RAPID RISK ASSESSMENT SUMMARY SHEET

Updated: April 2017

Pumpkinseed (*Lepomis gibbosus*)

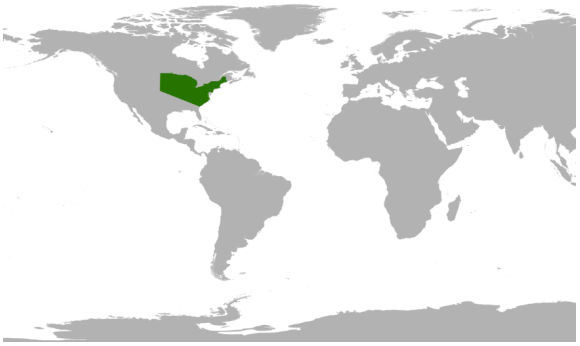
- Freshwater fish from eastern North America.
- Present at a handful of sites in the south and south-east of England.
- Impacts on native biodiversity through competition with other fish species and predation of small fish & invertebrates.

History in GB

Thought to have been introduced to GB in the early 20th Century (around 1915), although it may have been earlier (late 19th Century). The majority of records in the National Biodiversity Network are from post 1990. Currently present in 25 sites in the south and south east of England, previously recorded in Scotland but has since gone extinct there.

Native distribution

Native to eastern North America



Source: NNSIP 2017

Distribution in GB

Source: NBN 2017

Impacts

Environmental

- Feeds on small fish and other vertebrates, fish eggs and a wide range of invertebrates.
- Effective competitor of native fish due to plasticity of diet, parental care behaviour which enhances reproductive success, and aggressive behaviour which can affect native species' foraging success, reproduction and microhabitat selection.

Economic

- May cause some loss of income to recreational fisheries by reducing their native fish populations through competition.

Social

- Often regarded as a pest by anglers.

Introduction pathways

Ornamental - license requirements under the ILFA orders have severely restricted demand and the ornamental pet trade for *L. gibbosus*, but have not eliminated the risk entirely.

Contaminant of fish stock - accidental introductions could occur with legal fish stocking from Europe and regulated fish movements within GB.

Spread pathways

Natural - as this species has already established in over thirty sites it is likely that further dispersal will occur.

Summary

	Risk	Confidence
Entry	**VERY LIKELY**	**VERY HIGH**
Establishment	**LIKELY**	**HIGH**
Spread	**LIKELY**	**MEDIUM**
Impacts	**MODERATE**	**MEDIUM**
Conclusion	**MEDIUM**	**MEDIUM**

Information about GB Non-native Species Risk Assessments

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

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

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

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

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

Common misconceptions about risk assessments

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

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

Period for comment

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

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

Rapid Assessment of: *Lepomis gibbosus*
Date: 4th November 2013
Signed off by NNRAP: June 2015
Approved by Programme Board: February 2017
Placed on NNSS website: April 2017

This is a rapid risk assessment produced by an independent Environment Agency expert in support of the NNSS and the GB Programme Board. It is not a full risk assessment and has not been through the full GB Risk Analysis Process. The information provided should be considered initial advisory guidance from an independent expert.

Rapid Risk Assessment:

1 - What is the principal reason for performing the Risk Assessment? (Include any other reasons as comments)

Response:

While *Lepomis gibbosus* has been present in the UK for over 100 years it has undergone a slow range expansion, but is still spatially confined to the South and South East of England. Given predicted climate change scenarios, decisions about the future management of this species need to be taken, before its further dispersal and subsequent establishment makes eradication action untenable.

2 - What is the Risk Assessment Area?

Response: GB

3 - What is the name of the organism? (Other names used for the organism can be entered in the comments box)

Response:
Lepomis gibbosus (Linnaeus, 1758) - Perciformes, Centrarchidae. Common names include pumpkinseed, common sunfish, sun bass, pond perch and sun perch.

4 - Is the organism in its present range known to be invasive?

