Lagoon sand shrimp (*Gammarus insensibilis*)

MarLIN – Marine Life Information Network
Marine Evidence–based Sensitivity Assessment (MarESA) Review

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A report from:
The Marine Life Information Network, Marine Biological Association of the United Kingdom.

Please note. This MarESA report is a dated version of the online review. Please refer to the website for the most up-to-date version [https://www.marlin.ac.uk/species/detail/1142]. All terms and the MarESA methodology are outlined on the website (https://www.marlin.ac.uk)

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See online review for distribution map

Distribution data supplied by the Ocean Biogeographic Information System (OBIS). To interrogate UK data visit the NBN Atlas.

Researched by	Dr Heidi Tillin & Nicola White	**Refereed by**	Admin
Authority	Stock, 1966		
Other common names	-	**Synonyms**	-

Summary

Description

A small shrimp-like species which grows up to about 19 mm in length. The head has lateral lobes that slope forwards and the eyes are moderately large and kidney-shaped. It is most easily confused with the more familiar *Gammarus locusta*. The most easily observed difference is the absence in the male *Gammarus insensibilis* of calceoli (club-shaped sensory projections) on the flagellum of the 2nd antennae.

Recorded distribution in Britain and Ireland

Recorded from the Humber and the Wash, along the south-east and south coasts of England with additional records in the Severn and Milford Haven, Pembrokeshire.

Global distribution

Recorded south from the English Channel along the Atlantic coasts of Europe to the Mediterranean and in the Black Sea.

Habitat

This species is limited to sheltered, shallow, brackish water habitats with a variety of sediments ranging from organic muds to shingle with various admixtures of sand and silt-clay. *Gammarus insensibilis* appears to be associated with the alga *Chaetomorpha linum*, which may form extensive floating mats. Sheader & Sheader (1985) report that in the Mediterranean the species is generally subtidal down to 15m. In the UK lagoons are shallow so the species is found to a maximum depth of 2-3m.

Depth range

0-15 m

Identifying features

- The inner ramus of uropod 3 is relatively short.
- Setae are unusually fairly dense.
- Spines on the ventral border of epimeral plates 2 and 3 are strong in some specimens. Posterior border of epimeral plate 3 with 0-1 small setae or setules (compare with *Gammarus locusta* where there are several).
- Urosome segments 1-3 with prominent dorsal humps.
- There is a strong tendency in some males for the setae on antenna 2 to be curled.
- Lack of calceoli on second antennae of mature males (compare with *Gammarus locusta* where calceoli are present).

Additional information

Information on this *Gammarus insensibilis* was limited. Therefore, the review and sensitivity assessments are supported by evidence from other *Gammarus* spp. or other amphipods where appropriate.

Listed by

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Further information sources

Search on:

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Biology review

Taxonomy

Order	Amphipoda	Sand hoppers and skeleton shrimps
Family	Gammaridae	
Genus	Gammarus	
Authority	Stock, 1966	
Recent Synonyms	-	

Biology

Typical abundance	Moderate density
Male size range	up to 19 mm
Male size at maturity	
Female size range	up to 19 mm
Female size at maturity	
Growth form	Articulate
Growth rate	Data deficient
Body flexibility	Low (10-45 degrees)
Mobility	Crawler / Walker, Mobile, Swimmer
Characteristic feeding method	Grazer (fronds/blades)
Diet/food source	Herbivore
Typically feeds on	*Chaetomorpha*
Sociability	Gregarious
Environmental position	Epifaunal
Dependency	No information found.
Supports	No information
Is the species harmful?	Data deficient

Biology information

This species is often found in dense populations.

