcome competitor within cultures of other species being reared. They also noted the occurrence of numerous populations of *C. gibelio* in fishponds that caused considerable economic losses as there was no market for the species. Where sold, it reached lower prices. Moreover, Halačka et al. (2003) suggested estimated economic losses of €200 to 300 per hectare per year (as of 1999) suggesting that in countries where pond aquaculture is used extensively for cyprinid species, economic losses could be severe – hence a major impact is given but given some uncertainties in this, then it is of medium confidence.
2.11. How great is the economic cost of the organism **currently** in the risk assessment area	minimal	Very high	While there is some uncertainty as to whether the species is present, given morphological similarity with *C. auratus*, it has been assumed as absent in the risk assessment area and as such, a minimal economic

excluding management costs (include any past costs in your response)?			cost has been given. Very high confidence has been given as economic costs of *C. auratus* in the risk assessment area are considered as minimal.
2.12. How great is the economic cost of the organism likely to be **in the future** in the risk assessment area **excluding management** costs?	moderate	low	The economic costs associated with the species elsewhere have been limited to mixed species pond aquaculture systems (e.g. Halačka et al. 2003; Lusková et al. 2010). Although these are used in the risk assessment area, they are not commonplace, used primarily to rear fish used in recreational fisheries. As such, the economic costs in the event of their introduction, establishment and spread are considered as moderate at most, but with the lack of information available on this, of low confidence. There is also the possibility that an accidental introduction into a specialist recreational fishery (based on common carp or even crucian carp) could result in reduced angler-based income due to disruptions in catch rates and reduced angler satisfaction, but the extent of these potential future impacts are not considered high. There is also high uncertainty around thus, hence the low confidence remains.
2.13. How great are the economic costs **associated with managing** this organism **currently** in the risk assessment area (include any past costs in your response)?	minimal	high	There are no known economic costs associated with managing gibel carp in the risk assessment area, other than some regulatory control and enforcement by competent authorities.
2.14. How great are the economic costs **associated with managing** this organism likely to be **in the future** in the risk assessment area?	moderate	medium	Given that *Carassius auratus* has been present in the risk assessment area for a long time (first introduced in 1690s; Britton et al. 2010) and is now considered to have a widespread distribution following its use in both recreational pond fisheries and ornamental releases (Britton et al. 2011b), with minimal economic costs associated with managing the

			species in the risk assessment area, it is considered that *C. gibelio* would be treated similarly and thus only minor economic costs would accrue. However, *C. gibelio* is likely to prove more invasive than *C. auratus* and thus management costs could well be higher. Thus, the response is moderate and of medium confidence.
2.15. How important is environmental harm caused by the organism within its existing geographic range **excluding the risk assessment area**?	major	high	*Carassius gibelio* has been reported as causing significant environmental harm in all countries of introduction in Europe (Savini et al. 2010). A 6-year study in a mesotrophic reservoir in Turkey by Tarkan et al. (2012b) showed a relative decrease in native cyprinid density following *C. gibelio* establishment (when their abundance increased), with the driver of this being the combination of degraded environmental conditions (including, but not exclusively due to foraging activities, with this also not tested explicitly) and reproductive competition by *C. gibelio*. Impacts on the abundance of native species are often recorded (e.g. Marković & Adrović 2020), with the species becoming dominant in some waterbodies (Perdikaris et al. 2012), competing with native fish (Innal 2011). Indeed, impacts on native species are often apparent due to increased inter-specific competition (Specziar et al. 1998; Lusk et al. 2010). However, there are no reported extirpations of native species resulting from environmental harm (NB. genetic considerations are not considered here). Other impacts include increased water turbidity due to their foraging behaviours (Crivelli 1995). As such, a response of major is provided and of high confidence.
2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in native	minimal	high	As with previous responses, the organism has not yet been confirmed definitively as present (acknowledging given the probability that the species is present (Copp & Sayer 2020)).