Response:

Yes. *L. gibbosus* is listed among the top ten introduced fish species with adverse ecological effects (Casal 2006). Initially widely introduced across Europe it continues to spread as a result of releases from aquaria and by accidental inclusions when other fish are transferred. It has also been deliberately introduced in Denmark in the belief that it can control the fish louse *Argulus foliaceus* (Przybylski, M. & Zięba G., 2011). The species has become widely established being present in 28 countries in Europe and western Asia Minor (Cucherousset *et al*. 2009). The species became established in France as a result of repeated introductions (Klaar,M. *et al*. 2004) and is now present across the entire French hydrographic network (Dembski *et al.* 2006) the concern is that this could happen in GB in the absence of any management strategies.

This species has the potential to be a strong competitor due to both plasticity of diet shown between populations, new populations showing altered diet (García-Berthou & Moreno-Amich, 2000) and parental care has the potential to enhance reproductive success. While *L. gibbosus* are not invasive in England they have the potential to become invasive under predicted climate change scenarios.

5 - What is the current distribution status of the organism with respect to the Risk Assessment Area?

Response:

L. gibbosus has been present in the UK for over 100 years at a handful of sites in the South and South East of England, the species now has 34 records on the National Biodiversity Network the earliest record being in Scotland at NO42 in 1918, which has long since expired.

Of the 34 records, 24 of are in sheet TQ with others in ST32, ST 627722, ST658693, TL23 & TL53, SU09 and TR35. The majority of these records (26/34) are from post 1990. There are currently 25 confirmed sites in England. However it is probable that there are more in isolated lentic waterbodies, given no species-specific surveillance programs have been initiated. That said, *L. gibbosus* are very distinctive in colouration and are unlikely to be misidentified up on capture. *L. gibbosus* are present in some lotic waters, however, these populations are not self-sustaining and are buoyed up by escapees from online waterbodies (Villeneuve *et al*. 2005). No populations of *L. gibbosus* are known to be present in Wales.

6 - Are there conditions present in the Risk Assessment Area that would enable the organism to survive and reproduce? Comment on any special conditions required by the species?

Response:

L. gibbosus is regarded as a warm water fish, and although it can tolerate cold conditions (4°C to 22°C; Froese, R. & Pauly, D, 2009), elevated water temperatures facilitate *L. gibbosus* metabolism and growth performance (Cucherousset *et al.* 2009). Reproduction requires water temperatures ~14°C (Burns, 1979), which has not impeded reproduction in lentic waterbodies in England. However, no reproduction of *L. gibbosus* has been observed in lotic waters, with Villeneuve *et al*. (2005) suggesting that the reduced water temperature in streams indicates that *L. gibbosus* are incapable of establishment in such waters, indeed, in much of its invaded range, *L. gibbosus* is almost exclusively associated with lacustrine environments (Cucherousset *et al*. 2009). In a study undertaken by Almeida *et al*. (2009), it was concluded that anthropogenically altered habitats facilitate the establishment of *L. gibbosus*. A preference for very shallow water when nest building is also exhibited (van Kleef *et al*. 2008), indicating that reservoirs and heavily managed lotic systems would provide suitable habitat for establishment.

7 - Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment Area or sufficiently similar for the organism to survive and thrive?

Response:

Yes. The Western European regions where *L. gibbosus* is present include regions such as northern France and the Netherlands which share a strong bioclimatic match to much of Britain's freshwaters. The heat maps produced by Gallardo & Aldridge (2013) reflect the similarity between the ecoclimates of the two regions.

8 - Has the organism established viable (reproducing) populations anywhere outside of its native range?

Response:

Yes, viable populations have been established in all countries detailed in section 4 and Brazil (de Magalhães & Ratton 2005; Santos *et al.* 2012). Reproducing populations are known to exist in the England, but are confined to lentic waterbodies.

9 - Can the organism spread rapidly by natural means or by human assistance?

Response:

Rapidly, no, but *L. gibbosus* can spread primarily via two introduction pathways; escapement to the lotic environment from a lentic one and anthropogenically. Villeneuve *et al*. (2005) suggests that the latter, human-assisted pathway is likely to be more of a risk. As established *L. gibbosus* populations are already present in lentic waters, there is also a risk of inadvertent transfer, with consignments of other fish species destined for recreational stocking enhancements (Davies *et al*. 2013; Villeneuve *et al*. 2005; Copp *et al*. 2007). However, allied to increased temperatures, under climate change scenarios, the magnitude and frequency of flooding events is also predicted to increase, increasing the likelihood of *L. gibbosus* dispersal from hydrologically connected waterbodies (Zieba *et al*. 2015; Forbert *et al*. 2013). It is of note, that no self-sustaining reproducing populations have been detected in English streams or rivers.

