RISK ASSESSMENT SUMMARY SHEET

Pontogammarus robustoides

- A pale yellow freshwater amphipod crustacean, approx. 12mm long.
- Native to the Ponto-Caspian region, from where it has spread mainly into northern, eastern and central Europe. More recently (2018) detected in the Biesbosch area of the Netherlands.
- Modelling has provided mixed results, but it is likely to be able to establish in the south-east of England.
- Has significant, adverse impacts upon the richness, biodiversity, and biomass of native littoral communities within many invaded regions.

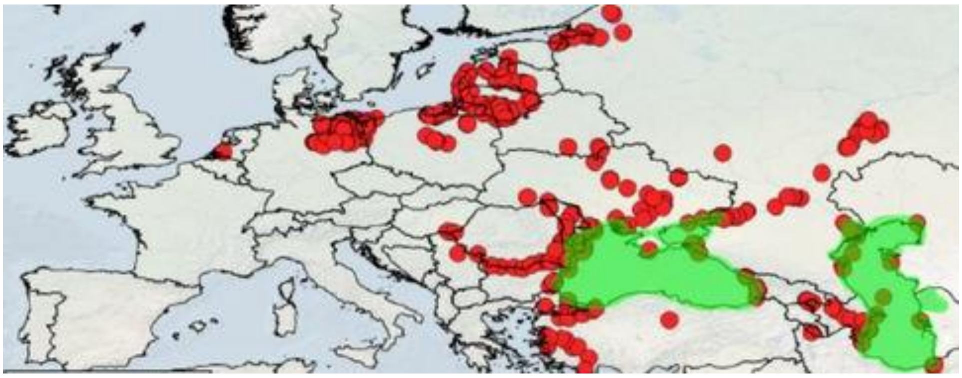
Photograph: Ton van Haaren, 2018

History in GB and Europe

Not yet present in GB. Biotic characteristics and most abiotic factors of GB waters are suitable for establishment; however, climatic conditions may be a limitation. Main introductions to northern and eastern Europe were deliberate introduction for aquaculture. Subsequently spread throughout these regions, to northern Germany and the Netherlands. Also introduced to some lagoons in the Mediterranean sea.

Global Distribution

Native to the Black, Azov, and Caspian Sea basins (green) with non-native populations in Europe, Russia and western Asia (red.) Not known to be introduced elsewhere.



Copilaș-Ciocianu et al., 2021. https://www.biorxiv.org/content/10.1101/2021.07.19.452907v1

Impacts

Environmental: (moderate, high confidence)

- A strong competitor and predator associated with the decline and/or displacement of amphipod species in invaded regions, with consequential impact on nutrient cycling and ecosystems.
- Native plants may be impacted, with reports of heavy grazing on littoral macrophytes, leading to a reduction in algal biomass.
- Can be infected by a range of parasites, including several microsporidia, gregarines and possibly acanthocephalans.

Economic: (minimal, medium confidence)

- None reported.

Societal: (minimal, high confidence)

- None reported.

Introduction pathway

Most likely pathway is introduction as a hitchhiker with ballast, boats or angling equipment.

Spread pathway

Natural: (major, high confidence) – dispersal along interconnected waterways is likely, as reported in Europe, where rates have been recorded at ~2km per year.

Human: (major, high confidence) – as hitchhikers with angling or attached to vessels moving between freshwater systems.

Summary

	Response	Confidence
Entry	LIKELY	MEDIUM
Establishment	LIKELY	MEDIUM
Spread	MODERATELY	HIGH
Impact	MODERATE	HIGH
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 NNRAP (an independent risk analysis panel) only when they are satisfied the assessment is fit-for-purpose.
- Approved 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 and GB 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 NNRAP 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: *Pontogammarus robustoides* (a freshwater amphipod)
Author: Daniel Warren, Swansea University
Risk Assessment Area: Great Britain
Version: Draft 1 (Apr 2021), Peer Review (Jun 2021), NNRAP 1 (Nov 21), Draft 2 (Feb 2022), NNRAP 2 (Mar 2022), Draft 3 (Apr 2022)
Signed off by NNRAP: March 2022
Approved by Programme Board: *to be completed*
Placed on NNSS website: *to be completed*

What is the principal reason for performing the Risk Assessment?

Horizon scanning has identified this species as one of the top 20 non-native species that pose a threat to biodiversity in Great Britain.

SECTION A – Organism Information	
Stage 1. Organism Information	**RESPONSE and 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?	Yes. *Pontogammarus robustoides* (Sars, 1894) – no common name Taxonomic Hierarchy: Animalia, Arthropoda, Crustacea, Malacostraca, Amphipoda, Gammaridae Whilst *P. robustoides* was fully described by Sars (1894), accepted nomenclature for this amphipod species was based on earlier identification by Grimm (1876; cited from Sars), who originally identified the organism as *Gammarus robustoides*. As such, *G. robustoides* is recognised as a basionym for the identity of *P. robustoides*, commonly cited in early Russian and Eastern European scientific literature. In 1924, Derzhavin described a potential subspecies of *P. robustoides*, *P. robustoides aestuarius*, but this was later classified as a separate *Pontogammarus* species (reviewed in CABI, 2021). Identification of *P. robustoides* is relatively simple when compared to other Ponto-Caspian amphipod species present in Great Britain (i.e. *Dikerogammarus villosus*, *D. haemobaphes*, *Chelicorophium curvispinum*), with individuals possessing a distinct monomorphic body pigmentation (usually pale yellow), shorter primary and secondary antennae (more or less the same length), and unique fan-like arrangements of armatures (i.e. spines) on the first urosome (5 – 7 spines), second urosome (4 – 6 spines), and endopod of the third urosome (three clusters of spines on outer edge and no spines on inner edge; CABI, 2021). Adequate magnification is required to visualise structures.
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)	NA

3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	NA
5. Where is the organism native?	The Ponto-Caspian Region In its native range, *P. robustoides* occurs in the coastal zones of the Black, Azov, and Caspian Sea basins, which span Russia, Turkey, Caucasia, Romania, Bulgaria, and Ukraine territories. It inhabits freshwater and brackish coastal lagoons and lakes and is also native to the lower reaches of numerous major Ponto-Caspian rivers, including the Volga, Don, Kuban, Bug, Terek, Kura, Dnieper, Dniester, Danube, and Prut.
6. What is the global distribution of the organism (excluding the risk assessment area)?	In addition to its native range (i.e. Ponto-Caspian region), *P. robustoides* has been found in Belarus, Estonia, Germany, Latvia, Lithuania, and Poland, as well as the Gulf of Finland (Baltic Sea) and various Brackish lagoons of the Mediterranean Sea. It has also spread from its native coastal range to inland waterbodies and waterways in Ukraine and Turkey. Since the early 1960's *P. robustoides* has been successfully introduced into numerous artificial hydroelectric reservoirs on the Dnieper, Neman, and Daugava rivers, in Ukraine, Caucasia, and Lithuania. In the Ponto-Caspian region, it was intentionally translocated to the Crimea water reservoirs (e.g. Simferopol) and Dnieper water reservoirs (e.g. Kakhovka; Jażdżewski, 1980). Following the development of several reservoirs along the River Volga in the 1950 – 1960's, it also spread along the middle reaches of the river, colonising several reservoirs, like the Volgograd and Saratov, and spreading as far as the Kuybyshev reservoir by 2000 (Kurina, 2012, 2017; CABI, 2021) – situated more than 570km away from Volgograd. In the Baltic region, the spread of *P. robustoides* began in 1960, with the deliberate release of individuals, taken from the Dnieper and Simferopol reservoirs, into the newly developed Kaunas reservoir on the Neman River, Lithuania (Arbačiauskas & Gumuliauskaitė, 2007).

	From 1963 – 1989, and later from 1995 – 1998, *P. robustoides* from Kaunas reservoir were intentionally introduced into other Lithuanian watercourses, including two additional water reservoirs (Antaliepte and Elektrenai), 103 lakes and several river systems (Vaitonis et al., 1990; Lazauskiene, 1997). It was also translocated north and released into Estonia, Latvia, and Western Russia (St. Petersburg region) between 1964 and 1969 (Gasiūnas , 1972). From these initial introduction areas, *P. robustoides* spread in a northern direction, along the coast of the Baltic Sea, colonising the Gulf of Riga (Kalinkina & Berezina, 2010; Strode et al., 2013), Gulf of Finland, Luga Bay (Zuev & Malavin, 2012), and the River Neva (Panov & Berezina, 2003), before expanding eastward into Lake Ladoga – one of the most northern reaches of its distribution (Kurashov & Barbashova, 2008). From the Kaunas reservoir, *P. robustoides* spread westerly, travelling down the River Neman, and entering the Curonian Lagoon – a second source-reservoir for the introduction of Ponto-Caspian organisms (Arbačiauskas et al., 2010). *P. robustoides* also spread south into Poland, entering the Vistula Lagoon (probably from the Curonian Lagoon or from the River Pregola; Dobrzycka-Krahel & Surowiec, 2001; Arbaciauska & Gumuliauskaitė, 2007), the Wloclawski reservoir (Grabowski et al., 2006) the Great Masurian lakes (Jażdżewska & Jażdżewski, 2008), and the Oder Estuary (Szczecin Lagoon; Gruszka, 1999). In 1994, *P. robustoides* was found in the Peene River in Germany (Rudolf, 1997). Later (1996-1997, 2014-2015), the species was found to be widespread in north-eastern Germany, present in numerous federal waterways and connected lakes in Mecklenburg-Western Pomerania (Mecklenburg-Vorpommern; Zettler, 1998; Zettler, 2002; Messner & Zettler, 2016), as well as Mittelland Canal (Martens et al., 1999). In 2018, the western-most point for *P. robustoides* was identified, when Moedt & van Haaren (2018) reported its presence in the Biesbosch area of the Netherlands. Although *P. robustoides* is considered native to the coastal zones of the Black Sea, recent studies have reported evidence of spread into inland waters. In 1964, *P. robustoides* was found to be present in four Turkish waterbodies, situated primarily around the Sea of Marmara (Morukhai-Boltovskoi, 1964). Since then, it has been confirmed in 20 inland lakes, reservoirs, and rivers, belonging to the Marmara, Thrace, Aegean, Central Anatolia, and Mediterranean