species communities, hybridisation) **currently** in the risk assessment area (include any past impact in your response)?			Even if the species is subsequently confirmed as present, only one population is currently known and thus the current impact of the organism will be minimal on wider biodiversity.
2.17. How important is the impact of the organism on biodiversity likely to be in the **future** in the risk assessment area?	major	medium	The organism will potentially threaten the status of crucian carp *Carassius carassius*, primarily via genetic introgression given that *Carassius* species are able to hybridise easily (Hänfling et al. 2005). Moreover, there is potential for significant changes to the fish and benthic invertebrate communities, with higher abundances of gibel carp significantly associated with lower abundances of a majority of native fish species in North America (Ruppert et al. 2017). There are also impacts recorded on other fish species in other invaded countries (e.g. Moldova (Gaygusuz et al. 2007; Dumitru et al. 2013), Turkey (Innal 2011) and Hungary (Tóth1975)). A response of major is provided, but of only medium confidence due to the lack of current assessment in the risk assessment area.
2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism **currently** in the risk assessment area (include any past impact in your response)?	minimal	high	There is no current evidence of altered ecosystem function or losses to ecosystem services caused by the organism in the risk assessment area. As with previous responses, the organism has yet to be definitively confirmed as present in the risk assessment area in the scientific literature (although its isolated presence is suggested by Copp & Sayer 2020). As such, the response has been given as ‘minimal’. The response is given with high confidence, rather than very high. This is because there is the possibility the species is also present elsewhere following misidentification with other *Carassius* species. This is important, as *C. auratus* is considered as a potentially high impacting species in the risk assessment area (Britton et al. 2010). Where these

			have been quantified for trophic interactions, they suggest some potential for competition with *C. carassius*, although detrimental consequences were not apparent in experimental conditions (Busst & Britton 2017). Moreover, the trophic impacts on *C. carassius* were considerably higher from interactions with common carp *Cyprinus carpio* (Busst & Britton 2017). If gibel carp are indeed present, then they could disrupt nutrient cycling (Paulovits 1998).
2.19. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism likely to be in the risk assessment area in the **future**?	major	medium	Impacts of *Carassius gibelio* in Turkey have included degraded environmental conditions due to their foraging activities, although it is noted that the main degradation was driven by anthropogenic activities (Tarkan et al. 2012b). Also in Turkey, Özdilek et al. (2019) utilised the ecological application of stable isotope analysis to revealed that gibel carp had an extensive trophic (isotopic) niche overlap with the native fish species, suggesting it was a strong competitor, and due to its high abundance and large niche width, represented a threat to the native fish fauna. In North America, established populations altered fish and macroinvertebrate communities that would affect ecosystem processed (Ruppert et al. 2017). Gibel carp do have preferences for anthropogenically modified habitats (e.g. reservoirs; Tarkan et al. 2012a) where ecosystem functions have already been altered. As such, the most severe impacts are likely to be in inland waters that have already been subject to modification and changes in their ecosystem functioning. The response has thus been given as major but of only medium confidence. Impacts on (increased) water turbidity are also reported (Crivelli 1995).
2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by	minimal	High	There are no known declines in conservation status associated with the species in the conservation area. Its congener *Carassius auratus* (for which there is the possibility of misidentification) has also not been associated with declines in conservation status in the risk assessment area.

the organism **currently** in the risk assessment area?			
2.21. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the **future** in the risk assessment area?	major	low	The organism has been associated with impacts on environmental harm, biodiversity and ecosystem function elsewhere in its range (see responses above). Predictions for the risk assessment area are for major impacts in future to be high on biodiversity and ecosystem function. As such, declines in conservation status are likely to occur in future and, given the predicted impacts on environmental harm, biodiversity and ecosystem function, these could be major. However, how a single invasive fish could result in major declines in conservation status within environments where other invaders are likely to be present and anthropogenic activities could be acting as additional stressors, is unclear. As such, while a major response is given, this is of low confidence.
2.22. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their economic, environmental or social effects more serious?	major	very high	The organism can introgress with *Carassius auratus* and *Carassius carassius*, both of which are present in the risk assessment area (Hänfling et al. 2005; Britton et al. 2010). The extent to which this would make their economic and social effects more serious are considered very unlikely. However, the environmental effects are potentially high, but note *C. auratus* is non-indigenous in the risk assessment area, with recent work by Jeffries et al. (2017) suggesting this is also the case for *C. carassius*. As such, the severity of this has been given as major rather than massive. Very high confidence is given, as *Carassius* species will hybridise if present together, with the literature unequivocal in this (e.g., Papoušek et al. 2008; Wouters et al. 2012).
2.23. How important is social, human health or other harm (not	minimal	moderate	Evidence of social, human health or other harm is limited. There is speculation in the literature of impacts of *C. gibelio* on the income of