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10 - Could the organism as such, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment Area?

Response:

Yes. One likely form of harm could come in the form of ecological damage to other biota through either direct predation, or through cascading indirect effects through different trophic levels. For example, in other countries, including its native range, it has been demonstrated that abundance of *L. gibbosus* can affect snail abundance (Osenberg *et al.* 1992) and may have an impact on fish eggs (Garcia-Berthou & Moreno-Amich, 2000). However, studies in GB have found no evidence of ecological impact (Copp *et al.* 2010; Vilizzi *et al.* 2012; Stakėnas *et al.* 2013). Jackson *et al*. (2016) detected little evidence of negative interactions between *L. gibbosus* and native brown trout *Salmo trutta* in English streams with Nildeniz *et al*. (2016) finding a lack of competition for habitat between *L. gibbosus* and both native and non-native fish species in a Turkish stream. Additionally, Gkenas *et al*. (2016) demonstrated a shift in dietary specialization from establishment to integration, suggesting that potential ecological effects of *L. gibbosus* introductions can vary with invasion step.

Another potential threat is changes to recreational fishery quality and performance. *L. gibbosus* are regarded as a nuisance fish in France due to their diminutive size (Roule, 1931), and are likely to be regarded in a similar manner in UK recreational fisheries. Subsequent to establishment, *L. gibbosus* mean length at age decreases with increasing population numbers (Dembski *et al.* 2006, Fox *et al.* 2007), minimizing any potential recreational angling benefits. *L. gibbosus* populations have also been attributed to the increase of chlorophyll *a* and turbidity levels, whilst reducing zooplankton biomass (Angeler *et al*. 2002). With juvenile *L. gibbosus* dependent on soft-bodied macro-invertebrates (Copp *et al*. 2004), large *L. gibbosus* populations within recreational fisheries could reduce natural food abundance for native species, leading to stunting of extant populations and poor juvenile recruitment.

There is no reason to expect that an abundance of *L. gibbosus* would negatively impact a potable water supply, however as *L. gibbosus* can lead to reduced species diversity at invaded sites, this could have implications for scoring of water quality using biological metrics and have implications for the Water Framework Directive**.** Presence of large numbers *of L. gibbosus* are likely to influence chironomid species structure (Macchiusi & Baker 1992) and may therefore bias the WFD lake tool, CPET.

A study by Hockley *et al.* (2011) revealed *L. gibbosus* obtained from a stillwater in Southern England were host to the ancyrocephalid monogenean parasite *Onchocleidus dispar*. This parasite is non-native to GB and most likely introduced along with its host. *O. dispar* shows strong host specificity and was not found on any of the native fish species from the same water, indicating that the parasite poses no threat to native fauna.

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Entry Summary

Please estimate the overall likelihood of entry into the Risk Assessment Area for this organism (please comment on the key issues that lead to this conclusion).

Response: Very likely

Confidence: Very high

Comments (include list of entry pathways in your comments):

L. gibbosus has already entered GB and introduction pathways are still open, suggesting further introductions are possible. The species is present in high abundance in many countries in mainland Europe and it is possible that accidental introductions could occur, with *L. gibbosus* as a contaminant of a legal fish stocking from Europe and from regulated fish movements within GB already (Davies *et al.* 2013). However, due to disease controls under the Aquatic Animal Health Regulations in the EU there is now very limited fish movement trade with Europe and certainly none directly to fisheries and the wild. In addition, license requirements under the ILFA orders have severely restricted demand and the ornamental and pet trade for *L. gibbosus*. While these restrictions will have reduced the risk of new introductions they have not eliminated the risk

entirely.

Intentional release from ponds and/ or aquaria can also occur, but likelihood is low.

It should be noted that while further entry into GB is considered likely, current *L. gibbosus* populations within GB do pose a risk of further dispersal (anthropogenically assisted and natural) without any further introductions from Europe.