	regions, with Çayboğazı reservoir representing the southern-most point of its distribution (Arslan et al., 2020). Whilst *P. robustoides* has been successful in its spread along the northern and central migration corridors in Europe, there is minimal evidence concerning its effective progression along the southern corridor; despite inhabiting the lower reaches of the River Danube – regarded as the backbone of the southern migration corridor. In 2015, Borza et al. reported the presence of *P. robustoides* in the River Danube at Kozloduy (Bulgaria), 686 river km upstream from the Black Sea. Since then, established populations have been found in the River Tisza catchment (Hungary), situated 707 river km upstream from Kozloduy, indicating recent advancement (Csabai et al., 2020).
7. What is the distribution of the organism in the risk assessment area?	No current distribution within Great Britain known
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes. *P. robustoides* is reported to have a significant, adverse impact upon the richness, biodiversity, and biomass of native littoral communities, within many invaded regions (Berezina & Panov, 2003; Arbačiauskas & Gumuliauskaitė, 2007; Berezina, 2007; Gumuliauskaitė & Arbačiauskas, 2008). It is capable of displacing native European amphipods, with dramatic declines in native amphipod populations having been attributed to competitive exclusion over access to resources, as well as asymmetric intraguild predation by this organism (Arbačiauskas, 2002, 2005; Jażdżewski et al., 2004; Grabowski et al., 2006; Arbačiauskas & Gumuliauskaitė, 2007). In some regions, *P. robustoides* has even been found to out-compete previously established invaders, such as *Gmelinoides fasciatus* (Berezina & Panov, 2003) and *Dikerogammarus haemobaphes* (Jażdżewska & Jażdżewski, 2008). *P. robustoides* has also caused a decline in the abundance and body size of other (non-amphipod) native macroinvertebrate species through predation and/or competition (Arbačiauskas, 2005; Arbačiauskas & Gumuliauskaitė, 2007; Gumuliauskaitė & Arbačiauskas, 2008)

	P. robustoides has been recorded at super-abundant densities within some invaded regions (e.g. ≥10,000 individuals per m^2; Wawrzyniak-Wydrowska & Gruszka, 2005), often dominating native fauna in terms of biomass (representing up to 90% of total biomass of zoobenthos; Gumuliauskaitė & Arbačiauskas, 2008), which can adversely disrupt native communities (Arbačiauskas, 2005; Arbačiauskas & Gumuliauskaitė, 2007). In regions where *P. robustoides* abundance is moderate, impacts towards native macroinvertebrates communities are less severe (Arbačiauskas & Gumuliauskaitė, 2007). *P. robustoides* can also affect nutrient flow within invaded regions, through intense grazing upon native algal communities (Berezina et al., 2005; Berezina & Golubkov, 2008), and disruption to primary consumers (e.g. bivalves; Kobak et al. 2012).
9. Describe any known socio-economic benefits of the organism in the risk assessment area.	*P. robustoides* is not believed to be currently present in Great Britain.

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**	**CONFIDENCE**	**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)	few	high	
1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways. For each pathway answer questions 1.3 to 1.10 (copy and paste	i. Released as a desirable commodity species. ii. Introduced as a hitchhiker from ship ballast or hull, or from boating and/or angling equipment.		

additional rows at the end of this section as necessary).			
Pathway name:	i. Released as a desirable commodity species.		
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	Historically, *P. robustoides* have been intentionally translocated to various regions of eastern Europe as a resource species for aquaculture (Arbačiauskas & Gumuliauskaitė, 2007); intended to provide food for native, and introduced, commercially valued fish species (Grigorovich et al., 2002; Kostrzewa & Grabowski, 2003; Grabowski & Grabowski, 2005). Introductions have been conducted in numerous waterways in Lithuania (Arbačiauskas et al., 2017), as well as areas of Estonia, Latvia, Western Russia, and Turkey (Grudule et al., 2007; Ozbek, 2011; see Section A, Q6 for detailed description of invasion history).
i.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.	very unlikely	medium	Deliberate introductions are unlikely, but should they take place then large numbers may be introduced.
i.1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	very likely	very high	Intentional introductions for aquaculture would transfer *P. robustoides* into targeted freshwater habitats.

i.1.10. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	very unlikely	high	In Great Britain, it is unlikely that *P. robustoides* will be intentionally introduced by organisations with high environmental awareness. However, there is a small risk of deliberate unofficial introductions by independent aquaculturists/fisheries, importing amphipods, potentially of Ponto-Caspian origin, from regions of mainland Europe to provide a resource species for fish.
End of pathway assessment, repeat as necessary.			
Pathway name:	ii. Introduced as a hitchhiker from ship ballast (water and/or sedimentation) or hull, or from boating and/or angling equipment (e.g. mooring ropes, fishing nets).		
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)? (If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)	accidental	medium	Introduction as a hitchhiker is likely to be the most important point of entry for invasive freshwater invertebrates (Knight et al., 2017). If *P. robustoides* populations occur in regions where there is shipping/boating activity, organisms may be accidentally taken up in ballast water (collected in freshwater/brackish ports) or become attached to the hull and/or submerged shipping/boating equipment, such as mooring ropes (again in freshwater/brackish waters). Indeed, unintentional introductions via shipping activities have been identified as a main form of entry into freshwater and brackish habitats across Europe, particularly in the Baltic region (Gasiūnas, 1972; Jazdzewksi & Konopacka, 2000; Arbačiauskas, 2002, 2005; Jazdzewksi et al., 2002; Grabowski et al., 2003; Kurashov & Barbashova, 2008; Jażdżewska & Jażdżewski, 2008; Panov et al., 2009; Arbačiauskas et al., 2011; Kurashov et al., 2012; Csabai et al., 2020). Similarly, if recreational activities, such as angling, take place in regions colonised by *P. robustoides*, it may also be possible for sub-populations to attach to, and be translocated by various pieces of angling equipment (e.g. fishing nets). Equipment fouling has been shown to be a key route of invasion for other invasive amphipod

			species (Bacela-Spychalska et al., 2013; Anderson et al., 2014; Bacela-Spychalska, 2015; Smith et al., 2020). As such, this route is also likely to be important for *P. robustoides*.
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.	likely	medium	Depending on the volume of water taken up in ship/boat ballasts, a relatively large sub-population of amphipods may be collected, particularly within sediment and/or aquatic vegetation (see Poznanska et al., 2013). Translocation on the hulls and/or equipment of commercial/recreational boats/ships is likely to involve a relatively small sub-population of amphipods - depending on how successful they are at attaching themselves and persisting on substrata. For example, previous studies have demonstrated that *P. robustoides* can effectively attach to lengths of sailing rope, with a relatively high percentage (17%) remaining on the ropes even after attempts to remove them via rope shaking (Bacela-Spychalska, 2015). Probability of release for large numbers of amphipod organisms within a single year will be largely dependent on the volume of traffic between regions (e.g. Anderson et al., 2014; Smith et al., 2020).
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.	likely	high	*P. robustoides* is a freshwater/brackish-tolerant species and is therefore likely to survive translocation in the absence of ballast water exchange. *P. robustoides* has a wide-ecophysiological tolerance to conditions such as low oxygen concentration (Šidagytė & Arbačiauskas, 2016), salinity (up to 3.4%; Santagata et al., 2008), current velocity, and temperature ($\geq$ 30^{o}C; Kobak et al., 2017), making them adapted to survive transport in freshwater/brackish ballast water. Previous literature has also reported effective long-term survival in Ponto-Caspian amphipods whilst attached to angling/boating equipment, again in the absence of management (Anderson et al., 2015). Furthermore, *P. robustoides* appears to be more resistant to

			desiccation when compared to other amphipods, including *D. villosus* and *D. haemobaphes* (Poznanska et al., 2013). With evidence indicating an even greater tolerance to extreme environmental conditions, demonstrated by *P. robustoides* when compared to invasive *D. villosus* (see Poznanska et al., 2013; Kobak et al., 2017), it is highly likely that *P. robustoides* will survive translocation.
ii.1.6. How likely is the organism to survive existing management practices during passage along the pathway?	likely	high	If ballast water exchange takes place at sea, *P. robustoides* may survive, with previous research having identified the potential for this organism to survive in saline water (up to 3.4% salinity; Santagata et al., 2008). If boating/sailing equipment is adequately decontaminated, via thermal exposure (e.g. hot water spray/steam; Anderson et al., 2015; Shannon et al., 2018; Bradbeer et al., 2020, 2021), application of chemical disinfectants (e.g. Virkon; Bradbeer et al., 2020), followed by an appropriate period of drying, then *P. robustoides* is unlikely to survive. However, it is important to note that survival depends on the consistency with which management practices are applied.
ii.1.7. How likely is the organism to enter the risk assessment area undetected?	very likely	high	In the absence of surveillance, it is likely to go undetected. Detection is possible if there is appropriate inspection of ballast tanks, boat hulls and equipment. However, if amphipods are situated within aquatic vegetation, or within equipment (e.g. weave of mooring rope), then it may be more difficult to detect invaders.