directly included in economic and environmental categories) caused by the organism within its existing geographic range?			fishermen, but no empirical evidence is provided (Mustafa 2020). The lack of supporting evidence has resulted in moderate confidence.
2.24. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	major	low	There are no reported impacts of the species relating to these categories. However, its congeners can harbour SVC infections, a disease listed by the OIE and controlled under additional guarantees in GB. They can also host of a number of non-native parasite species (inluding regulated parasites) in England, including *Pomphorhynchus* spp., *Bothriocephalus acheilognathi*, and *Philometroides sanguinea*, and can can also carry Koi herpes virus (Xu et al. 2013). However, the importance of impacts of the species as a vector for these are unknown, hence the low confidence rating.
2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA	very high	The impacts of the species in its invasive range have largely been noted already. They can be summarised as: altered trophic level; selective loss of genotypes; damaged ecosystem services; habitat alteration; modification of natural benthic communities; modification of nutrient regime; negatively impacts aquaculture/fisheries; and reduced native biodiversity. These result from their foraging behaviours, their competition with native species and their hybridization with other *Carassius* species. As these have all been noted above, NA is provided with very high confidence.
2.26. 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	major	medium	Natural control by predators, parasites or pathogens are not considered to be important in reducing the impact of the species, with Kucher et al. (2019) outlining that low infections of native parasites in introduced *C. gibelio* may be facilitating their invasion success in Alberta, Canada.

present in the risk assessment area?			As noted already, native parasites will potentially infect gibel carp, with native parasites often being recorded in non-native fish in the risk assessment area (e.g. Sheath et al. 2015). However, these infections are considered as very unlikely to prevent impacts accruing. Although the species could be vulnerable to predation, *Carassius carassius* alters their body shape when present with northern pike *Esox lucius* (Bronmark & Miner 1992). *Carassius carassius* might also use alarm-substance related and predator-related cues to identify predators, can discriminate between large and small predators, and individuals from populations that coexist with predators exhibit less pronounced fright responses due to their induced morphological defences, i.e. a deeper body (Petterson et al. 2000). If similar traits are evident in *Carassius gibelio* then these would decrease the chance of predation. Thus, their expected impacts would be unchanged. Note that Vetemaa et al. (2005) at least partially attributed the invasion success of introduced *C. gibelio* to the low abundance of predatory fish, although this was not demonstrated conclusively. The uncertainties in this resulted in the medium confidence
2.27. Indicate any parts of the risk assessment area where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	freshwaters in lowland areas, especially lentic environments (ponds, lakes, reservoirs), including waters that have been	high	Economic and social impacts are not likely to occur in the risk assessment area. Environmental impacts are likely to occur in modified water bodies located in lowland areas. NB. A map has purposely not been provided as it is considered all waters in lowland areas in the risk assessment area could be at risk, but with the risk being highest in lentic habitats and those that have been modified anthropogenically.

	anthropogenically modified.		
2.28. Estimate the overall impact of this organism in the risk assessment area (using the comment box to indicate any key issues).	major	medium	The species has potential to cause impacts in the risk assessment area that cover altered trophic level; selective loss of genotypes; damaged ecosystem services; habitat alteration; modification of natural benthic communities; modification of nutrient regime; negatively impacts aquaculture/fisheries; and reduced native biodiversity. These result from their foraging behaviours, their competition with native species and their hybridization with other *Carassius* species. With the exception of hybridisation with other *Carassius* species (that are now considered non-indigenous), these impacts are unlikely to lead to extirpations of species, although they are likely to alter ecosystem functioning and change habitat structure - but mainly in waters that are already modified. As such, the overall impact is given as major. There are some uncertainties in the assessment, hence the medium confidence.

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	Moderate	Low	There remains some uncertainty whether the species is likely to enter the risk assessment area due to the low demand for the species in the risk assessment area, and that entry would most likely have to be illegal given extant legislation and policy. However, it is noted that Copp & Sayer (2020) suggest it is already present - but without providing definitive evidence of presence. However, the organism is present in NW Europe (e.g. Belgium) and is similar in morphology to two *Carassius* species present in the risk assessment area, of which *Carassius auratus* is imported on occasion (although they are also reared in the risk assessment areas), and thus entry could be through accidental contamination.
Summarise Establishment	Very likely	high	It is considered very likely and of high confidence that the species will establish if introduced.
Summarise Spread	Moderately	medium	Some spread of the species is predicted but the rate of spread will depend on where the species is introduced. As such a moderate response is given of medium confidence, where this confidence level results from some uncertainty over where the species would be introduced (e.g. fully enclosed water versus open water) and the extent to which spread would be dependent on natural versus anthropogenic spread. If released into an open system, there is potential for fast spread, especially to downstream areas.
Summarise Impact	Major	medium	Environmental impacts on habitat, biodiversity (including the genetic integrity of other *Carassius* species) and ecosystem functioning are likely following establishment and spread). Other than the genetic integrity of other *Carassius* species (both of which are now considered

			non-native in the risk assessment area), these impacts are unlikely to result in extirpations of species. As such, these impacts are considered as major but could be reversible if the organism was eradicated. Economic and social impacts are considered minimal, but with some uncertainty. This, the impacts are summarised as major and of medium confidence.
Conclusion of the risk assessment	moderate	medium	The demonstrated impact of gibel carp elsewhere in the world, the difficulties to eradicate the species (except in enclosed waters) ranks *C. gibelio* with other high-risk invaders (e.g. topmouth gudgeon). It is an internationally recognised invader.