Establishment Summary

Please estimate the overall likelihood of establishment (mention any key issues in the comment box)

Response: Likely

Confidence: High

Comments (please state where in GB this species could establish in your comments):

Much of Southern GB is likely to be climatically matched with the native and invaded range of *L. gibbosus*. The current status of the species can be regarded as establishment in this area, but only in lentic environments. No *L. gibbosus* reproduction has been observed in rivers and/ or streams, primarily due to reduced water temperatures Villeneuve *et al*. (2005).

Any slow flowing or still water with summer temperatures > 15C is likely to be suitable for this species to establish in.

Spread Summary

Please estimate overall potential for spread (using the comment box to indicate any key issues).

Response: Likely

Confidence: Moderate

Comments (include list of entry spread in your comments):

As the species has already established in over thirty sites it is likely that further dispersal will occur, predominantly from lentic waterbodies with direct hydrological connection to rivers and streams or those within a floodplain. Future climate change scenarios are likely to increase the chance of spread, with elevated flows and frequency expected to contribute to dispersal of *L. gibbosus* from hydrologically connected sites, increasing propagule pressure on the receiving environments (Fobert *et al.* 2013).

Impact Summary

Overall impact rating (please comment on the main reasons for this rating)

Response: Moderate

Confidence: Moderate

Comments (include list of impacts in your comments):

There is currently little evidence of ecological impact in GB (Copp *et al.* 2010; Vilizzi *et al.* 2012; Stakėnas *et al.* 2013); however this could change under predicted climatic models.

This species has the potential to be competitor with native fish species due to both plasticity of diet shown between old and new populations (García-Berthou & Moreno-Amich 2005). Parental care has the potential to enhance reproductive success, compared to that of native species. Aggressive behavior, displayed by *L. gibbosus,* can also adversely affect native species' foraging success, reproduction and microhoabitat selection (Almeida *et al*. 2014). When present at high water temperatures these fish mature early and breed in their first year resulting in high densities of poorly conditioned fish (Dembski *et al.* 2006). Once present in high densities there is likely to be a deleterious impact via competition. Van Kleef *et al*. (2008) work in the Netherlands demonstrated that macroinvertebrate abundance in pools populated by large numbers of *L. gibbosus* was 83% lower than in pools without *L. gibbosus* in the Netherlands. *L. gibbosus* compete with native fish for food, which has been shown in roach, *Rutilus rutilus* (Declerk *et al.* 2002) with diet shifts observed in perch *P. fluviatilis* (Fobert *et al.* 2011). However, recent studies (Jackson *et al.* 2016; Top *et al*. 2016) failed to detect any deleterious impacts, interspecific resource competition or altered trophic positions of native (& non-native) fish populations when in sympatry with *L. gibbosus*.

Whilst a non-native parasite, *Onchocleidus dispar*, was found on *L. gibbosus* from an established population in Southern England, its high host-specificity meant it was confined to just the *L. gibbosus* population and was not detected on any native species with the same waterbody. Thus the risk of impact from parasites introduced by *L. gibbosus* is thought to be minimal.

L. gibbosus has been demonstrated to switch from trophic specialization to generalism as they integrate with native fauna in the receiving environment (Gkenas *et al*. 2016; Goncalves 2011), which may lessen impact on native species as *L. gibbosus* shift to less exploited food sources. Further research is required, to determine how this trophic plasticity will affect native species in GB. Thus, confidence of an impact is moderate, given *L. gibbosus* are close to their most Northerly latitude, which is currently limiting their invasion in GB and as yet, little evidence is available to accurately conclude on the extent of which *L. gibbosus* will impact native biota.

Climate change

What is the likelihood that the risk posed by this species will increase as a result of climate change?

Response: Very likely

Confidence: High

Comments (include list of impacts in your comments):

Under current climate conditions *L. gibbosus* is poses a relatively low risk to native biota and ecosystem function. Although *L. gibbosus* is not currently considered invasive in the United Kingdom, this status is likely to shift to' invasive' under predicted future climate scenarios as *L. gibbosus* populations are currently constrained by low water temperatures, preventing further establishment (Villeneuve *et al.* 2005). Forbert *et al*. (2013) did show fast juvenile growth and early age at maturity within a recently established *L. gibbosus* population, compared to the source population, traits which are associated with invasion success.