ii.1.8. How likely is the organism to arrive during the months of the year most appropriate for establishment?	very likely	high	*P. robustoides* is capable of breeding throughout most of the year, with the reproductive period typically beginning between March and May (depending on region) and ending in October (Bacela & Konopacka, 2005; Berezina, 2016). *P. robustoides* produces several broods per year with the highest abundance of brooding (ovigerous) females occur in spring and summer (Bacela & Konopacka, 2005). Propagules translocated during spring and summer months, are also likely to contain brooding females.
ii.1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	very likely	high	Ballast exchange within freshwater systems will release *P. robustoides* into novel regions. The use of contaminated angling/boating equipment will also provide opportunity for release.
ii.1.10. Estimate the overall likelihood of entry into the risk assessment area based on this pathway?	likely	medium	Probability of release is dependent on the volume of traffic between regions (e.g. Anderson et al., 2014; Smith et al., 2020).
End of pathway assessment, repeat as necessary.			
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).	likely	medium	The overall probability of *P. robustoides* entering Great Britain is high/likely, expected to be facilitated by two main entry routes (aquaculture and hitchhiking). Release as a hitchhiker from ballast water or equipment is the more likely route of entry, whereas intentional release for aquacultural purposes is expected to be driven by unofficial activities by independent aquaculturists only, rather than by the actions of organisations with a high environmental awareness. Given its recent establishment in the Netherlands (see Moedt & Haaren, 2018) – a region which is most likely to facilitate the entry of invaders into Great Britain due to high volumes of trade – and

			evidence indicating that the time between first recordings of invaders in the Netherlands and then Great Britain has reduced significantly over recent years (see Gallardo & Aldridge, 2014) – it is likely that *P. robustoides* may enter Great Britain in the near future.

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?	likely	high	In 2013, Gallardo & Aldridge developed a series of climate suitability models for 16 Ponto-Caspian species, including *P. robustoides*, shortlisted by the Environment Agency as future invaders. Incorporating a range of bioclimatic variables, including temperature (minimum/maximum/mean), precipitation (annual, seasonal, and during the driest month), and altitude, these models predicted a high probability of establishment for *P. robustoides* in Great Britain (Gallardo & Aldridge, 2013a). Later modifications to these models by Gallardo & Aldridge (2014), using updated distribution data and the addition of several anthropogenic variables (Human influence index (HII), land use, population density, and proximity to roads and ports), continued to predict a high probability of establishment for *P. robustoides*, and identified relatively large areas of Great Britain as potentially suitable for colonisation; particularly those regions with high-traffic ports like the south-east (e.g. London and Medway), the East of England (e.g. Ipswich, Lowestoft, Felixstowe), the north-west (e.g. Liverpool and Manchester), and the south of Wales (e.g. Bristol, Cardiff, Port Talbot).
1.13. How likely is it that the organism will be able to establish in the risk assessment area based on the similarity	likely	high	There are numerous freshwater and brackish systems in Great Britain, that are similar to those in its native range (Ponto-Caspian), as well as those in its invaded range. Abiotic factors which are likely to determine the probability of establishment for *P. robustoides*

between other abiotic conditions in the risk assessment area and the organism's current distribution?			include alkalinity, nitrate and sulphate levels, pH, and dissolved oxygen (Gallardo & Aldridge, 2013b). Abiotic factors in Great Britain are typically within the range suitable for *P. robustoides* survival, including dissolved oxygen concentration, current velocity, and salinity (Santagata et al., 2008; Gallardo & Aldridge, 2013b; Šidagytė & Arbačiauskas, 2016; Kobak et al., 2017). *P. robustoides* are likely to become established in systems which receive by-products of environmental services (e.g. water treatment) or agricultural run-off, as it is tolerant to several water contaminants (nitrates, sulphates, etc.) which can affect alkalinity, water conductivity, pH and reduction (i.e. redox) potential (Arbačiauskas & Gumuliauskaitė, 2007; Gallardo et al., 2012; Paidere et al., 2019). There is a high probability for it to become established in systems with an alkalinity value > 120mg/L (Gallardo & Aldridge, 2013b).
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	likely	high	If *P. robustoides* were to be introduced to British aquaculture facilities (e.g. commercial fisheries), for example as a resource species, it is likely to become established.

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	Freshwater and brackish habitats are very common in Great Britain.
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	NA	
1.17. How likely is it that establishment will occur despite competition from existing species in the risk assessment area?	likely	high	*P. robustoides* may become established in freshwaters inhabited by competing species. Laboratory and field-based research has shown *P. robustoides* to be an effective competitor against other amphipod species (Arbačiauskas & Gumuliauskaitė, 2007; Bacela-Spychalska & Van der Velde, 2013), including other Ponto-Caspian invaders (e.g. *D. haemobaphes*; Jażdżewska & Jażdżewski, 2008; Kobak et al., 2016). In some instances, competition between *P. robustoides* and other amphipod species, might result in niche partitioning, and therefore coexistence. For example, in parts of Poland and Russia, *P. robustoides* has been reported to co-exist with *D. villosus* by occupying different habitat types, with *P. robustoides* inhabiting shallow sandy substrates, whereas *D. villosus* occur at greater depths (Yakovleva & Yakovleva, 2010; Kobak et al., 2014), typically inhabiting more rocky substrates (Boets et al., 2010).

1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?	very likely	high	The presence of higher order predators (e.g. fish) may lead to stress-induced reductions in *P. robustoides* growth, which may subsequently impair reproduction (Jermacz et al., 2017). However, it has established in Europe in the presence of fish, so predators are unlikely to prevent establishment in Great Britain. *P. robustoides* may potentially acquire some parasites from native species. In Europe, microsporidian parasites have been found to infect both *P. robustoides* and the British-native amphipod *Gammarus pulex*, such as *Dictyocoela muelleri* (Bacela-Spychalska et al., 2018). In invasive populations in Europe, it coexists or has displaced native amphipods, so it seems unlikely that acquired parasites would prevent establishment.
1.19. How likely is the organism to establish despite existing management practices in the risk assessment area?	very likely	very high	There are no management practices that would remove it. However, some biosecurity initiatives, such as "Check, Clean, Dry" may be effective in preventing the initial introduction of amphipods into waterways, thereby preventing their establishment along recreational pathways.
1.20. How likely are management practices in the risk assessment area to facilitate establishment?	very unlikely	high	*P. robustoides* is likely to invade wild, unmanaged freshwater and brackish habitats. Therefore, management practices are unlikely to affect establishment.
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?	very likely	high	There may be a few possible mechanisms of eradication. The treatment of entire water courses using insecticides, such as pyrethroids, followed by drainage, may be a possible method of eradication. However, given that some Ponto-Caspian species exhibit a high tolerance to pyrethroids, and a mortality rate of ≥60% (see Bundschuh et al., 2013; Wood et al., 2021), it is highly likely

			that some animals would survive, enabling populations to potentially become re-established over time.
1.22. How likely are the biological characteristics of the organism to facilitate its establishment?	likely	high	*P. robustoides* can exploit a range of food resources, including detritus, algae, copepods, isopods, and chironomids (Arbačiauskas, 2005; Berezina et al., 2005; Berezina, 2007). It is also a strong competitor for native, and invasive, European amphipods, capable of asymmetric intraguild predation (Arbačiauskas & Gumuliauskaitė, 2007; Jażdżewska & Jażdżewski, 2008; Bacela-Spychalska & Van der Velde, 2013; Kobak et al., 2016). *P. robustoides* is a highly fecund species, regarded as one of the most fecund in some invaded regions (e.g. Poland; Bij de Vaate et al., 2002; Bacela & Konopacka, 2005). Mean brood size is large (64.5 eggs per clutch; minimum – maximum = 11 – 185 eggs; Bacela & Konopacka, 2005), when compared with native *G. pulex* (6 – 29 eggs; Sutcliffe, 1992). Breeding typically occurs over a long period, from Spring to Autumn (Bacela & Konopacka, 2005; Berezina, 2016). *P. robustoides* reaches sexually maturity quickly, has a short gestation period (approximately 4-5 weeks), and therefore can have a multivoltine life cycle (2-3 generations per year; Bacela & Konopacka, 2005).
1.23. How likely is the capacity to spread of the organism to facilitate its establishment?	likely	high	Natural dispersal via interconnected waterways has been identified as a mode of spread and establishment for *P. robustoides* in Europe, particularly the Baltic region (e.g. Grudule et al., 2007; Jażdżewska & Jażdżewski, 2008) where natural dispersal rates have been recorded at approximately 2km per year (Arbačiauskas et al., 2011). As with *D. haemobaphes*, introductions into Britain's highly connected canals system may enable extensive spread through