Additional questions are on the following page ...

ADDITIONAL QUESTIONS - CLIMATE CHANGE			
3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	Warming in summer Increased precipitation in winter	high	Climate change projections for the risk assessment area are, in general, for warmer and drier summers, and warmer, wetter winters. In summer, river flows will be reduced with the converse for winter.
3.2. What is the likely timeframe for such changes?	50 years	low	There is high uncertainty over how the climate change projections outlined above will act upon gibel carp if they were introduced into the risk assessment area. However, Britton et al. (2010) predicted that the reproduction and recruitment of *C. auratus* will benefit from future climate conditions and so its congener *C. gibelio* might well also benefit.
3.3. What aspects of the risk assessment are most likely to change as a result of climate change?	Establishment Spread	medium	Establishment rates will potentially increase through elevated temperatures resulting in earlier and prolonged reproductive seasons, and increasing growth rates of 0-group fish. Rates of natural dispersal will potentially increase through increased episodes of flooding, especially during winter, through flood events increasing passive and active dispersal through increased flow rates and breaches of flood defences that result in flooding of ponds in the floodplain that could potentially have populations of gibel carp, as has already happened with other non-native fishes in GB (e.g. *C. carpio*; European catfish *Silurus glanis*; Britton et al. 2010).

ADDITIONAL QUESTIONS – RESEARCH			
4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here.	yes	medium	There could be benefit if research was completed on the genetics of *Carassius* spp. in the risk assessment area to ensure the species was not already present via misidentification with congeners. However, the extent to which this would benefit is uncertain, as there have been studies completed on *Carassius* genetics in the risk assessment area in recent years (e.g. Jeffries et al. 2017). Note that the main uncertainties in this risk assessment relate to aspects - such as likelihood of entry via different pathways and economic/ social impacts - that are unlikely to be assisted by further research. The biology and environmental impacts of the organism have been well studied across their invasive range.

Please provide a reference list on the following page ...

REFERENCES:

Almeida, D., Ribeiro, F., Leunda, P.M., Vilizzi, L. and Copp, G.H., 2013. Effectiveness of FISK, an invasiveness screening tool for non-native freshwater fishes, to perform risk identification assessments in the Iberian Peninsula. *Risk Analysis*, *33*(8), pp.1404-1413.

Balik, İ., Özkök, R., Çubuk, H. and Uysal, R., 2004. Investigation of some biological characteristics of the silver crucian carp, *Carassius gibelio* (Bloch 1782) population in Lake Eğirdir. *Turkish Journal of Zoology*, *28*(1), pp.19-28.

Bonow, M., Cios, S. and Svanberg, I., 2016. Fishponds in teh Baltic States: Historical Cyprinid Culture in Estonia, Latvia and Lithuania. pp. 139–156 (Chapter 6) In: M. Bonow, H. Olsén & I. Svanberg (Eds). *Historical Aquaculture in Northern Europe*. Södertörn University, Huddinge, Sweden. ISBN 978–91–87843–62–4

Britton, J.R., Brazier, M., Davies, G.D. and Chare, S.I., 2008. Case studies on eradicating the Asiatic cyprinid *Pseudorasbora parva* from fishing lakes in England to prevent their riverine dispersal. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *18*(6), pp.867-876.

Britton, J.R., Copp, G.H., Brazier, M. and Davies, G.D., 2011. A modular assessment tool for managing introduced fishes according to risks of species and their populations, and impacts of management actions. *Biological Invasions*, *13*(12), pp.2847-2860.

Britton, J.R., Cucherousset, J., Davies, G.D., Godard, M.J. and Copp, G.H., 2010. Non-native fishes and climate change: predicting species responses to warming temperatures in a temperate region. *Freshwater Biology*, *55*(5), pp.1130-1141.