Habitat preferences

Physiographic preferences	Isolated saline water (Lagoon)
Biological zone preferences	Lower littoral fringe
Substratum / habitat preferences	Mud, Muddy sand, Sandy mud
Tidal strength preferences	No information
Wave exposure preferences	Extremely sheltered, Very sheltered
Salinity preferences	See additional Information
Depth range	0-15 m
Other preferences	No text entered

Migration Pattern	Non-migratory / resident

Habitat Information

- Distribution is restricted to southern parts of England and probably represents the northern limit of the species' range. Found in Dorset, Hampshire, Sussex, Isle of Wight, Essex and Kent in the south and sites in Lincolnshire and Suffolk on the east coast, the Wash and the Humber estuary.
- The species was present in Widewater lagoon, Sussex, but has not been recorded there since 1979.
- Other habitat characteristics include: a regular tidal input of seawater; a small tidal range; no or low freshwater input other than rainfall; water retained at all states of the tide and at all seasons; salinity within the range 10-58 psu, usually 15-35 psu, with seasonal variation.

Life history

Adult characteristics

Reproductive type	Gonochoristic (dioecious)
Reproductive frequency	Annual protracted
Fecundity (number of eggs)	11-100
Generation time	<1 year
Age at maturity	35 days at 21 degrees C
Season	Not relevant
Life span	<1 year

Larval characteristics

Larval/propagule type	Not relevant
Larval/juvenile development	Direct development
Duration of larval stage	Not relevant
Larval dispersal potential	Not relevant
Larval settlement period	Not relevant

Life history information

Reproduction continues throughout the year with peak reproductive activity in the warm summer months in the UK. In France, lifespan varies from 48 to 408 days according to the water temperature when born (Janssen *et al.*, 1979). Those born in the winter develop 4 to 5 times slower than those born in the summer. Egg incubation time also increases with a reduction in water temperature from 7 days in summer to 50 days in winter.

Sensitivity review

Resilience and recovery rates

Gammarus insensibilis produce brooded young and reproduction continues throughout the year (Gates, 2006), with peak reproductive activity in the warm summer months in the UK. The males form precopula pairings with the smaller females, carrying them around in their gnathopods. After the female moults, insemination takes place, the pairing is maintained for a short time to prevent the female mating with other rival males (Barnes, 1994). Reproductive investment (size of eggs and number of eggs) varies throughout the year and is most influenced by water temperature although other factors such as day length (photoperiod) and salinity may have some effects on reproductive rates (In France, the lifespan varies from 48 to 408 days according to the water temperature when born (Janssen *et al*., 1979). Individuals born in the winter develop 4 to 5 times slower than those born in the summer. Egg incubation time also increases with a reduction in water temperature from 7 days in summer to 50 days in winter.

Methods of dispersal between lagoons is unclear, birds may transport animals via debris caught on their feet or algae or other debris containing animals may be transported into lagoons by water movements (Barnes, 1994). Where coastal defenses are heightened, lagoons may end-up cut-off from the sea so that the populations contained within are isolated and local extinctions may occur (Barnes, 1994). Whatever the method of transport of *Gammarus insensibilis* into lagoons it is likely that these migrations rely on chance events and that recovery from a local extinction, if recovery occurs, may be protracted.Reproductive isolation is indicated by the increase in homozygosity of alleles (lack of genetic variation) in lagoon populations of *Gammarus insensibilis* (Pearson, 2003, cited from Gates, 2006).

Resilience assessment. *Gammarus insensibilis* produce brooded young throughout the year, although losses in the population may occur through natural mortality, predation and parasitism (among other factors) the enclosed lagoon limits transport by water movements into and out of the lagoon. Recovery rates therefore depend on the presence and persistence of the *Gammarus insensibilis* population within the lagoon. Recovery, when resistance is assessed as 'Medium', is assessed as 'High' (recovery within 2 years) as most of the population remains to support in-situ recovery. Where resistance is assessed as 'Low' (removal of .25-75% of the population) resilience is assessed as 'Medium' as recovery to pre-impact population levels may require more than 2 years, particularly where the impact is towards the higher end of the scale (loss of 75% of the population). Where resistance is assessed as None' and the population is removed in its entirety from a lagoon (not from just a small portion of the habitat within the impact footprint), then resilience is assessed as 'Very Low' (prolonged recovery, at least 25 years), due to the lack of inward migration. This assessment assumes that transport of animals between lagoons is very limited and that lagoons are a habitat with limited distribution and that lagoons are spatially isolated and surrounded by habitat barriers (terrestrial/freshwater and fully marine) that prevent or reduce transport.