			natural dispersal. However, accidental anthropogenic movement is also likely to contribute far more to the spread of *P. robustoides* within Great Britain (Anderson et al., 2014; Knight et al., 2017; Smith et al., 2020).
1.24. How likely is the adaptability of the organism to facilitate its establishment?	likely	high	A wide eco-physiological tolerance to conditions such as desiccation, dissolved oxygen concentration, current velocity, temperature, salinity, alkalinity and pollutants (excluding heavy metals; see Strode & Balode, 2013) is likely to aid in the establishment of *P. robustoides* in freshwater and brackish habitats in Great Britain (Arbačiauskas & Gumuliauskaitė, 2007; Santagata et al., 2008; Gallardo & Aldridge, 2013b; Poznanska et al., 2013; Šidagytė & Arbačiauskas, 2016). This is facilitated by its ability to exploit a wide range of food resources.
1.25. How likely is it that the organism could establish despite low genetic diversity in the founder population?	likely	high	There is no published evidence regarding the effects of post-invasional genetic bottlenecking on the establishment of *P. robustoides* in Europe. However, many other invasive amphipod species have become established despite experiencing this (Muller et al., 2002; Cristescu et al. 2004; Kelly et al., 2006).
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.)	moderately likely	medium	There have been numerous instances of establishment in new regions within mainland Europe, and parts of Asia. *P. robustoides* has spread extensively along the northern invasion corridor, colonising vast stretches of the Volga-Don canal (Kurina, 2012, 2017; CABI, 2021), large amounts of coastal and inland areas in the Baltic region (Gasiūnas, 1972; Panov et al., 2003; Grabowski et al., 2006; Arbačiauskas & Gumuliauskaitė, 2007; Kalinkina & Berezina, 2010; Zuev & Malavin, 2012), and even expanding into Western Russia (Kurashov & Barbashova, 2008). It has also expanded its range south/westerly, invading Germany (Zettler, 1998;

			Zettler, 2002; Messner & Zettler, 2016), and has successfully dispersed along the central invasion corridor – having recently been found in the Netherlands (Moedt & van Haaren, 2018); a region which has been a common entry route for invaders into Great Britain (see Gallardo & Aldridge, 2014).
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.	moderately likely	medium	Repeated introductions of *P. robustoides* sub-populations, via the invasion pathways described above, could lead to new or transient populations.
1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box).	likely	medium	Biotic characteristics and most abiotic factors of Great British waters are suitable for establishment; however, human activity is also likely to determine establishment.

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.)	major	high	If *P. robustoides* were to become established in freshwater and/or brackish habitats in Britain, then natural dispersal along interconnected waterways is likely, having been reported as a mode of spread and establishment in Europe, particularly the Baltic region (e.g. Grudule et al., 2007; Jażdżewska & Jażdżewski, 2008) where natural dispersal rates have been recorded at approximately 2km per year (Arbačiauskas et al., 2011). As with other invasive Ponto-Caspian amphipods, natural dispersal is likely to be a combination of active (i.e. swimming) and passive (drift) mechanisms (van Riel et al., 2011). Other potential modes of natural dispersal might include spread by migratory waterfowl, which has been reported for other amphipods (Swanson, 1984), including Ponto-Caspian invaders (e.g. *D. villosus*; Gallardo et al., 2012).
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 spread of *P. robustoides* is likely to occur via the same vectors associated with initial entry (excluding ballast water). Human-assisted dispersal is likely to be a major driver of spread for *P. robustoides* within Great Britain, providing multiple opportunities for introduction into novel habitats. The movement of commercial/recreational vessels (e.g. canal boats, narrowboats, kayaks, canoes) between and within freshwater systems, could facilitate the spread of *P. robustoides* sub-populations, as hitchhikers attached to hulls and/or boating equipment (e.g. mooring ropes; Anderson et al., 2014; Bacela-Spychalska, 2015; Csabai et al., 2020).

			Similarly, if recreational activities, such as angling, take place in regions colonised by *P. robustoides*, it may also be possible for sub-populations to attach to, and be spread by, various pieces of equipment (e.g. fishing nets), as reported in other Ponto-Caspian amphipods (Anderson et al., 2014; Smith et al., 2020). All vectors, mentioned above, are likely to facilitate "jump" dispersal between regions (Minchin et al., 2019; Csabai et al., 2020). Depending on the frequency of traffic, received in areas colonised by *P. robustoides*, dissemination between freshwater systems is likely to be rapid, and extensive (Anderson et al., 2014; Smith et al., 2020). There may be a small risk of deliberate introductions by independent aquaculturists/fisheries, translocating organisms in order to bolster stock populations. For example, in Lithuania deliberate introductions have contributed to the spread of *P. robustoides* (Arbačiauskas et al., 2017). Similar events may have also occurred in Great Britain, where anglers may have translocated *Dikerogammarus villosus* from Grafham Water (Cambridgeshire) into Pitsford Reservoir (Northamptonshire) (Anglian Water, pers. comms.).
2.3. Within the risk assessment area, how difficult would it be to contain the organism?	very difficult	high	*P. robustoides* is unlikely to be detected until a sufficiently large population has been established. As such, containment is likely to be very difficult.
2.4. Based on the answers to questions on the potential for establishment and spread in the risk assessment area, define the area endangered by the organism.	See comment	medium	Major rivers in SE England (e.g. River Thames) and the surrounding tributaries. Climate suitability models have predicted very high probability for *P. robustoides* establishment in Great Britain, as bioclimatic variables appear to be highly suitable (Gallardo & Aldridge, 2013a).

			Should establishment occur, spread is likely to affect rivers with higher human activity (e.g. Thames, Anglian, Severn and Humber river basin districts; Gallardo & Aldridge, 2013a, 2014).
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	high	*P. robustoides* is not believed to be currently present in Great Britain.
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)?	0-10	medium	The likelihood of introduction into Great Britain is probably quite high (i.e. likely). If introduced, the potential spread of *P. robustoides* within Great Britain is unlikely to be contained.
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.)	40	medium	Based on the historical spread of *P. robustoides* in mainland Europe over the past 60 years (Section A, part 6) – and the predicted spread of invasive freshwater organisms within Great Britain, it is likely that, following the introduction of *P. robustoides* into British freshwaters, a relatively large area of Britain may become invaded within 30 – 40 years (Gallardo & Aldridge, 2020). For example, Gallardo & Aldridge (2020) predicted a potential range increase of 15 – 18% (best-case scenario) and 24 – 28% (worst-case scenario) for *D. villosus* and *D. haemobaphes* by 2050, based on projected changes to environmental conditions. With the re-evaluation of previous suitability models (see Gallardo & Aldridge,

			2013a), incorporating evidence of wide eco-physiological tolerances by *P. robustoides* (e.g. Gallardo & Aldridge, 2013b; Kobak et al., 2017), changes to climatic and environmental conditions in Great Britain, as well as recent range expansions into regions similar to Great Britain (e.g. the Netherlands; see Moedt & van Haaren, 2018), similar rates of spread may be expected by *P. robustoides* over a similar time frame, once established in Great Britain.
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	medium	See comments for section 2.7
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	high	If *P. robustoides* becomes established in Great Britain, human-mediated spread is likely to be moderately rapid. Future, post-establishment spread is also likely to occur through interconnected waterbodies/waterways.

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**	**COMMENT**
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?	minimal	medium	There are currently no studies that indicate any economic losses as a result of invasions by *P. robustoides*. Reductions in macroinvertebrates have been observed in invaded areas (Arbačiauskas & Gumuliauskaitė, 2007), which could potentially impact upon commercially valued fish species.
2.11. How great is the economic cost of the organism **currently** in the risk assessment area **excluding management** costs (include any past costs in your response)?	minimal	very high	*P. robustoides* is not believed to be currently present in Great Britain.
2.12. How great is the economic cost of the organism likely to be **in the future** in the risk	minimal	very high	There are currently no studies concerning the potential economic cost of *P. robustoides* in British freshwaters. However, this invader may have an indirect impact upon aquaculture (i.e. fisheries; Arbačiauskas & Gumuliauskaitė, 2007).

assessment area **excluding management** costs?			
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	very high	*P. robustoides* is not believed to be currently present in Great Britain.
2.14. How great are the economic costs **associated with managing** this organism likely to be **in the future** in the risk assessment area?	minor	high	There is no standard, ecologically sound method prescribed for the eradication of Ponto-Caspian amphipods from British freshwaters. Any economic costs associated with the future management of *P. robustoides* in Great Britain are likely to be attributable to schemes to improve national biosecurity, and therefore prevent the spread of *P. robustoides*, if it becomes established (e.g. Check, Clean, Dry initiative; GB NNSS, 2021). Dissemination of these biosecurity practices at a national scale, amongst stakeholders, site managers, and recreational water users, is likely to incur some economic costs.
2.15. How important is environmental harm caused by the organism within its existing geographic range **excluding the risk assessment area**?	moderate	medium	Amphipods are keystone detritivores in freshwater ecosystems, which process primary basal energy resources (e.g. submerged leaf litter), releasing nutrients for other aquatic organisms (e.g. filter feeding bivalves). As such, displacement of shredding-efficient native amphipod species (e.g. *G. pulex*) by *P. robustoides* is likely to disrupt nutrient flow within invaded regions (MacNeil et al., 2011). Further disruptions to nutrient cycling may be expected, if predation/competition by *P. robustoides* extends to other native shredders such as *Asellus aquaticus* (Arbačiauskas, 2005; MacNeil et al., 2011). See also detail provided in response to question 8.

