RISK ASSESSMENT SUMMARY SHEET

Acartia tonsa

- A translucent, planktonic copepod (<1.5mm) found in estuaries worldwide, probably introduced with ballast water.
- Cryptogenic, making invasion history difficult to trace.
- Present in a few sites in GB, presumed established, but full extent unknown given limited surveillance.
- Could displace native copepod species and possibly have impacts on the food chain; however, impacts are considered minor.
- Used as live feed for marine animals and available for use / sale in GB.

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History in GB

Uncertain. Recorded in GB from Southampton Water c.1916 and subsequently found in the Tamar Estuary, the Exe Estuary and the Firth of Forth. Globally widely distributed, with populations present in northern Europe since 1916.

Native Distribution

The native range of *A. tonsa* is difficult to determine due to its cryptogenic nature and cosmopolitan distribution. It is reported as native to the Atlantic, Indian, and Pacific Oceans.

GB Distribution

Recorded from Southampton Water, the Tamar Estuary, the Exe Estuary and the Firth of Forth. Reports are multi-year over several decades, implying establishment.

Impacts

Environmental (minor, low confidence)

- No known impacts in GB
- Some evidence worldwide of impacts on native copepod abundance and distribution
- Possible impacts on food chains by changing nutrient availability for fish

Economic (minor, medium confidence)

- None documented

Social (minor, medium confidence)

- None documented

Introduction pathway

Ballast water - the main introduction pathway worldwide and most likely for GB

Live food for marine animals – sold to feed to fish and coral (available online in GB)

Spread pathway

Natural (slow, low confidence) – planktonic and so can spread slowly in marine currents

Human mediated (intermediate, medium confidence) - ballast and bilge may help to spread this species

Summary

	Response	Confidence
Entry	V. LIKELY	HIGH
Establishment	LIKELY	HIGH
Spread	INTERMEDIATE	LOW
Impact	MINOR	MEDIUM
Overall risk	LOW	LOW

Rapid Risk Assessment of: *Acartia tonsa*
Author: Hannah Tidbury and Debbie Murphy (Cefas)
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GB Non-native species Rapid Risk Assessment (NRRA)

Introduction:
The rapid risk assessment is used to assess invasive non-native species more rapidly than the larger GB Non-native Risk Assessment. The principles remain the same, relying on scientific knowledge of the species, expert judgement and peer review. For some species the rapid assessment alone will be sufficient, others may go on to be assessed under the larger scheme if requested by the Non-native Species Programme Board.

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

Response:

To rapidly assess the risk associated with the planktonic copepod, *Acartia tonsa,* in line with requirements under the UK Marine Strategy (UKMS). Specifically, the risk assessment was performed as part of a series of risk assessments conducted to identify high and moderate risk species, already present or at risk of introduction, which should be prioritised for monitoring and surveillance.

2 - What is the Risk Assessment Area?

Response: Great Britain (GB)

3 - What is the name of the organism (scientific and accepted common; include common synonyms and notes on taxonomic complexity if relevant)?

Response: *Acartia tonsa* (Dana 1849)

Common names: A planktonic copepod

Synonyms:
Acartia bermudensis (Esterly, 1911)
Acartia floridana (Davis, 1948)
Acartia giesbrechti (Dahl, 1894)
Acartia gracilis (Herrick, 1887)
Acartia tonsa cryophylla (Björnberg, 1963)

4 - Is the organism known to be invasive anywhere in the world?

Response:

The native range of *A. tonsa* is difficult to determine due to its cosmopolitan distribution. The species is referred to as both non-indigenous and cryptogenic. Where categorised as cryptogenic, the precautionary approach has generally been applied, while the risk posed is monitored and assessed. It is unclear whether distribution data relating to this species throughout the 1900s reflect new introductions or the first confirmation of the species presence in these locations, e.g., if monitoring had not taken place before.

The native range of *A. tonsa* is reported as Atlantic, Indian, and Pacific Oceans (Gonzalez, 2013, Narščius, A, 2019). This species is often described as cosmopolitan with an almost worldwide distribution in coastal subtropical and temperate waters (Jensen, 2010) and has been reported in the Atlantic, Sea of Azov, the Baltic, Black, Capsian, Mediterranean, and North Seas, and also the Gulf of Mexico.