Britton, J.R., Gozlan, R.E. and Copp, G.H., 2011. Managing non-native fish in the environment. *Fish and Fisheries*, *12*(3), pp.256-274.

Brönmark, C. and Miner, J.G., 1992. Predator-induced phenotypical change in body morphology in crucian carp. *Science*, *258*(5086), pp.1348-1350.

Busst, G.M. and Britton, J.R., 2017. Comparative trophic impacts of two globally invasive cyprinid fishes reveal species-specific invasion consequences for a threatened native fish. *Freshwater Biology*, *62*(9), pp.1587-1595.

Card, J.T., Hasler, C.T., Ruppert, J.L., Donadt, C. and Poesch, M.S. 2020. A three-pass electrofishing removal strategy is not effective for eradication of Prussian Carp in a North American stream network. Journal of Fish and Wildlife Management, 11(2), pp.485-493

Copp G. H. & Sayer, C. D. 2020 Demonstrating the practical impact of publications in Aquatic Conservation - The case of the crucian carp Carassius carassius in the East of England. Aquatic Conservation. 30(9). 1753-1757.

Copp, G.H., Vaughn, C. & Wheeler, A.C. 1993. First occurrence of the North American white sucker *Catostomus commersoni* in Great Britain. *Journal of Fish Biology* 42, 615–617.

Copp, G.H., Carter, M.G., England, J. & Britton, J.R. 2006. Re-occurrence of the white sucker *Catostomus commersoni* in the River Gade (Hertfordshire). *The London Naturalist* 85, 115–119.

Copp, G.H., Vilizzi, L., Mumford, J., Fenwick, G.V., Godard, M.J. and Gozlan, R.E., 2009. Calibration of FISK, an invasiveness screening tool for nonnative freshwater fishes. *Risk Analysis: An International Journal*, *29*(3), pp.457-467.

Crivelli, A.J., 1995. Are fish introductions a threat to endemic freshwater fishes in the northern Mediterranean region?. *Biological Conservation*, *72*(2), pp.311-319.

Davies, G.D. and Britton, J.R., 2016. Assessment of non-native fish dispersal from a freshwater aquaculture site. *Fisheries Management and Ecology*, *23*, pp. 428-430.

Docherty, C., Ruppert, J., Rudolfsen, T., Hamann, A. and Poesch, M.S., 2017. Assessing the spread and potential impact of Prussian Carp *Carassius gibelio* (Bloch, 1782) to freshwater fishes in western North America. *BioInvasions Record*, *6*(3).

Dumitru, B., Bulat, D., Toderaş, I., Usatîi, M., Fulga, N., Dumbrăveanu, D., Rusu, V. and Silitrari, A., 2013. Potenţialul invaziv al speciilor de peşti şi factorii determinanţi ai ihtiocenozelor ecosistemelor acvatice din Republica Moldova. Buletinul Academiei de Ştiinţe a Moldovei. Ştiinţele vieţii, 320(2), pp.35-48.

Elgin, E.L., Tunna, H.R. and Jackson, L.J., 2014. First confirmed records of Prussian carp, *Carassius gibelio* (Bloch, 1782) in open waters of North America. *BioInvasions Record*, *3*(4).

Ford, T. and Beitinger, T.L., 2005. Temperature tolerance in the goldfish, Carassius auratus. *Journal of Thermal Biology*, *30*(2), pp.147-152.

Froese, R. and Pauly, D. 2019. FishBase World Wide Web electronic publication.https://www.fishbase.de/Nomenclature/SynonymsList.php?ID=6376&SynCode=112373&GenusName=Carassius&SpeciesName=gibelio. Last accessed 21/01/2021

Gaygusuz, Ö., Tarkan, A.S. and Gaygusuz, Ç.G., 2007. Changes in the fish community of the Ömerli Reservoir (Turkey) following the introduction of non-native gibel carp *Carassius gibelio* (Bloch, 1782) and other human impacts. Aquatic invasions, 2(2), pp.117-120.

Grabowska, J., Kotusz, J. and Witkowski, A., 2010. Alien invasive fish species in Polish waters: an overview. Journal of Vertebrate Biology, 59(1), pp.73-85.

Halačka, K., Lusková, V. and Lusk, S., 2003. *Carassius gibelio* in fish communities of the Czech Republic. Ecohydrology & Hydrobiology 3(1), 133–138.

Hänfling, B., Bolton, P., Harley, M. and Carvalho, G.R., 2005. A molecular approach to detect hybridisation between crucian carp (*Carassius carassius*) and non-indigenous carp species (*Carassius* spp. and *Cyprinus carpio*). *Freshwater Biology*, *50*(3), pp.403-417.