			However, *P. robustoides* might actually increase organic matter availability through higher levels of detritivory and/or herbivory, when compared to native amphipods, which may be enhanced by high invader densities (Berezina & Panov, 2003). Other indirect effects on nutrient cycling might occur. For example, Ponto-Caspian amphipods, including *P. robustoides* and *D. villosus*, can alter the normal functioning of filter-feeding mussel colonies, by triggering responses comparable to anti-predator defences (e.g. stronger attachment to substrates, vertical migration; Kobak et al., 2012).
2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in native species communities, hybridisation) **currently** in the risk assessment area (include any past impact in your response)?	minimal	very high	*P. robustoides* is not believed to be currently present in Great Britain.
2.17. How important is the impact of the organism on biodiversity likely to be in the **future** in the risk assessment area?	major	high	The largest impact to biodiversity may be towards native amphipods, which could be locally excluded. Previous research has identified *P. robustoides* as a strong competitor and predator, associated with the decline and/or displacement of various non-/native amphipod species (Arbačiauskas & Gumuliauskaitė, 2007). For example, declines in *Gammarus zaddachi*, *G. duebeni*, *G. salinus*, *G. oceanicus* and *G. varsoviensis* have been reported in Poland, following the arrival of *P. robustoides* (Jazdzewki et al., 2004; Ezhova et al., 2005; Grabowski et al., 2006). *P. robustoides* has also completely replaced *G. lacustris* in many

			inland lakes in Lithuania (Arbačiauskas, 2005), as well as *Chaetogammarus ischnus* (syn. *Echinogammarus ischnus*) in the Vistula Lagoon and Delta (Poland; Surowiec & Dobrzycka-Krahel, 2008). Predatory impacts imposed by *P. robustoides* can also extend to other macroinvertebrate taxa, with reports of intense predation of chironomids, oligochaetes, and amphipods in the Gulf of Finland (Berezina & Panov (2003). In Lithuania, *P. robustoides* abundance has been shown to have a significant negative correlation with higher invertebrate taxa, including Hirudinea, Ephemeroptera, Odonata, Trichoptera, Megaloptera, and Diptera (Gumuliauskaitė & Arbačiauskas, 2008). At high densities, *P. robustoides* may also have a detrimental predatory effect on populations of Isopoda (Gumuliauskaitė & Arbačiauskas, 2008). Native plants and algae may also be impacted, with reports of heavy grazing by *P. robustoides* on littoral macrophytes (e.g. *Cladophora glomerata*), leading to a reduction in algal biomass in regions densely populated by *P. robustoides* (Berezina & Panov, 2003). In some regions, heavy grazing by *P. robustoides* may have contributed to the disappearance of some macrophyte species (Gasiūnas , 1972).
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	very high	*P. robustoides* is not believed to be currently present in Great Britain.

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**?	moderate	medium	The decline and/or displacement of native amphipod species, as well as other shredding macroinvertebrates, may affect nutrient cycling within invaded regions (Jazdzewki et al., 2004; Arbačiauskas, 2005; Ezhova et al., 2005; Grabowski et al., 2006; Arbačiauskas & Gumuliauskaitė, 2007; MacNeil et al., 2011; Bacela-Spychalska & Van der Velde, 2013).
2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism **currently** in the risk assessment area?	minimal	very high	*P. robustoides* is not believed to be currently present in Great Britain.
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?	moderate	high	In Europe, the presence of invasive species can lead to reduced ecological status, as reported following the spread of *P. robustoides* into the Baltic region (Arbačiauskas et al., 2008, 2010, 2011).
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?	minimal	high	No reports of crossbreeding with other amphipods, although no explicit tests have been documented. Crossbreeding with native amphipods is very unlikely as *P. robustoides* is phylogenetically distant from natives.

2.23. How important is social, human health or other harm (not directly included in economic and environmental categories) caused by the organism within its existing geographic range?	minimal	high	NA
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)?	minimal	medium	If established, *P. robustoides* may be a suitable alternative food source for various native fish species (e.g. salmonids). In areas containing other Ponto-Caspian amphipod invaders, for example *D. villosus*, predation of *P. robustoides* may be higher, due to displacement via competition between amphipod species (e.g. Jermacz et al., 2015). Several studies have identified a range of parasites, capable of infecting *P. robustoides*, including several microsporidia (Fungi) and gregarines (Protozoa; Ovcharenko et al., 2006; Ovcharenko & Yemeliyanova, 2009; Bacela-Spychalska et al., 2018), and possibly acanthocephalans (Trematoda; Sulgostowska & Vojtkova, 1992). It is possible that parasites co-introduced with *P. robustoides* may spread to native amphipods. For example, Bacela-Spychalska et al. (2018) report that *Dictyocoela muelleri*, a microsporidian found in *P. robustoides*, can also be found in native *G. pulex*. In stressful environments, infections by *D. muelleri* negatively affect *Gammarus* hosts, (Gismondi et al., 2012) and can distort the sex ratio of infected populations (Haine et al., 2004).
2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the	NA	NA	

organism? (specify in the comment box)			
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 present in the risk assessment area?	moderate	low	Predation by native fish species (e.g. trout) may regulate *P. robustoides* populations in Great Britain, reducing the impact of this invasive organism.
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).	SE England	medium	Similar impacts are predicted for any invaded regions. Invasion is more likely in SE England, particularly freshwater and brackish habitats connected to major rivers which receive high volumes of traffic from commercial and/or recreational vessels (e.g. River Thames; Gallardo & Aldridge, 2013a, 2014).
2.28. Estimate the overall impact of this organism in the risk assessment area (using the comment box to indicate any key issues).	moderate	high	There is little likelihood of economic or societal impacts within Great Britain, with invasions expected to lead to the degradation of habitat, as well as water quality. *P. robustoides* may impose an environmental/ecological impact, primarily on native amphipods, but is also likely to affect a range of invertebrate species.

RISK SUMMARIES			
SUMMARY	**RESPONSE**	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	medium	Probability of entry is high, with two main pathways identified: intentional as an aquaculture species (e.g. fish-food) and accidental as a hitchhiker in ballast water or on equipment. Historically *P. robustoides* has been intentionally translocated across a wide region of eastern Europe as an aquaculture species, however, with increasing awareness and implementation of biosecurity this form of entry is less likely to occur, unless performed by independent aquaculturists, anglers, etc. Accidental release as a hitchhiker is much more likely to facilitate the entry of *P. robustoides* into regions of Great Britain, as reported in other Ponto-Caspian species currently present in Britain. Entry to Great Britain is likely to occur from the Netherlands – an area in which *P. robustoides* has recently become established - given the high volume of trade conducted between these regions.
Summarise Establishment	likely	medium	Probability of establishment for *P. robustoides* is predicted to be high, with abiotic conditions (i.e. climate, water chemistry) and human activity/proximity likely to determine suitable areas. Systems with high alkalinity (> 120mg/L) are the most likely areas for it to become established, as well as regions with high-traffic ports, like the south-east of England.
Summarise Spread	moderate	high	Should entry and establishment occur, spread is likely to proceed at a moderate rate, facilitated by the movement of contaminated boating/angling equipment, but also through natural dispersal along highly interconnected waterways.
Summarise Impact	moderate	high	There is little likelihood of economic or societal impacts within Great Britain, with invasions expected to lead to the degradation of habitat, as well as water quality. *P. robustoides* may impose an environmental/ecological impact, primarily on native amphipods, but is also likely to affect a range of invertebrate species through direct predation, or through indirectly altering nutrient cycling.
Conclusion of the risk assessment	medium	medium	*P. robustoides* is likely to enter Great Britain in the near future. Risk is considered to be moderate based on the significant expansion of this invader in mainland Europe, its

			recent discovery in the Netherlands – a potential gateway to the UK – and the projected suitability for *P. robustoides* in GB freshwaters. Should this species become established, then spread is likely to be moderately rapid with effects on native biodiversity expected.

Additional questions are on the following page ...

ADDITIONAL QUESTIONS - CLIMATE CHANGE			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	Ambient temperature, precipitation, water chemistry	medium	
3.2. What is the likely timeframe for such changes?	50 years	medium	
3.3. What aspects of the risk assessment are most likely to change as a result of climate change?	Probability of establishment and spread	medium	Climate warming may increase the suitability of Great Britain for *P. robustoides* establishment (Gallardo & Aldridge, 2020).
ADDITIONAL QUESTIONS - RESEARCH			
4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here.	Further research concerning the ecological impact of *P. robustoides* towards native UK freshwater communities, either through competition or predation, would provide greater insights into this invader's impact potential. It would also enable in-depth comparisons between *P. robustoides* and other Ponto-Caspian amphipod species currently present in the UK.	high	

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

REFERENCES:

Anderson, L.G., White, P.C.L., Stebbing, P.D., Stentiford, G.D. & Dunn, A.M. (2014), Biosecurity and Vector Behaviour: Evaluating the Potential Threat Posed by Anglers and Canoeists as Pathways for the Spread of Invasive Non-Native Species and Pathogens. *PLoS ONE*, **9**(4): e92788.