With increased survival and recruitment under conditions of a warmer climate, and life history traits that enable colonisation and establishment in novel environments, *L. gibbosus* will be able to exploit the increased hydrological variability and the extensive connectivity of canals and water course in southern England to expand its introduced range (Davies & Britton, 2016; Fobert *et al*. 2013, Masson *et al*. 2015, Zeiba, Fox & Copp 2015).

Conclusion

Please estimate the overall risk (comment on the main reasons for this rating)

Response: Moderate

Confidence: Moderate

Comments:

Risk is considered to be moderate based on the fact that *L. gibbosus* has already entered GB and established a number of viable populations, but no impacts have been detected to date and range expansion has been limited. Equally, lotic populations are 'buoyed' up by propagules dispersing from on-line lentic populations, with no *in situ* reproduction taking place. However, caution must be applied from these findings, given that predicated climate change scenarios are likely to facilitate the invasion of L. gibbosus in GB.

Confidence is moderate as the species is currently regarded as having a lower invasive potential than populations in mainland Europe (Cucherousset *et al*. 2009) and there is still a paucity of studies on GB *L. gibbosus* populations with no evidence of impact to date.

References

Almeida D, Merino-Aguirre R, Vilizzi L, Copp GH (2014) Interspecific Aggressive Behaviour of Invasive Pumpkinseed Lepomis gibbosus in Iberian Fresh Waters. *PLoS ONE* 9(2): e88038. doi:10.1371/journal.pone.0088038

Angeler, D. G., Álvarez-Cobelas, M., Sánchez-Carrillo, S., Rodrigo, M. A. (2002) Assessment of exotic fish impacts on water quality and zooplankton in a degraded semi-arid floodplain wetland. *Aquatic Sciences*. 64, 76-86.

Beyerlea, G.B. & Williams J.E., (1967) Attempted Control of Bluegill Reproduction in Lakes by the Application of Copper Sulfate Crystals to Spawning Nests. *The Progressive Fish-Culturist*, 29, 150-155.

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

Burns, J. R. (1976) The reproductive cycle and its environmental control in the Pumpkinseed, Lepomis gibbosus (Pisces: Centrarchidae). *American Society of Ichtyologists and Herpetologists (ASIH)*. 3, 449-455.

Casal, C.M.V. (2006) Global documentation of fish introductions: the growing crisis and recommendations for action. *Biological Invasions*, 8, 3–11.

Castro, B.B. & Goncalves, F. (2011) Planktivory in non-indigenous fish and implications for trophic interactions in a Mediterranean shallow lake. *Annales De Limnologie-International Journal of Limnology,* 47, 269-280.

Copp, G.H., Fox, M.G. & Kovac, V. (2002) Growth, morphology and life history traits of a cool-water European population of pumpkinseed Lepomis gibbosus. *Archiv Fur Hydrobiologie,* 155, 585-614.

Copp, G.H., Fox, M.G., Przybylski, M., Godinho, F.N. & Vila-Gispert, A. (2004) Life-time growth patterns of pumpkinseed Lepomis gibbosus introduced to Europe, relative to native North American populations. *Folia Zoologica,* 53, 237-254.

Copp, G. H., Templeton, M. & Gozlan, R. E. (2007) Propagule pressure and the invasion risks of non-native freshwater fishes: a case study in England. *Journal of Fish Biology*. 71, 148-159.

Copp, G.H., Stakėnas, S. & Cucherousset, J. (2010) Aliens vs. the natives: interactions between introduced Lepomis gibbosus and indigenous Salmo trutta in small streams of southern England. pp. 347–370 In: K.B. Gido & D. Jackson (eds) Community Ecology of Stream Fishes: Concepts, Approaches and Techniques. American Fisheries Society, Bethesda, Maryland.

Copp, G.H., Vilizzi, L. & Gozlan, R.E. (2010) The demography of introduction pathways, propagule pressure and occurrences of non-native freshwater fish in England. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 20, 595-601.

Cucherousset, J., Copp, G.H., Fox, M.G., Sterud, E., van Kleef, H.H., Verreycken, H. & Zahorska,E. (2009) Life-history traits and potential invasiveness of introduced pumpkinseed Lepomis gibbosus populations in northwestern Europe. *Biological Invasions,* 11, 2171-2180.