Hickley, P. and Chare, S., 2004. Fisheries for non-native species in England and Wales: angling or the environment?. *Fisheries Management and Ecology*, *11*(3-4), pp.203-212.

İnnal, D., 2011. Distribution and impacts of *Carassius* species (Cyprinidae) in Turkey: a review. Management of Biological Invasions, 2(1), pp.57-68.

Jeffries, D.L., Copp, G.H., Maes, G.E., Lawson Handley, L., Sayer, C.D. and Hänfling, B., 2017. Genetic evidence challenges the native status of a threatened freshwater fish (*Carassius carassius*) in England. *Ecology and Evolution*, *7*(9), pp.2871-2882.

Kalous, L., D. Memis, and J. Bohlen. 2004. Finding of triploid *Carassius gibelio* (Bloch, 1780) (Cypriniformes, Cyprinidae), in Turkey. *Cybium*, 28, pp.77–79

Kalous, L., Bohlen, J., Rylková, K. & Petrtýl, M. 2012. Hidden diversity within the Prussian carp and designation of a neotype for Carassius gibelio (Teleostei: Cyprinidae). Ichthyol. Explor. Fres., 23, 11–18.

Karakuş, U., Ağdamar, S., Tarkan, A.S. and Özdemir, N., 2013. Range extension of the invasive freshwater fish species, gibel carp *Carassius gibelio* (Bloch, 1782) in western Turkey. *BioInvasions Records*, *2*(2), pp.153-157.

Keskin, E., Ağdamar, S. and Tarkan, A.S., 2013. DNA barcoding common non-native freshwater fish species in Turkey: Low genetic diversity but high population structuring. *Mitochondrial DNA*, *24*(3), pp.276-287.

Kottelat, M. 1997. European freshwater fishes. An heuristic checklist of the freshwater fishes of Europe (exclusive of former USSR), with an introduction for non-systematists and comments on nomenclature and conservation. *Biologia* **52** (Suppl. 5), 1–271.

Kottelat, M. and Freyhof, J., 2007. *Handbook of European freshwater fishes*.

Kucher, H., Stock, T.M. and Das, M.K., 2019. Parasites of Prussian carp (Carassius gibelio): an invasive species in Alberta, Canada. *Canadian Journal of Zoology*, *97*(9), pp.849-853.

Lusk, M.R., Lusková V., and Hanel. L. 2010. Alien fish species in the Czech Republic and their impact on the native fish fauna. *Folia Zoologica 59*, pp.57-72.

Lusková, V., Lusk, S., Halačka, K. and Vetešník, L., 2010. *Carassius auratus gibelio* - The most successful invasive fish in waters of the Czech Republic. *Russian Journal of Biological Invasions*, *1*(3), pp.176-180.

Marković, G. and Adrović, A. 2020. Uticaj introdukovanih ribljih vrsta a autohtonu ihtiofaunu nekih akumulacija Centralnog Balkana. Xxv Savetovanje O Biotehnologiji, P.47.

Matthews, J., Van der Velde, G., Collas, F.P., de Hoop, L., Koopman, K.R., Hendriks, A.J. and Leuven, R.S., 2017. Inconsistencies in the risk classification of alien species and implications for risk assessment in the European Union. Ecosphere, 8(6), p.e01832.

Mustafa, S.O., 2020. The Future Extinction of Common Carp Fish (Cyprinus Carpio) effecting by climate change that cause appearing a new fish species Gibel carp (Carassius gibelio) in Tigris River and Mosul Dam in Duhok Province, Iraqi Kurdistan. *Journal of Agriculture and Aquaculture*, *2*(1).

Özdilek, Ş.Y., Partal, N. and Jones, R.I., 2019. An invasive species, *Carassius gibelio*, alters the native fish community through trophic niche competition. *Aquatic Sciences*, *81*(2), pp.1-11.

Özuluğ, M., Acıpınar, H., Gaygusuz, Ö., Gürsoy, Ç.D. and Tarkan, A.S., 2005. Effects of human factor on the fish fauna in a drinking-water resource (Ömerli Dam Lake-Istanbul, Turkey). Research Journal of Agriculture and Biological Sciences, 1(1), pp.50-55.

Papoušek, I., Vetešník, L., Halačka, K., Lusková, V., Humpl, M. and Mendel, J., 2008. Identification of natural hybrids of gibel carp *Carassius auratus gibelio* (Bloch) and crucian carp *Carassius carassius* (L.) from lower Dyje River floodplain (Czech Republic). *Journal of Fish Biology*, *72*(5), pp.1230-1235.