Anderson, L.G., Dunn, A.M., Rosewarne, P.J. & Stebbing, P.D. (2015), Invaders in hot water: a simple decontamination method to prevent the accidental spread of aquatic invasive non-native species. *Biological Invasions*, **17**: 2287 – 2297.

Arbačiauskas, K. (2002), Ponto-Caspian amphipods and mysids in the inland waters in Lithuania: History of introduction, current distribution and relations with native malacostracans. In: Leppäkoski F, Gollasch S, Olenin S (eds) Invasive Aquatic Species of Europe–Distribution, impacts and management. Kluwer, Dordrecht, pp 104–115.

Arbačiauskas, K. (2005), The distribution and local dispersal of Ponto-Caspian Peracarida in the Lithuanian fresh waters with notes on Pontogammarus robustoides population establishment, abundance, and impact. *Oceanological and Hydrobiological Studies*, **34**.

Arbačiauskas, K. & Gumuliauskaitė, S. (2007) Invasion of the Baltic Sea basin by the Ponto-Caspian amphipod Pontogammarus robustoides and its ecological impact. In: Gherardi F. (eds) Biological invaders in inland waters: Profiles, distribution, and threats. Invading Nature - Springer Series in Invasion Ecology, vol 2. Springer, Dordrecht.

Arbačiauskas, K., Semenchenko, V., Grabowski, M., Leuven, R.S.E.W., Paunović, M., Son, M.O., Csányi, B., Gumuliauskaitė, S., Konopacka, A., Nehring, S., Van der Velde, G., Vezhnovetz, V. & Panov, V.E. (2008), Assessment of biocontamination of benthic macroinvertebrate communities in European inland waterways. *Aquatic Invasions*, **3**: 211–230.

Arbačiauskas, K., Rakauskas, V. & Virbickas, T. (2010), Initial and long-term consequences of attempts to improve fish-food resources in Lithuanian waters by introducing alien peracaridan species: a retrospective overview. *Journal of Applied Ichthyology*, **26**(2): 28 – 37.

Arbačiauskas, K., Višinskienė, G., Smilgevičienė, S. & Rakauskas, V. (2011), Non-indigenous macroinvertebrate species in Lithuanian fresh waters, Part 1: Distributions, dispersal and future. *Knowledge and Management of Aquatic Ecosystems*, **402**(12).

Arbačiauskas, K., Višinskienė, G. & Smilgevičienė, S. (2011), Non-indigenous macroinvertebrate species in Lithuanian fresh waters, Part 2: Macroinvertebrate assemblage deviation from naturalness in lotic systems and the consequent potential impacts on ecological quality assessment. *Knowledge and Management of Aquatic Ecosystems*, **402**(13).

Arbačiauskas, K., Šidagytė, E., Šniaukštaitė, V. & Lesutienė, J. (2017), Range expansion of Ponto-Caspian peracaridan Crustaceans in the Baltic Sea basin and its aftermath: Lessons from Lithuania. *Aquatic Ecosystem Health & Management*, **20**(4), 393-401.

Arslan, N., Çamur-Elipek, B. & Mercan, D. (2020), Distribution of the Ponto-Caspian Species Pontogammarus robustoides (Sars, 1894) (Amphipoda) in the Inland Waters of Turkey. *Acta Zool. Bulg.*, **72**: 525-530.

Bacela, K. & Konopacka, A. (2005), The life history of Pontogammarus robustoides, and alien amphipod species in Polish waters. *Journal of Crustacean Biology*, **25**(2): 190-195.

Bacela-Spychalska, K. (2015), Attachment ability of two invasive amphipod species may promote their spread by overland transport. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **26**(1): 196 – 201.

Bacela-Spychalska, K., Grabowski, M., Rewicz, T., Konopacka, A. & Wattier, R. (2013), The ‘killer shrimp’ *Dikerogammarus villosus* (Crustacea, Amphipoda) invading Alpine lakes: overland transport by recreational boats and scuba-diving gear as potential entry vectors?. *Aquatic Conserv: Mar. Freshw. Ecosyst.*, **23**: 606-618.

Bacela-Spychalska, K. & Van der Velde, G. (2013), There is more than one ‘killer shrimp’: trophic positions and predatory abilities of invasive amphipods of Ponto-Caspian origin. *Freshwater Biology*, **58**: 730-741.

Bacela-Spychalska, K., Wróblewski, P., Mamos, T., Grabowski, M., Rigaud, T., Wattier, R., Rewicz, T., Konopacka, A. & Ovcharenko, M. (2018), Europe-wide reassessment of Dictyocoela (Microsporidia) infecting native and invasive amphipods (Crustacea): molecular versus ultrastructural traits. *Sci Rep*, **8**(8945).

Berezina, N.A. (2007), Invasions of alien amphipods (Amphipoda: Gammaridae) in aquatic ecosystems of North-Western Russia: pathways and consequences. *Hydrobiologia*, **590**: 15-29.

Berezina, N.A. (2016), Changes in life cycle of the Ponto-Caspian amphipod *Pontogammarus robustoides* at in the northernmost part of its range. *Marine Ecology*, **37**(6): 1434-1446.

Berezina, N.A. & Golubkov, S.M. (2008), Macrozoobentos of the Finland bay littoral: structural reorganisation as a result of new species invasions and eutrophication. (Macrozoobentos pribreznoj zoni Finskogo zaliva: strukturnie perestroyki v svjazi s vseleniem novich vidov i evtfofirovaniem.) In: Materials of the Xth Science Seminar 'Chtenia pamiaty KM Derjugina' [ed. by Katolikova, M.V.]. Saint Petersburg, Russia: Saint Petersburg University Press, 35-49.

Berezina, N.A. & Panov, V.E. (2003), Establishment of new gammarid species in the Eastern Gulf of Finland (Baltic Sea) and their effects on littoral communities. *Proc. Estonian Acad. Sci. Biol. Ecol.*, **52**(3): 284-304.

Berezina, N.A., Golubkov, S. & Gubelit, J.I. (2005), Grazing effects of alien amphipods on macroalgae in the littoral zone of the Neva Estuary (Eastern Gulf of Finland, Baltic Sea). *Oceanological and Hydrobiological Studies*, **34**: 63-82.

Berezina, N.A., Tsiplenkina. I.G., Pankova, E.S. & Gubelit, J.I. (2007), Dynamics of invertebrate communities on the stony littoral of the Neva Estuary (Baltic Sea) under macroalgal blooms and bioinvasions. *Transitional Water Bulletin*, **1**(1): 65-67.

Bij de Vaate, A., Jażdżewski, K., Ketelaars, H.A.M., Gollasch, S. & Van der Velde, G. (2002), Geographical patterns in range extension of Ponto-Caspian macroinvertebrate species in Europe. *Canadian Journal of Fisheries and Aquatic Sciences*, **59**(7): 1159-1174.

Boets, P., Lock, K., Messiaen, M. & Goethals, P.L.M. (2010), Combining data-driven methods and lab studies to analyse the ecology of *Dikerogammarus villosus*. *Ecological Informatics*, **5**(2): 133-139.

Borza, P., Csányi, B., Huber, T., Leitner, P., Paunović, M., Szekeres, J. & Wolfram, G. (2015), Longitudinal distributional patterns of Peracarida (Crustacea, Malacostraca) in the River Danube. *Fundamental and Applied Limnology*, **187**(2): 113-126.

Bradbeer, S.J., Coughlan, N.E., Cuthbert, R.N., Crane, K., Dick, J.T.A., Caffrey, J.M., Lucy, F.E., Renals, T., Davis, E., Warren, D.A., Pile, B., Quinn, C. & Dunn, A.M. (2020), The effectiveness of disinfectant and steam exposure treatments to prevent the spread of the highly invasive killer shrimp, *Dikerogammarus villosus*. *Sci Rep*, **10**(1919).

Bradbeer, S.J., Renals, T., Quinn, C., Warren, D.A., Pile, B., Hills, K. & Dunn, A.M. (2021), The effectiveness of hot water pressurised spray in field conditions to slow the spread of invasive alien species. *Management of Biological Invasions*, **12**(1).

Bundschuh, M., Gergs, R., Schadt, S. & Schulz, R. (2013), Do differences in sensitivity between native and invasive amphipods explain their coexistence in Lake Constance? A case study with lambda-cyhalothrin. *Chemosphere*, **92**(5): 483 – 489.

Cristescu, M.E.A., Witt, J.D.S., Grigorovich, I.A., Hebert, P.D.N. & MacIsaac, H.J. (2004), Dispersal of the Ponto-Caspian amphipod *Echinogammarus ischnus*: invasion waves from the Pleistocene to the present. *Heredity*, **92**: 197 – 203.