Hydrological Pressures

	Resistance	Resilience	Sensitivity
Temperature increase (local)	Medium Q: High A: High C: NR	High Q: High A: Low C: NR	Low Q: High A: Low C: NR

Gammarus insensibilis is found in the Mediterranean Black Sea and on the Atlantic coast of Europe, its northern limit being the Humber on the east coast of England (Gates, 2006). Over the geographic range, populations of *Gammarus insensibilis* are likely to experience higher temperatures than those typical of the UK.

Species that inhabit lagoons are naturally subject to wide variations in temperature as shallow lagoon waters, isolated from the sea may experience wide temperature fluctuations as air temperatures vary (although these temperature shocks are probably lower than those that species in the upper intertidal experience). On the south coast of England temperatures in lagoons containing *Gammarus insensibilis* populations varied in temperature from 2-28°C over a year (Gates, 2006). Although *Gammarus insensibilis* survived the temperature and salinity fluctuations, these were shown to result in changes in reproductive strategies (brood size and weight) (Gates, 2006). The evidence suggests an inverse relationship between egg size and temperature, with larger eggs produced at colder temperatures, these larger eggs enhance juvenile survival (Sheader, 1996; Gates, 2006).

Specimens of the congener *Gammarus salinus* were tolerant of temperature fluctuations between 8 °C and 20 °C over a period of up to four weeks, acute temperature changes caused additional stress but did not result in mortality (Furch, 1972).

Sensitivity assessment. *Gammarus insensibilis* is not considered sensitive to a chronic increase in temperature at the pressure benchmark as this is likely to be within the range of natural fluctuations, however, an acute increase at the pressure benchmark may result in changes in reproductive success. Resistance is therefore assessed as 'Medium'; resilience as 'High' and sensitivity is assessed as 'Low'. An acute increase in temperature coupled with extended hot weather may exceed thermal tolerances in shallow, enclosed lagoons where tidal flushing is limited as the water is able to heat up rapidly and is not recharged with cooler waters. However, no evidence was found to indicate the temperature thresholds at which mortality may occur.

Temperature decrease (local)	Medium Q: High A: High C: NR	High Q: High A: Low C: NR	Low Q: High A: Low C: NR

Gammarus insensibilis is found in the Mediterranean Black Sea and on the Atlantic coast of Europe, its northern limit being the Humber on the east coast of England (Gates, 2006). Populations in the UK are, therefore, towards the northern edge of the recorded distribution and may be sensitive to decreases in temperature.

Species that inhabit lagoons are naturally subject to wide variations in temperature as shallow waters isolated from the sea may experience wide temperature fluctuations as air temperatures vary (although these temperature shocks are probably lower than those that species in the upper intertidal experience). On the south coast of England temperatures in lagoons containing *Gammarus insensibilis* populations varied in temperature from 2-28°C over a year (Gates, 2006). Although *Gammarus insensibilis* survived the temperature and salinity fluctuations, these were shown to result in changes in reproductive strategies (brood size and weight) (Gates, 2006). The evidence suggests an inverse relationship between egg size and temperature, with larger eggs produced at colder temperatures, these larger eggs enhance juvenile survival (Sheader, 1996; Gates, 2006).

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Salinity increase (local)	None	Very Low	High
	Q: High A: High C: NR	Q: Low A: NR C: NR	Q: Low A: Low C: Low

Gammarus insensibilis is found in hyper and hyposaline waters in the UK and fully saline conditions in the Mediterranean (where the congener *Gammarus locusta* is absent). *Gammarus insensibilis* is, therefore, probably able to tolerate a wide range of salinities.