There are reports of *A. tonsa's* presence throughout northern European waters since its first report in France in 1925 including Denmark, Gulf of Riga in the Baltic, Gulf of Gdansk, Poland, Gulf of Finland and the waters around Helsinki, France, several estuaries in the Bay of Biscay, the estuary of the Weser in Germany, Baltic coast, Sweden. Since 1968, *A. tonsa* has also been found in the Mediterranean, the Black Sea and the Caspian Sea. It seems to be still spreading in the Mediterranean (Jensen, 2010).

A. tonsa was first reported on the east coast of North America around 1900, where it was found in brackish water. Presently its NW Atlantic distribution extends from New Brunswick, Canada to Argentina in the south. On the Pacific coast, it was also first reported around 1900 in San Diego and subsequently in San Francisco Bay then along the coast of Chile and Peru. Studies question the lineage of *A. tonsa* populations on both the east and west coasts of the USA. Molecular studies have indicated that the individuals identified as *A. tonsa* on the Pacific coast of North America are a distinct species (Caudill & Bucklin, 2004). Also, the high genetic variability between *A. tonsa* on the Atlantic and gulf of Mexico coasts of the USA indicate the presence of clades that are reproductively isolated cryptic species (Chen & Hare, 2008) and suggest that dispersal of the species is not human mediated (Caudill & Bucklin, 2004).

This species is commonly referred to as invasive. For example, in the estuaries of Bilbao and Gironde, *A. tonsa* has altered the abundance, and/or the spatial and seasonal distribution of native copepod species (Aravena et al., 2009, David et al., 2007).

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

Response:

Records of this species in GB include in Southampton Water, the Tamar Estuary, the Exe Estuary and the Firth of Forth (Castro-Longoria, 2003; Eno et al., 1997; Forrest et al., 2000; Razouls et al., 2018). Reports are multi-year over several decades, implying establishment, but given the sightings' proximity to ports/ marinas it is not possible to confirm if this is a result of multiple introductions or establishment. It would presumably be difficult for any monitoring/ reportee to confirm anything more than presence/ absence in relation to this species given its lifecycle/ size.

Currently the only routine monitoring in the risk assessment area, which may detect *A. tonsa*, is the ongoing monitoring using the continuous plankton recorder. The sampling effort is offshore and, therefore, in locations where detection of this species is less likely. As a consequence, it is possible that further populations may be present that have not been identified.

The species can be imported legally to GB and its keeping does not require permits under any current non-native species (NNS) legislation. However the release of NNS does require permission under the Wildlife and Countryside Act 1981. Internet searches for "*Acartia tonsa* for sale" show it is widely available for use as live feed for captive marine species and often marketed as live UK cultured stock. It is, therefore, likely that *A. tonsa* is held by businesses and individuals with fish and/ or coral keeping facilities, including those within the risk assessment area that have potential drainage links to the marine environment. The species is also used in GB by laboratories for acute toxicity testing.

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: Yes

This species is present in the risk assessment area, supporting the fact that the conditions present in the risk assessment area are suitable for this species.

A. tonsa inhabits estuaries and lagoons throughout the world, often dominating coastal and estuarine plankton samples. *A. tonsa* is tolerant to a wide temperature range (-1 to 32˚C) (Paffenhöfer & Stearns, 1988) with a temperatures of 15°C required for egg hatching (Castro-Longoria, 2003). Its salinity range is 3-30 psu, however survival between 0.5-70 psu is reported (Svetlichny & Hubareva, 2014). *A. tonsa* egg production rate was found to reduce under low salinity (15 psu) (Castro-Longoria, 2003). *A. tonsa* is found throughout the water column, but mainly occurs in surface layers.

It has a short generation time (13 days at 16-18˚C) (Berggreen et al., 1988) and females survive longer (70-80 days) than males (15 days) (Gonzalez, 2013). Longevity is influenced by food availability, predation, salinity, and temperature (Calliari, et al., 2008; Gonzalez, 2013, Holste and Peck, 2006; Marcus and Wilcox, 2007; Mauchline, 1998; Richmond, et al., 2006; Sei & Ferrari, 2006). *A tonsa* is adapted to high food (phytoplankton) concentrations, which it encounters in estuaries and upwelled waters. It is unable to obtain sufficient food for reproduction on the middle and outer shelf, where food concentrations are usually low (Paffenhöfer & Stearns, 1988). It has the ability to produce subitaneous and diapause eggs (Castro-Longoria, 2001) in response to unfavourable conditions.

The habitat and environmental conditions required by *A. tonsa* are present within the risk assessment area.