Csabai, Z., Borza, P., Rewicz, T., Pernecker, B., Berta, B.J. & Móra, A. (2020), Mass appearance of the Ponto-Caspian invader Pontogammarus robustoides in the River Tisza catchment: bypass in the southern invasion corridor? *Knowl. Manag. Aquat. Ecosyst.*, **421**(9).

Dobrzycka-Krahel, A. & Surowiec, J. (2011), Osmoregulation in Pontogammarus robustoides (G. Sars, 1894) (Amphipoda) and its distribution in the Brackish waters of northern Poland. *Crustaceana*, **84**(14): 1755-1767.

Ezhova, E., Żmudziński, L. & Maciejewska, K. (2005), Long-term trends in the macrozoobentos of the Vistula Lagoon, southeastern Baltic Sea: species composition and biomass distribution. *Bulletin of the Sea Fisheries Institute*, **164**.

Gallardo, B., Dodd, J.A. & Aldridge, D.C. (2012), A Preliminary Assessment of the Impact of Dikerogammarus villosus on Ecological status for the Water Framework Directive. Technical Report.

Gallardo, B. & Aldridge, D.C. (2013a), Review of the ecological impact and invasion potential of Ponto Caspian invaders in Great Britain: Technical Report. *Cambridge Environmental Consulting*.

Gallardo, B. & Aldridge, D.C. (2013b), Priority setting for invasive species management: Risk assessment of Ponto-Caspian invasive species into Great Britain. *Ecological Applications*, **23**(2): 352 – 364.

Gallardo, B. & Aldridge, D.C. (2014), Is Great Britain heading for a Ponto-Caspian invasional meltdown? *Journal of Applied Ecology*, **52**(1): 41 – 49.

Gallardo, B. & Aldridge, D.C. (2020), Priority setting for invasive species management by the water industry. *Water Research*, **178**: 115771.

Gasiūnas, I. (1972a), Enrichment of fodder basis of water bodies of Lithuania by acclimatized crustaceans-like organisms from the Caspian Sea complex. In: Maniukas, J. and Virbickas, J. (eds.), On the breeding of fish and crustacean-like organisms in the water bodies of Lithuania, Mintis, Vilnius, 57–68.

Grabowska, J. & Grabowski, M. (2005), Diel-feeding activity in early summer of racer goby *Neogobius gymnotrachelus* (Gobiidae): a new invader in the Baltic basin. *Journal of Applied Ichthyology*, **21**: 282-286.

Grabowski, M., Jażdżewski, K. & Konopacka, A. (2003), Gammarid invasion routes in Poland – a molecular approach. In: Abstracts, XIth International Colloquium on Amphipoda, Tunis, Tunisia, March 25-30/2003, Universite Tunis EL MANAR, p 36.

Grabowski, M., Konopacka, A., Jażdżewski, K. & Janowska, E. (2006), Invasions of alien gammarid species and retreat of natives in the Vistula Lagoon (Baltic Sea, Poland). *Helgol Mar Res*, **60**(90).

Gismondi, E., Rigaud, T., Beisel, J.N. & Cossu-Leguille, C. (2012), Microsporidia parasites disrupt the responses to cadmium exposure in a gammarid. *Environ Pollut.*, **160**(1): 17-23.

Grigorovich, I.A., MacIsaac, H.J., Shadrin, N. & Mills, E.L. (2002), Patterns and mechanisms of aquatic invertebrate introductions in the Ponto-Caspian region. *Canadian Journal of Fisheries and Aquatic Sciences*, **59**(7).

Grudule, N., Parele, E. & Arbačiauskas, K. (2007), Distribution of Ponto-Caspian amphipod *Pontogammarus robustoides* in Latvian waters. *Acta Zoologica Lituanica*, **17**(1): 28-32.

Gruszka, P. (1999), The River Odra estuary as a gateway for alien species immigration to the Baltic Sea basin. *Acta hydrochim. Hydrobiol*, **27**(5): 374-382.

Gumuliauskaitė, S. & Arbačiauskas, K. (2008) The impact of the invasive Ponto-Caspian amphipod *Pontogammarus robustoides* on littoral communities in Lithuanian lakes. In: Nõges, T. et al. (eds) European Large Lakes Ecosystem changes and their ecological and socioeconomic impacts. Developments in Hydrobiology, vol 199. Springer, Dordrecht.

Haine, E.R., Brondani, E., Hume, K.D., Perrot-Minnot, M.J., Gaillard, M. & Rigaud, T. (2004), Coexistence of three microsporidia parasites in populations of the freshwater amphipod *Gammarus roeseli*: evidence for vertical transmission and positive effect on reproduction. *Int J Parasitol.* **34**(10): 1137-1146.

Jażdżewska, A. & Jażdżewski, K. (2008), *Pontogammarus robustoides* (G.O. Sars, 1894) (Crustacea: Amphipoda), a new Ponto-Caspian invader in Great Masurian Lakes (NE Poland). *Fragmenta Faunistica*, **51**(1-2): 1-7.

Jażdżewski, K. (1980), Range extensions of some gammaridean species in Europe inland waters caused by human activity. *Crustaceana*, Supplementary No. 6.: 84-107.

Jażdżewski, K. & Konopacka, A. (1988), Notes on the Gammaridean Amphipoda of the Dniester River Basin and Eastern Carpathians. *Crustaceana*. Supplement, 13:72 – 89 pp.

Jażdżewski, K. & Konopacka, A. (2000), Immigration history and present distribution of alien crustaceans in Polish waters. In: von Vaupel Klein, J.C. & Schram, F.R. (eds), The biodiversity crisis and Crustacea, Proceedings of 4th International Crustacean Congress, Brill, Leiden, Crustacean Issues 12, pp 55-64.

Jażdżewski, K., Konopacka, A., & Grabowski, M. (2002), Four Ponto-Caspian and one American gammarid species (Crustacea, Amphipoda) recently invading Polish waters. *Contributions to Zoology*, **71**(4): 115-122.

Jażdżewski, K., Konopacka, A. & Grabowski, M. (2004), Recent drastic changes in the gammarid fauna (Crustacea, Amphipoda) of the Vistula River deltaic system in Poland caused by alien invaders. *Diversity and Distributions*, **10**: 81-87.

Jermacz, Ł., Dzierżyńska, A., Kakareko, T., Poznańska, M. & Kobak, J. (2015), The art of choice: predation risk changes interspecific competition between freshwater amphipods. *Behavioural Ecology*, **26**(2): 656-664.

Jermacz, Ł. & Kobak, J. (2017), Keep calm and don't stop growing: Non-consumptive effects of a sympatric predator on two invasive Ponto-Caspian gammarids *Dikerogammarus villosus* and *Pontogammarus robustoides*. *PLOS ONE*, **12**(8): e0182481.

Kalinkina, N.M. & Berezina, N.A. (2010), First record of *Pontogammarus robustoides* Sars, 1894 (Crustacea: Amphipoda) in the Gulf of Riga (Baltic Sea). *Aquatic Invasions*, **5**(Supplement 1).

Kelly, D.W., Muirhead, J.R., Heath, D.D., MacIsaac, H.J. (2006), Contrasting patterns in genetic diversity following multiple invasions of fresh and brackish waters. *Molecular Ecology*, **15**(12): 3641 – 3653.

Knight, C., Hughes, J.M.R. & Johns, T. (2017), What drives non-native amphipod distributions in the River Thames? The role of habitat and human activity on species abundance. *Crustaceana*, **90**(4): 399 – 416.

Kobak, J., Poznańska, M. & Kakareko, T. (2012), Behavioural changes of zebra mussel *Dreissena polymorpha* (Bivalvia) induced by Ponto-Caspian gammarids. *Biol Invasions*, **14**: 1851–1863.

Kobak, J., Jermacz, Ł. & Płąchocki, D. (2014), Effectiveness of zebra mussels to act as shelters from fish predators differs between native and invasive amphipod prey. *Aquat Ecol*, **48**: 397–408.

Kobak, J., Rachalewski, M. & Bacela-Spychalska, K. (2016), Conquerors or exiles? Impact of interference competition among invasive Ponto-Caspian gammarideans on their dispersal rates. *Biological Invasions*, **18**(7): 1953 – 1965.

Kobak, J., Jermacz, Ł., Marcińczyk, J., Bartoszyńska, E., Rutkowska, D. & Pawłowska, K. (2017), Abiotic factors affecting habitat selection by two invasive gammarids *Dikerogammarus villosus* and *Pontogammarus robustoides*. *Hydrobiologia*, **797**: 247–263.

Kostrzewa, J. & Grabowski, M. (2003), Opportunistic feeding strategy as a factor promoting racer goby (*Neogobius gymnotrachelus* Pallas, 1811) expansion in the Vistula basin. *Lauterbornia*, **48**: 91-100.

Kurashov, E.A. & Barbashova, M.A. (2008), First record of the invasive Ponto-Caspian amphipod *Pontogammarus robustoides* G.O. Sars, 1894 from Lake Ladoga, Russia. *Aquatic Invasions*, **3**(2): 253-256.

Kurashov, E.A., Barbashova, M.A., Djudakova, D.S. & Maljavin, S.A. (2012), Alien Crustacea species in aquatic ecosystems of the East part of Finland Bay, Baltic Sea). (Chuzherodnie vidi rakoobraznich v vodnich ecosystemach basseina vostochnoj chasti Finskogo zaliva Baltijskogo morja.) In: Actual problems of Crustacean study in continental waters: Lectures and Reports of the International Conference and Training [ed. by Korovchinsky, N.M., Zdanova, S.M. & Krilov, A.B.]. Kostroma, Russia: Kostroma Publishing House, 209-212.