Salinity regimes in lagoons will vary according to site specific factors such as the level of freshwater input, the level of seawater input by open channels or percolation and the balance of precipitation and evaporation (Barnes, 1994). Salinity may vary daily or on longer timescales throughout the year (Barnes, 1994). In Gilkicker lagoon (Hampshire, southern UK), in which *Gammarus insensibilis* are abundant, salinity varies seasonally depending on the balance between precipitation and evaporation. Salinities are low in winter (20-25), high in July and August (38-41) and intermediate (25-37- mean 300) during the rest of the year (Al Suwailem, 1991, cited from Gates, 2006). Greater variation can occur in parts of this system with recorded salinities varying from 9-46 (Gates, 2006).

Gammarus insensibilis has been lost from Widewater, West Sussex, where a reduction in sea-water input has resulted in hypersaline conditions during the summer months (M. Sheader, pers. comm, previous MarLIN review).

Sensitivity assessment. *Gammarus insensibilis* is clearly a euryhaline species able to tolerate a wide range of salinities and varying salinities suggesting that a short-term (hours/days) change in salinity at the pressure benchmark may not directly affect this species. However, a change to a permanently increased salinity regime may result in mortality and/or favour other amphipods, such *as Gammarus locusta*, better adapted to stable, higher salinities resulting in replacement. As salinity appears to be a key habitat factor long-term changes to a stable increased salinity regime is likely to result in loss of the population. Resistance is therefore assessed as 'None' and resilience as 'Very low', so that sensitivity is assessed as 'High'.

Salinity decrease (local)	None	Very Low	High
	Q: High A: High C: NR	Q: Low A: NR C: NR	Q: High A: Low C: Low

Gammarus insensibilis is found in hyper and hyposaline waters in the UK and fully saline conditions in the Mediterranean (where the congener *Gammarus locusta* is absent). *Gammarus insensibilis* is, therefore, probably able to tolerate a wide range of salinities.

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Gammarus insensibilis has been lost from the western Keyhaven-Pennington section, following sea-wall reconstruction which resulted in markedly hyposaline conditions, especially in winter (M. Sheader, pers. comm., previous MarLIN review). To a certain extent, the distribution of *Gammarus* species is correlated with salinity. Distinct zonation patterns may be observed, *Gammarus salinus* prefers intermediate salinities, whilst *Gammarus zaddachi* and *Gammarus duebeni* predominantly live in more dilute brackish waters, locally penetrating into freshwater transition zones (Bulnheim, 1984).

Sensitivity assessment. *Gammarus insensibilis* is clearly a euryhaline species able to tolerate a wide range of salinities and varying salinities suggesting that a short-term change in salinity at the pressure benchmark would not directly affect this species. However, a change to a permanently reduced salinity regime may favour other amphipods better adapted to stable, lower salinities resulting in replacement. Resistance is therefore assessed as 'None' and resilience as 'Very low', so that sensitivity is assessed as 'High'.

Water flow (tidal current) changes (local)	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

Gammarus insensibilis lives in lagoons that are separated from the sea and where there is reduced tidal influence and therefore low flow. An increase in water flow rate could cause the species to be washed away or disturb the mats of *Chaetomorpha linum* and could result in loss of habitat where the sediment barriers are eroded and removed. It is not clear what level of change would be required to remove the lagoon habitat and this threshold would be likely to be site-specific and depend on the size of the barriers and sediments.

Sensitivity assessment. *Gammarus insensibilis* is a lagoon species occurring in habitats with low water movement. Reduction in water flow is not considered relevant, increases in water flow at the pressure benchmark within the lagoon may result in increased erosion resulting in sediment re-suspension, disturbance of *Gammarus insensibilis* and removal/damage/or break-up of the *Chateomorpha linum* mat. Resistance of *Gammarus insensibilis* is, therefore, assessed as 'Low' and resilience (of the amphipod population) as 'Medium' so that sensitivity is assessed as 'Medium'.