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 species is already present in the risk assessment area and locations, such as coastal waters of mainland Europe (e.g. Aravena et al., 2009; Brylinski, 1981), with closely matched ecoclimatic zones to the risk assessment area.

8 - Has the organism established viable (reproducing) populations anywhere outside of its native range (do not answer this question if you have answered 'yes' to question 4)?

Response: N/A

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

Response: Yes.

The introduction and spread of this species has primarily been linked to its transportation in ballast water (Gubanova, 2000). Its production of diapause eggs may have helped with transport in ballast water (Eno et al. 1997). Transport in bilge water of smaller boats and recreation craft may also have contributed to its introduction and spread.

Given the planktonic nature of *A. tonsa,* coastal spread over short distances via natural dispersal on ocean currents may be possible (Hays, 2017), though evidence of spread of *A. tonsa* via natural dispersal was not found. Further, the resting eggs of *A. tonsa* are found in the sediment (Katajisto et al., 1998) reducing the likelihood of them dispersing on ocean currents.

A. tonsa was first recorded from the Black Sea in 1990 (Belmonte et al., 1994), but examination of older plankton samples showed that it was present in 1976. It was not reported in the Mediterranean until 1985, indicating that introduction into the Black Sea was human mediated (i.e. via ballast water) (Gubanova, 2000) rather than through natural dispersal.

Given the wide use of the species as a live feed for captive marine species, including within mariculture and ornamental fish/ coral keeping, release cannot be ruled out as means of spread, especially in the form of diapause eggs released into coastal drainage systems that link to the marine environment.

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

Response: Yes.

Most studies of *A tonsa* focus on its life cycle and the environmental factors affecting its growth and cultivation, primarily in enclosed facilities. There is limited information regarding the impact of the non native copepods being investigated. Competitive interactions between copepod species, including *A. tonsa*, may be limited by their often distinct environmental niches, spatial distribution and seasonality (e.g Gubanova, 2000). However, evidence of negative impacts of *A tonsa* on native copepod abundance and distribution do exist. In the Gironde estuary, France, the establishment and proliferation of *A. tonsa* (attributed to salinity and temperature changes) was linked to altered and extended seasonal patterns in total copepod community abundance, and limited seasonal abundance of the native copepods *Acartia bifilosa* and *Eurytemora affinis*, without affecting their population stability (David et al., 2007). For example, it was suggested that the reduction in abundance of *A. bifilosa* in autumn, recorded between two sampling periods (1978-1982 – no *A. tonsa* present, and 1999-2000 –*A. tonsa* highly abundant) could be explained by *A. tonsa* preying on *A. bifilosa* nauplii in late summer (David et al., 2007). In a study conducted in Bilbao estuary, Spain, competitive interactions between *A. tonsa* and the native *A. clausi* were documented (Aravena et al., 2009). More specifically, an increase in *A. tonsa* abundance, linked to environmental changes (temperature and dissolved oxygen), resulted in the displacement of *A clausi* in intermediate salinity waters (average salinity of 33 psu), where spatial overlap with *A. tonsa* was most pronounced, reducing its distribution to outer part of the estuary (average salinity of ≥34 psu) (Aravena et al., 2009). The grazing impact of *A. tonsa* appears minor; for example it has been shown to consume only 1% of the phytoplankton in a Mediterranean lagoon (Cervetto et al., 1995).

Entry Summary

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

Response: *very likely*
Confidence: *high*

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

The fact that the species is already located in the risk assessment area provides support for the 'very likely' entry response score given with high confidence.

Introduction of *A. tonsa* into new locations has been linked to ballast water exchange (Gubanova, 2000). Its planktonic life history, its ability to produce resting eggs during periods of unfavourable environmental and biotic conditions (Katajisto, 2006) and its tolerance to a large range of salinities (Camatti et al., 2019, Chaalali et al., 2013; Chinnery and Williams, 2003; Peck et al., 2015; Svetlichny and Hubareva, 2014) may facilitate its transport in ballast tanks. Given its link to ballast water, introduction may be predicted to occur in locations within the risk assessment area which have high shipping activity, i.e. ports (Tidbury et al., 2016). However, with the implementation of the ballast water management convention (International Maritime Organization, 2004) risk of its introduction in the future is likely to reduce. Introduction into new locations may also be possible as a result of transfer in the bilge water of smaller boats and recreational craft.

Given the planktonic nature of *A. tonsa,* coastal spread over short distances via natural dispersal on ocean currents may be possible (Hays, 2017), though evidence of spread of *A. tonsa* via natural dispersal was not found. Further, the resting eggs of *A. tonsa* are found in the sediment (Katajisto et al., 1998) which reduces the likelihood of them dispersing on ocean currents.