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

Davies, G. D., Gozlan, R. E. & Britton, J. R. (2013) Can accidental introductions of non-native species be prevented by fish stocking audits. *Aquatic Conservations: Marine and Freshwater Ecosystems.* 23, 366-373.

de Magalhães, A.L.B. & Ratton, T.F. (2005) Reproduction of a South American population of pumpkinseed sunfish *Lepomis gibbosus* (Linnaeus) (Osteichthyes, Centrarchidae): a comparison with the European and North American populations. *Revista Brasileira de Zoologia*. 22, 477–483.

Declerck, S., Louette, G., De Bie, T. & De Meester, L. (2002) Patterns of diet overlap between populations of non-indigenous and native fishes in shallow ponds. *Journal of Fish Biology,* 61, 1182-1197.

Dembski, S., Masson, G., Monnier, D., Wagner, P. & Phan, J.C. (2006) Consequences of elevated temperatures on life-history traits of an introduced fish, pumpkinseed Lepomis gibbosus. Journal of Fish Biology, 69, 331-346.

Fobert, E., Fox, M.G., Ridgway, M. & Copp, G.H. (2011) Heated competition: how climate change will affect non-native pumpkinseed Lepomis gibbosus and native perch Perca fluviatilis interactions in the UK. *Journal of Fish Biology,* 79**,** 1592-1607.

Fobert, E., Zięba, G., Vilizzi, L., Godard, M.J., Fox, M.G., Stakėnas, S. & Copp, G.H. (2013) Predicting non-native fish dispersal under conditions of climate change: case study in England of dispersal and establishment of pumpkinseed Lepomis gibbosus in a floodplain pond. *Ecology of Freshwater Fish*. 22, 106–116.

Fox, M.G., Vila-Gispert, A. & Copp, G.H. (2007) Life-history traits of introduced Iberian pumpkinseed Lepomis gibbosus relative to native populations. Can differences explain colonization success? *Journal of Fish Biology,* 71, 56-69.

Fox, M.G., Villeneuve, F. & Copp G.H. (2011) Seasonal reproductive allocation, local-scale variation and environmental influences on life history traits of introduced pumpkinseed (Lepomis gibbosus) in Southern England. *Fundamental & Applied Limnology*. 178, 231–243.

Froese R, Pauly D. (2009). FishBase. http://www.fishbase.org.

Gallardo, B. & Aldridge, D. (2013) Priority setting for invasive species management: risk assessment of Ponto – Caspian invasive species into Great Britain. *Ecological applications.* 23, 352-364.

García-Berthou, E. & Moreno-Amich, R. (2000) Food of introduced pumpkinseed sunfish: ontogenetic diet shift and seasonal variation. *Journal of Fish Biology,* **57,** 29-40.

Gkenas, C., Magalhã, M. F., Cucherousset, J., Domingos, I. & Ribeiro, F. (2016) Long term patterns in the late summer trophic niche of invasive pumpkinseed sunfish *Lepomis gibbosus*. *Knowledge and Management of Aquatic Ecosystems*. DOI: http://dx.doi.org/10.1051/kmae/2016006.

Godinho, F.N. & Ferreira, M.T. (1998) Spatial variation in diet composition of pumpkinseed sunfish, Lepomis gibbosus, and largemouth bass, Micropterus salmoides, from a Portuguese stream. *Folia Zoologica,* 47, 205-213.

Jackon, M. C., Britton, J. R., Cucherousset, J., Guo, Z., Stakenas, S., Gozlan, R. E., Godard, M. G., Roussel, J-M. & Copp, G. H. (2016) Do non-native pumpkinseed *Lepomis gibbosus* affect the growth, diet and trophic niche breadth of native brown trout *Salmo truta*? *Hydrobiologia*. 772, 63-75.

Klaar, M., Copp, G.H. & Horsfield, R. (2004) Autumnal habitat use of non-native pumpkinseed Lepomis gibbosus and associations with native fish species in small English streams. *Folia Zoologica*, 53, 189-202.

Künstler, J. 1908. Ameiurus nebulosus et Eupomotis gibbosus. Bulletin de la Societé d'Acclimatation. pp. 238–244.

Ling N. (2003) Rotenone – review of its toxicity and use in fisheries management. *Science for Conservation* 211. 40 pp.