Emergence regime changes	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

This pressure is considered relevant only to species that inhabit the intertidal and sublittoral fringe. *Gammarus insensibilis* would probably dry out when exposed to air and sunlight but some individuals may be able to avoid desiccation by burrowing under weed. It should be noted that lagoon habitats may be extremely sensitive to changes in sea level, decreased levels may prevent replenishment of sea water through percolation through sediments so that salinity may decrease until the lagoon becomes a freshwater lake. Conversely, sea level rise may result in the drowning of a lagoon resulting in the loss of the habitat.

	Resistance	Resilience	Sensitivity
Wave exposure changes (local)	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

Gammarus insensibilis lives in lagoons that are separated from the sea by a barrier and where wave action is reduced. An increase in wave action could cause the species to be washed away or disturb the mats of *Chaetomorpha linum* and could result in loss of habitat where the sediment barriers that create the lagoon are removed. It is not clear what level of change would be required to remove the lagoon habitat and this threshold would be likely to be site-specific and depend on the size of the barriers and sediments. Overtopping of the lagoon barrier could indirectly impact *Gammarus insensibilis* by altering salinity.

Sensitivity assessment. *Gammarus insensibilis* is a lagoon species occurring in habitats with low wave action. Reduction in wave action is not considered relevant, increases in wave action at levels greater than the pressure benchmark outside and within the lagoon may result in increased erosion resulting in sediment loss. As an increase in wave action at the pressure benchmark within the lagoon is likely to be negligible resistance is assessed as 'High' and resilience (of the amphipod population) as 'High' so that *Gammarus insensibilis* is considered to be 'Not sensitive' at the pressure benchmark. The lagoon habitat itself may be more sensitive to increases in wave action outside of the lagoon

Chemical Pressures

	Resistance	Resilience	Sensitivity
Transition elements & organo-metal contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed**.

	Resistance	Resilience	Sensitivity
Hydrocarbon & PAH contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed**.

	Resistance	Resilience	Sensitivity
Synthetic compound contamination	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed**.

	Resistance	Resilience	Sensitivity
Radionuclide contamination	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence was found to assess this pressure.

	Resistance	Resilience	Sensitivity
Introduction of other substances	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

This pressure is **Not assessed**.

De-oxygenation

	Resistance	Resilience	Sensitivity
De-oxygenation	Medium Q: Low A: NR C: NR	High Q: Low A: NR C: NR	Low Q: Low A: NR C: NR

No direct evidence was found to assess the sensitivity of *Gammarus insensibilis* to this pressure. In Gilkicker lagoon (Hampshire) where *Gammarus insensibilis* are present all year, there was seasonal and diurnal variation in dissolved oxygen concentration with variation from 3 mg/l to 16.4 mg/l. The lowest oxygen levels were recorded beneath the *Chaetomorpha linum* mats. As amphipods are mobile, individuals could migrate to avoid localised areas with low oxygen. However, if the entire lagoon was hypoxic this would not be possible. In some lagoons, tidal flushing may mitigate hypoxia but this will clearly be site specific.

Sensitivity assessment. Resistance to a change in dissolved oxygen is assessed as 'Low' and resilience is assessed as 'Medium' so that sensitivity is assessed as 'Medium'. It should be noted that confidence in this assessment is low, based on a lack of evidence

Nutrient enrichment

	Resistance	Resilience	Sensitivity
Nutrient enrichment	Medium Q: Low A: NR C: NR	High Q: Low A: NR C: NR	Low Q: Low A: Low C: Low

Changes in nutrient enrichment are not likely to directly affect *Gammarus insensibilis* but indirect effects may arise through effects on vegetation, including the filamentous green algae, *Chaetomorpha linum*, which forms an important part of its diet (Sheader & Sheader 1985). Decreased nutrients (in compliance with WFD criteria at the pressure benchmark) may lead to a reduction in productivity and extent of *Chaetomorpha linum* or other vegetation.