While ballast water is widely suggested in the literature to be the most likely route of introduction, *A. tonsa's* use as a live feed for captive marine species within the aquarium and ornamental trade, within GB, cannot be excluded as a possible pathway.

Establishment Summary

Estimate the overall likelihood of establishment (comment on key issues that lead to this conclusion).

Response: *likely*
Confidence: *high*

Comments (state where in GB this species could establish in your comments, include map if possible

Given the multi-year records of this species over several decades it is thought likely to already be established.

This species is common to estuarine environments and is tolerant of wide temperature and salinity ranges, and fluctuations. A temperature range from -1 to 32°C has been reported for this species (Paffenhöfer & Stearns, 1988) with a temperatures of 15°C required for egg hatching documented (Castro-Longoria, 2003). The reported salinity range for this species is 3-30psu, though survival between 0.5 psu and 70 psu is documented (Svetlichny & Hubareva, 2014). *A. tonsa* egg production rate was found to reduce under low salinity (15psu), indicating a reduction in reproductive potential under low salinity (Castro-Longoria, 2003).

Temperatures and salinities within the risk assessment area overlap with those required by this species. However, establishment likelihood will depend on the specific location into which the species is introduced and the specific conditions which are present in that location. For example, establishment may be more likely in summer months, given that egg hatching requires a water temperature of 15°C, though the ability to produce resting eggs means that, the species may be able to survive in this form until conditions are favourable to establish (Katajisto, 2006).

Spread Summary

Estimate overall potential for spread (comment on key issues that lead to this conclusion).

Response: *intermediate*
Confidence: *low*

Sub scores:

Natural spread only:
Response: low
Confidence: low

Human facilitated spread only:
Response: intermediate
Confidence: medium

The species has been reported in multiple locations within the risk assessment area. However, it is not clear whether this is the result of multiple introduction events or subsequent spread following a single introduction event. The extent to which this species may spread within the risk assessment area remains uncertain.

In addition to facilitating entry, transport in ballast (Gubanova, 2000) and potentially bilge water, may aid spread of this species. Given the relatively high volume of shipping and boating traffic within the risk assessment area there is potential for spread to occur widely and quickly. Implementation of the ballast water management convention (International Maritime Organization, 2004) is likely to reduce risk of spread of this species in ballast tanks.

Given the planktonic nature of *A. tonsa,* coastal spread over short distances may be possible via natural dispersal on currents (Hays, 2017), though salinity and temperature gradients experienced plus food availability will affect whether spread to new locations is successful.

The risk of spread will be greatest during summer/ autumn months, when the species may be most abundant in the risk assessment area (Castro-Longoria, 2003). Though transfer of resting eggs which are present throughout the year may be possible, their location within the sediment (Katajisto et al., 1998) reduces the likelihood of this.

A. tonsa has already been present in the risk assessment area for over 50 years and only a limited number of reports of its presence have been received. It is unclear if this is an accurate picture of its presence or reflects the lack of targeted monitoring currently taking place in locations most suitable for its survival and establishment.

Impact Summary

Estimate overall severity of impact (comment on key issues that lead to this conclusion)

Overall Response: *minor*
Confidence: *medium*

Sub-scores

Environmental impacts:
Response: minor
Confidence: low

Economic impacts:
Response: minor
Confidence: medium

Social impacts:
Response: minor
Confidence: medium

Comments (include list of impacts in your comments):

There are no known impacts within the risk assessment area, although it is unclear if this is because they have not been studied.

Social and economic impacts associated with the introduction of *A. tonsa* have not been documented.

Co-existence between copepod species, including *A. tonsa*, may be facilitated by their often distinct environmental niches, spatial distribution and seasonality (e.g Gubanova, 2000). However, evidence of negative impacts of *A tonsa* on native copepod abundance and spatial and temporal distribution do exist (Aravena et al. 2009, David et al., 2007). Also, the high abundance of *A. tonsa* in months when native copepods may be at low abundance could have knock on implications for marine fish species known to predate on copepods, with potential for impacts on the food chain (Chaalali et al., 2013). The grazing impact of *A. tonsa* appears minor; minor; for example, it consumes only 1% of the phytoplankton in a Mediterranean lagoon (Cervetto et al., 1995).