Paschos, I., Nathanailides, C., Tsoumani, M., Perdikaris, C., Gouba, E. and Leonardos, I., 2004. Intra and inter-specific mating options for gynogenetic reproduction of *Carassius gibelio* (Bloch, 1783) in Lake Pamvotis (NW Greece). *Belgian Journal of Zoology*, *134*(1), pp.55-60.

Paulovits, G., I. Tatrai, K. Matyas, J. Korponai, and N. Kovats. 1998. Role of Prussian carp (*Carassius auratus gibelio* Bloch) in the nutrient cycle of the Balaton Reservoir. *International Revue of Hydrobiology 83*(Suppl.), pp. 467–470.

Pegg, J., Williams, C.F., Cucherousset, J. and Britton, J.R., 2011. What are the consequences of infection by the introduced parasite *Philometroides sanguineus* for threatened crucian carp *Carassius carassius* populations in England? *Ecology of Freshwater Fish*, *20*(4), pp.598-604.

Perdikaris, C., Ergolavou, A., Gouva, E., Nathanailides, C., Chantzaropoulos, A. and Paschos, I., 2012. *Carassius gibelio* in Greece: the dominant naturalised invader of freshwaters. *Reviews in Fish Biology and Fisheries*, *22*(1), pp.17-27.

Pettersson, L. B., Nilsson, P. A. and Bronmark, C. 2000. Predator recognition and defence strategies in crucian carp, *Carassius carassius*. *Oikos 88*, pp.200–212.

Reichard, M. and Jurajda, P., 2007. Seasonal dynamics and age structure of drifting cyprinid fishes: an interspecific comparison. *Ecology of Freshwater Fish*, *16*(4), pp.482-492.

Ribeiro, F., Rylková, K., Moreno-Valcárcel, R., Carrapato, C. and Kalous, L., 2015. Prussian carp *Carassius gibelio*: a silent invader arriving to the Iberian Peninsula. *Aquatic Ecology*, *49*(1), pp.99-104.

Ruiz-Navarro, A., Britton, J.R., Jackson, M.C., Davies, G.D. and Sheath, D., 2015. Reproductive ecology and diet of a persistent *Ameiurus melas* (Rafinesque, 1820) population in the UK. *Journal of Applied Ichthyology*, *31*, pp.201-203.

Ruppert, J.L., Docherty, C., Neufeld, K., Hamilton, K., MacPherson, L. and Poesch, M.S., 2017. Native freshwater species get out of the way: Prussian carp (*Carassius gibelio*) impacts both fish and benthic invertebrate communities in North America. *Royal Society Open Science*, *4*(10), p.170400.

Rylková, K., L. Kalous, V. Šlechtová & J. Bohlen. 2010. Many branches, one root: First evidence for a monophyly of the morphologically highly diverse Goldfish (Carassius auratus). Aquaculture, 302: 36-41.

Rylková, K., Kalous, L., Bohlen, J., Lamatsch, D.K. and Petrtýl, M., 2013. Phylogeny and biogeographic history of the cyprinid fish genus *Carassius* (Teleostei: Cyprinidae) with focus on natural and anthropogenic arrivals in Europe. Aquaculture, 380, 13–20.

Şaşı, H. (2008). The Length and Weight Relations of Some Reproduction Characteristics of Prussian carp, Carassius gibelio (Bloch, 1782) in the South Aegean Region (Aydın-Turkey). Turkish Journal of Fisheries and Aquatic Sciences. 8: 87-92

Savini, D., Occhipinti–Ambrogi, A., Marchini, A., Tricarico, E., Gherardi, F., Olenin, S. and Gollasch, S., 2010. The top 27 animal alien species introduced into Europe for aquaculture and related activities. *Journal of applied ichthyology*, *26*, pp.1-7.

Sayer, C.D., Emson, D., Patmore, I.R., Greaves, H.M., West, W.P., Payne, J., Davies, G.D., Tarkan, A.S., Wiseman, G., Cooper, B. and Grapes, T., 2020. Recovery of the crucian carp Carassius carassius (L.): Approach and early results of an English conservation project. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *30*(12), pp.2240-2253.

Sheath, D.J., Williams, C.F., Reading, A.J. and Britton, J.R., 2015. Parasites of non-native freshwater fishes introduced into England and Wales suggest enemy release and parasite acquisition. *Biological Invasions*, *17*(8), pp.2235-2246.