Macchiusi, F. & Baker, R.L. (1992) Effects of Predators and Food Availability on Activity and Growth of Chironomus-Tentans (Chironomidae, Diptera). *Freshwater Biology,* 28, 207-216.

Osenberg, C. W., Mittelbach, G. G. & Wainwright, P. C. (1992) Two-stage life histories in fish: the interaction between juvenile competition and adult performance. *Ecology* 73, 255–267

Masson, G., Valente, E., Fox, M.G., Copp, G.H. (2015) Thermal influences on life-history traits and reproductive effort of introduced pumpkinseed sunfish *Lepomis gibbosus* in the river moselle basin (Northeastern France). *River Research and Applications*. 31, 563-575.

Przybylski, M., Zięba G. (2011) NOBANIS – Invasive Alien Species Fact Sheet – Lepomis gibbosus. – From: Online Database of the European Network on Invasive Alien Species – NOBANIS www.nobanis.org, Date of access 29/10/2013.

Roule, L. (1931) Les poisons et le monde vivant des eaux. Tome II. Les oeufs et les nids. Librairie Delegrave. Paris.

Santos, R.E., Silva, T.P., Chehayeb, I.V. & de Magalhães, A.L. (2012) Reproduction of the non-native fish Lepomis gibbosus (Perciformes: Centrarchidae) in Brazil. *Revista de Biologia Tropical*. 60, 1327–1334.

Stakėnas, S., Vilizzi, L. & Copp, G.H. (2013) Habitat use, home range, movements and interactions of introduced *Lepomis gibbosus* and native *Salmo trutta* in a small stream of Southern England. *Ecology of Freshwater Fish*. 22, 202–215.

Top, N., Tarkan, A. S., Vilizzi, L. & Karakuş, U. (2016) Microhabitat interactions of non-native pumpkinseed *Lepomis Gibbosus* in a Mediterranean-type stream suggest no evidence for impact on endemic fishes. *Knowledge and Management of Aquatic Ecosystems*. DOI: http://dx.doi.org/10.1051/kmae/2016023

van Kleef, H., van der Velde, G., Leuven, R. & Esselink, H. (2008) Pumpkinseed sunfish (*Lepomis gibbosus*) invasions facilitated by introductions and nature management strongly reduce macroinvertebrate abundance in isolated water bodies. *Biological Invasions*, 10, 1481-1490.

Vilizzi, L., Stakėnas, S. & Copp, G.H. (2012) Use of constrained additive and quadratic ordination in fish habitat studies: an application to introduced pumpkinseed (Lepomis gibbosus) and brown trout (Salmo trutta) in an English stream. *Fundamental & Applied Limnology.* 180, 69–75.

Villeneuve, F., Copp, G.H., Fox, M.G. & Stakenas, S. (2005) Interpopulation variation in growth and life-history traits of the introduced sunfish, pumpkinseed *Lepomis gibbosus*, in southern England. *Journal of Applied Ichthyology,* 21, 275-281.

Wheeler, A.C. & Maitland, P.S. (1973) The scarcer freshwater fishes of the British Isles I. Introduced species. *Journal of Fish Biology*. 5, 49–68.

Yavno, S. & Fox, M.G. (2013) Morphological change and phenotypic plasticity in native and non–native pumpkinseed sunfish in response to sustained water velocities. *Journal of Evolutionary Biology*. 26, 2383–2395.

Yavno, S., Fox, M.G., Vila-Gispert, A. & Bhagat, Y. (2013) Morphological differences between native and non-native pumpkinseed in traits associated with locomotion. *Environmental Biology of Fishes*. 96, 507–518.

Yavno, S., Rooke, A.C. & Fox, M.G. (2014) Morphological change and phenotypic plasticity in native and non–native pumpkinseed sunfish in response to competition. *Naturwissenschaften.* 101, 479-492.

Zięba, G., Fox, M.G. & Copp, G.H. (2010) The effect of elevated temperature on spawning of introduced pumpkinseed Lepomis gibbosus in Europe. *Journal of Fish Biology,* 77, 1850-1855.

Zięba, G., Fox, M.G., Copp, G.H. (2015) How will climate warming affect non-native pumpkinseed Lepomis gibbosus populations in the U.K.? *PLoS ONE* 10(8): e0135482. doi:10.1371/journal.pone.0135482