Climate Change

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

Response: *high*
Confidence: *medium*

Comments (include aspects of species biology likely to be effected by climate change (e.g. ability to establish, key impacts that might change and timescale over which significant change may occur):

Environmental parameters, namely temperature and salinity, are known to affect the temporal and spatial distribution of copepods (Castro-Longoria, 2003). Climate change may result in both increased sea temperatures and salinity (Chaalali et al 2013).

Given the minimum temperature requirement for egg hatching documented (15°C), increases in coastal water temperature, associated with climate change, may increase the abundance of the species within the risk assessment area.

Changing climate (increased temperature and salinity) in the Gironde Estuary in France has been highlighted as the cause of the increase in abundance of *A. tonsa* since its introduction into this location in 1983 (Chaalali et al., 2013). Also, in a study undertaken in Mondego estuary, Central Iberian Peninsula between, 2003 and 2012, temperature, salinity and suspended solid levels were positively correlated with *A. tonsa* abundance, indicating that an increase in temperature resulted in an accelerated settlement of *A. tonsa* (Marques et al 2018). It is possible, therefore that changes in coastal water conditions, as a result of climate change, may increase the risk posed by *A. tonsa*.

However, impacts of climate change may be complex, and environmental factors need to be considered in combination, not just in isolation.. For example, *A. tonsa* raised at high salinities (33psu) had a narrower thermal range relative to those raised at lower salinities, indicating interactive effects of salinity and temperature on this species (Peck et al., 2015).

Also, it is necessary to consider the effects of climate change on the risks posed by *A. tonsa* in the context of the whole food chain. For example, *A. tonsa* abundance in the USA, has reduced despite warming. This is due to shifts in the temporal occurrence of its predator, the ctenophore *Mnemiopsis leidyi,* and resulting intensification of its predation of *A. tonsa* (Costello et al., 2006; Sullivan et al., 2007).

Conclusion

Estimate the overall risk (comment on the key issues that lead to this conclusion).

Response: *low*
Confidence: *low*

Comments:

The risk attributed to this species is minor given that this species is already reported within the risk assessment area with no reported negative impacts.

Introduction and spread most likely occurs through ballast and bilge water transfer, a risk that should decline when ballast water management is implemented. There is also a low risk of discarded water from onshore holding sites containing *A. tonsa*, especially eggs, reaching the marine environment. Despite its planktonic nature, there is limited evidence for its dispersion via ocean currents, likely due to the environmental requirements of the species. Impacts, through displacement of native copepods, may occur following establishment. However, impacts may be minimal as co-existence between *A. tonsa* and native species may be facilitated by their distinct environmental niches, spatial distribution and seasonality.

Confidence is low given that impacts in the risk assessment are largely uncertain.

Management options (brief summary):

1 - Has the species been managed elsewhere? If so, how effective has management been?

Response:

No documentation of management of this species can be found.

2 - List the available control / eradication options for this organism and indicate their efficacy.

Response:

Control and eradication options have not been tested.

The thermal limits of this species have been defined as -1 and 32°c (Paffenhöfer & Stearns, 1988). While cooling below -1 or heating beyond 32°c may eradicate the nauplii and adult life history stages of the species, in most circumstances this does not offer a practical or feasible control or eradication solution.

Similarly, it has been documented that salinities above 30 and below 3psu (Svetlichny & Hubareva, 2014) are not generally tolerated by the species. Altering salinity to conditions outside the tolerance range of this species provides a potential control or eradication option, though again impractical in most situations.

The production of resting eggs by this species during unfavourable conditions presents a challenge for its control and eradication.

3 - List the available pathway management options (to reduce spread) for this organism and indicate their efficacy.

Response:

This species is mainly associated with the shipping pathway, specifically transfer via ballast water. Treatment of ballast water is likely to be a potential management option for this species (International Maritime Organization, 2004). Ballast water treatment options include filtration, chemical disinfection, ultraviolet, deoxygenation and heat (David & Gollasch, 2015).

The species is also widely available as a feed in mariculture and in the aquarium trade, management of this trade is a potential means by which to reduce further spread of the species.

Spread by natural dispersal on ocean currents would appear to be unlikely to take place. Management of this pathway is not possible.

4 - How quickly would management need to be implemented in order to work?

Response:

This is not certain, however, it is likely that rapid implementation of management, prior to establishment, could improve effectiveness. Management when young and adult life stages are abundant (rather than resting eggs) may improve the efficacy of management, though it is likely that management would have to be undertaken during multiple years, given the ability of this species to produce resting eggs.

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