Šimková, A., Hyršl, P., Halačka, K. & Lukáš Vetešník, L. 2015. Physiological and condition-related traits in gynogenetic-sexual Carassius auratus complex: different investments promoting the coexistence of two reproductive forms? BMC Ecology and Evolution. 15.

Slavík, O. and Bartoš, L., 2004. What are the reasons for the Prussian carp expansion in the upper Elbe River, Czech Republic?. Journal of Fish Biology, 65, pp.240-253

Specziar A, Biro L, Tolg L, 1998. Feeding and competition of five cyprinid fishes in different habitats of the Lake Balaton littoral zone. *Hungary and Italy Journal of Zoology, 6,*331-336.

Tarkan, A.S., Cucherousset, J., Zięba, G., Godard, M.J. and Copp, G.H., 2010. Growth and reproduction of introduced goldfish *Carassius auratus* in small ponds of southeast England with and without native crucian carp *Carassius carassius*. *Journal of applied ichthyology*, *26*, pp.102-108.

Tarkan, A.S., Gaygusuz, Ö., Gürsoy Gaygusuz, Ç., Saç, G. and Copp, G.H., 2012a. Circumstantial evidence of gibel carp, *Carassius gibelio*, reproductive competition exerted on native fish species in a mesotrophic reservoir. *Fisheries Management and Ecology*, *19*(2), pp.167-177.

Tarkan, A.S., Copp, G.H., Top, N., Özdemir, N., Önsoy, B., Bilge, G., Filiz, H., Yapici, S., Ekmekçi, F.G., Kirankaya, Ş.G. and Emiroğlu, Ö., 2012b. Are introduced gibel carp *Carassius gibelio* in Turkey more invasive in artificial than in natural waters?. *Fisheries Management and Ecology*, *19*(2), pp.178-187.

Tóth, J., 1975. A brief account on the presence of the silver crucian (*Carassius auratus gibelio* Bloch 1783) in the Hungarian section of the Danube. Sectio Biologica 18-19, 219–220.

Tran, T.N.Q., Jackson, M.C., Sheath, D., Verreycken, H. and Britton, J.R., 2015. Patterns of trophic niche divergence between invasive and native fishes in wild communities are predictable from mesocosm studies. *Journal of Animal Ecology*, *84*(4), pp.1071-1080.

Vetemaa, M., Eschbaum, R., Albert, A. & Saat, T. 2005. Distribution, sex ratio and growth of Carassius gibelio (Bloch) in coastal and inland waters of Estonia (north-eastern Baltic Sea). Journal Applied Icthyology. 21: 287-291

Verreycken, H., Anseeuw, D., Van Thuyne, G., Quataert, P. and Belpaire, C., 2007. The non-indigenous freshwater fishes of Flanders (Belgium): review, status and trends over the last decade. *Journal of Fish Biology*, *71*, pp.160-172.

Vetemaa, M., Eschbaum, R., Albert, A. and Saat, T., 2005. Distribution, sex ratio and growth of *Carassius gibelio* (Bloch) in coastal and inland waters of Estonia (northeastern Baltic Sea). *Journal of Applied Ichthyology*, *21*(4), pp.287-291.

Vilizzi, L., Copp, G.H., Adamovich, B., Almeida, D., Chan, J., Davison, P.I., et al. 2019. A global review and meta-analysis of applications of the Fish Invasiveness Screening Kit. Reviews in Fish Biology and Fisheries 29, 529–568.

Wouters, J., Janson, S., Lusková, V. and Olsén, K.H., 2012. Molecular identification of hybrids of the invasive gibel carp *Carassius auratus gibelio* and crucian carp *Carassius carassius* in Swedish waters. *Journal of Fish Biology*, *80*(7), pp.2595-2604.

Xu, J., Zeng, L., Zhang, H., Zhou, Y., Ma, J. & Fan, Y. 2013. Cyprinid herpesvirus 2 (CyHV-2) has been noted in C. gibelio (Cyprinid herpesvirus 2 infection emerged in cultured gibel carp, Carassius auratus gibelio in China. Veterinary Microbiology. 166(1-2). 138-144

Yerli, S.V., Mangıt, F., Emiroğlu, Ö., Yeğen, V., Uysal, R., Ünlü, E., Alp, A., Buhan, E., Yıldırım, T. and Zengin, M., 2014. Distribution of invasive *Carassius gibelio* (Bloch, 1782) (Teleostei: Cyprinidae) in Turkey. *Turkish Journal of Fisheries and Aquatic Sciences*, *14*(2), pp.581-590.