Kurina, E.M. (2012), MALACOSTRACA of the Saratov Water Resevoir. In: Actual problems of Crustacean study in continental waters: Lectures and Reports of the International Conference and Training [ed. by Korovchinsky, N.M., Zdanova, S.M. & Krilov, A.B.]. Kostroma, Russia: Kostroma Publishing House, 213-215.

Kurina, E.M. (2017) Alien species of amphipods (Amphipoda, Gammaridea) in the bottom communities of the Kuybyshev and Saratov reservoirs: Features of distribution and life cycle strategies. *Russ J Biol Invasions*, **8**: 251–260.

Lazauskienė, L. (1997), Efficiency assessment of fish-food basis enrichment with introduced crustaceans [Žuvų mitybinės bazės praturtinimo introdukuotais vėžiagyviais efektyvumo įvertinimas]. Lithuanian Hydrobiological Association and Fishery Enterprises Association Lampetra, [Lietuvos hidrobiologų draugija ir Žuvivaisos įmonių asociacija Lampetra], Report, Vilnius, 49 pp.

MacNeil, C., Dick, J.T.A., Platvoet, D. & Briffa, M. (2011), Direct and indirect effects of species displacements: An invading freshwater amphipod can disrupt leaf-litter processing and shredder efficiency. *Journal of the North American Benthological Society*, **30**(1): 38 – 48.

Martens, A., Eggers, T. O. & Grabow, K. (1999), First discovery of *Pontogammarus robustoides* (SARS) in the Mittelland Canal (Crustacea: Amphipoda). (Erste Funde von *Pontogammarus robustoides* (SARS) im Mittellandkanal (Crustacea: Amphipoda).) *Lauterbornia*, **35**: 39-42.

Messner, U. & Zettler, M.L. (2016), Die aktuelle Verbreitung von Amphipoda (Crustacea) im Verlauf der Oberen Havel. *Lauterbornia*, **81**: 57–69.

Minchin, D., Arbačiauskas, K., Daunys, D., Ezhova, E., Grudule, N., Kotta, J., Molchanova, N., Olenin, S., Višinskienė, G. & Strake, S. (2019), Rapid expansion and facilitation factors of the Ponto-Caspian invader *Dikerogammarus villosus* within the eastern Baltic Sea. *Aquatic Invasions*, **14**(2): 165– 181.

Moedt, S. & Van Haaren, T. (2018), *Pontogammarus robustoides* (Sars, 1894), a new non-indigenous amphipod in the Netherlands (Crustacea: Amphipoda). *Lauterbornia*, **85**: 123-126.

Mordukhai-Boltovskoi, (1964), Caspian Fauna Beyond the Caspian Sea. *Int. Revue ges. Hydrobiol. Hydrogr.*, **49**: 139-176.

Müller, J.C., Schramm, S. & Seitz, A. (2002), Genetic and morphological differentiation of *Dikerogammarus* invaders and their invasion history in Central Europe. *Freshwater Biology*, 47(11): 2039 – 2048 pp.

Ozbek, M. (2011), Distribution of the Ponto-Caspian Amphipods in Turkish Fresh Waters: An Overview. *Mediterranean Marine Science*, **12**(2): 447-453.

Paidere, J., Brakovska, A., Vezhnavets, V., Škute, A. & Savicka, M. (2019), Effects of the environmental variables on the alien amphipod *Pontogammarus robustoides* in the Daugava River and its reservoirs. *Acta Biol. Univ. Daugavp.*, **19**: 169—180.

Panov, V.E. & Berezina, N.A. (2003), Establishment of new gammarid species in the eastern Gulf of Finland (Baltic Sea) and their effects on littoral communities. *Proc Estonian Acad Sci Biol Ecol*, **52**: 284–304.

Panov, V.E., Alexandrov, B., Arbačiauskas, K., Binimelis, R., Copp, G.H., Grabowski, M., Lucy, F., Leuven, R.S., Nehring, S., Paunović, M., Semenchenko, V. & Son, M.O. (2009), Assessing the risks of aquatic species invasions via European inland waterways: from concepts to environmental indicators. *Integr Environ Assess Manag.*, **5**(1): 110-26.

Poznańska, M., Kakareko, T., Krzyżyński, M. & Kobak, J. (2013), Effect of substratum drying on the survival and migrations of Ponto-Caspian and native gammarids (Crustacea: Amphipoda). *Hydrobiologia*, **700**: 47–59.

Rudolph, K. (1997), The occurrence of the water flea *Pontogammarus robustoides* in the Peene estuary area. *Natur und Museum*, **127**(9): 306-312.

Santagata, S., Gasiūnaitė, Z. R., Verling, E., Cordell, J. R., Eason, K., Cohen, J. S., Bacela, K., Quilez-Badia, G., Johengen, T. H., Reid, D. F., & Ruiz, G. M. (2008), Effect of osmotic shock as a management strategy to reduce transfers of nonindigenous species among low-salinity ports by ships. *Aquatic Invasions*, **3**: 61–76.

Shannon, C., Quinn, C.H., Stebbing, P.D., Hassall, C. & Dunn, A.M. (2018), The practical application of hot water to reduce the introduction and spread of aquatic invasive alien species. *Management of Biological Invasions*, **9**(4): 417-423.

Šidagytė, E. & Arbačiauskas, K. (2016), Resistance to low oxygen in the Ponto–Caspian amphipod *Pontogammarus robustoides* varies among lentic habitats of its northern invaded range. *Limnologica*, **61**: 7-13.

Smith, E.R.C., Bennion, H., Sayer, C.D., Aldridge, D.C. & Owen, M. (2020), Recreational angling as a pathway for invasive non-native species spread: awareness of biosecurity and the risk of long distance movement into Great Britain. *Biological Invasions*, **22**: 1135 – 1159.

Strode, E., & Balode, M. (2013), Toxico-resistance of Baltic amphipod species to heavy metals. *Crustaceana*, **86**(7-8): 1007-1024.

Strode, E., Berezina, N.A., Kalnins, M. & Balode, M. (2013), New records of the amphipods *Gammarus tigrinus* Sexton, 1939 and *Pontogammarus robustoides* G.O. Sars, 1894 in Latvian waters of the Baltic Sea. *BioInvasions Rec*, **2**: 63—68.

Sulgostowska, T. & Vojtkova, L. (1992), The helminth fauna of *Gammarus spp.* (Amphipoda) from the south-east Baltic Sea (Poland). *Acta Parasitologica*, **37**(4): 189-193.

Surowiec, J. & Dobrzycka-Krahel, A. (2008), New data on the non-indigenous gammarids in the Vistula Delta and the Vistula Lagoon. *Oceanologia*, **50**:443–447.

Sutcliffe, D.W. (1992), Reproduction in *Gammarus* (Crustacea, Amphipoda): basic processes. *Freshwater Forum*, **2**(2): 102 – 128.

Vaitonis, G., Lazauskienė, L. & Razinkov, A. (1990), Study of results of economic efficiency, and perspectives of acclimatization of invertebrates in the Baltic water bodies [Izuchenije rezul'tatov ekonomicheskoj effektivnosti i perspektivy akklimatizacii bezpozvonochnykh v vodoemakh Pribaltiki]. *Scientific research report*, Institute of Ecology, Vilnius: 67 pp.

Van Riel, M.C., Van Der Velde, G. & Bij De Vaate, A. (2011), Dispersal of invasive species by drifting. *Current Zoology*, **57**(6): 818–827.

Wawrzyniak-Wydrowska, B. & Gruszka, P. (2005), Population dynamics of alien gammarid species in the River Odra estuary. *Hydrobiologia*, **539**: 13–25.

Wood, L.E., Smith, E.R.C., Bojko, J. & Stebbing, P. (2021), Options for the control of *Dikerogammarus villosus* (killer shrimp) and other invasive amphipods. *Management of Biological Invasions*, **12**(3): 662-684.s

Yakovleva, A.V. & Yakovlev, V.A. (2010), Modern fauna and quantitative parameters of invasive invertebrates in zoobenthos of upper reaches of the Kuybyshev Reservoir, Russia. *Russ J Biol Invasions*, **1**: 232–241.

Zettler, M.L. (1998), Zur Verbreitung der Malacostraca (Crustacea) in den Binnen- und Küstengewässern von Mecklenburg-Vorpommern. *Lauterbornia*, **32**: 49–65.

Zettler, M.L. (2002), Crustaceologische Neuigkeiten aus MecklenburgVorpommern. *Arch Freunde der Naturgeschichte Mecklenburg*, **41**: 15–36.

Zuev, Y.A. & Malavin, S.A. (2012), MALACOSTRACA of the Luga Bay (Finland Bay): condition and antropogenic impact. In: Actual problems of Crustacean study in continental waters: Lectures and Reports of the International Conference and Training [ed. by Korovchinsky, N.M., Zdanova, S.M. & Krilov, A.B.]. Kostroma, Russia: Kostroma Publishing House, 195-198.