Sensitivity assessment Resistance of *Gammarus insensibilis* is assessed as 'Medium', based on possible impacts on the productivity of *Chaetomorpha linum* and other vegetation that may reduce food supply and shelter. Resilience is assessed as 'High', so that sensitivity is assessed as 'Low'.

Organic enrichment

	Resistance	Resilience	Sensitivity
Organic enrichment	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

Lagoon systems accumulate fine sediments and organic matter that are washed in by storms. Cores through lagoons often record considerable thickness of fine fill (Barnes, 1994). An addition of organic matter at the pressure benchmark is likely to be incorporated into this fill and at the pressure benchmark, is unlikely to represent a significant elevation of organic matter. No evidence was found to suggest that *Gammarus insensibilis* feeds on detritus, an indirect effect on feeding may occur if organic matter settles on the *Chaetomorpha linum* mat preventing photosynthesis, however, as the alga has a filamentous growth form it is likely that fine particulate organic matter would sink through or be held within the mat with only small, localised effects on primary production.

Physical Pressures

	Resistance	Resilience	Sensitivity
Physical loss (to land or freshwater habitat)	None Q: High A: High C: High	Very Low Q: High A: High C: High	High Q: High A: High C: High

All marine habitats and benthic species are considered to have a resistance of 'None' to this pressure and to be unable to recover from a permanent loss of habitat (resilience is 'Very Low').

Sensitivity within the direct spatial footprint of this pressure is, therefore 'High'. Although no specific evidence is described confidence in this assessment is 'High', due to the incontrovertible nature of this pressure.

Physical change (to another seabed type)	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

Gammarus insensibilis are found in lagoons composed of a range of sediments. The key factors forming suitable habitat for this species appear to be the enclosed lagoon habitat with variable salinity and the presence of *Chaetomorpha linum* rather than sediment.

Sensitivity assessment. As substratum is not a key factor influencing habitat suitability, resistance to this pressure is assessed as 'High', resilience is assessed as 'High' by default and *Gammarus insensibilis* is assessed as 'Not sensitive'.

Physical change (to another sediment type)	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

Gammarus insensibilis are found in lagoons composed of a range of sediments. The key factors forming suitable habitat for this species appear to be the enclosed lagoon habitat with variable salinity and the presence of *Chaetomorpha linum* rather than sediment.

Sensitivity assessment. As substratum is not a key factor influencing habitat suitability, resistance to this pressure is assessed as 'High', resilience is assessed as 'High' by default and *Gammarus insensibilis* is assessed as 'Not sensitive'.

Habitat structure changes - removal of substratum (extraction)	None Q: Low A: NR C: NR	Very Low Q: Low A: NR C: NR	High Q: Low A: Low C: Low

Gammarus insensibilis is free-living and inhabits the bottoms of lagoons, usually associated with mats of the algae *Chaetomorpha linum*. Sediment extraction that also disturbed and removed the algal mats would be likely to remove individual *Gammarus insensibilis* and its food and shelter. *Gammarus insensibilis* are mobile and can crawl and swim and some individuals may be able to escape from disturbed areas if these were small in scale and did not affect the whole lagoon.

Sensitivity assessment. The impact of this pressure will depend on the type of removal and scale. It is considered that removal of the sediment would also remove *Gammarus insensibilis* and mats of *Chaetomorpha linum*. The resistance of *Gammarus insensibilis* is assessed as 'None' within the footprint of the extraction although some individuals may escape. Resilience may be 'High' if disturbance affects only a small part of the lagoon, e.g. a benthic sampling core and much of the lagoon population survives to replenish the lost individuals. However, if populations were removed from an entire lagoon resistance would be assessed as 'Very low' due to the isolation of lagoons. Sensitivity is assessed as 'High'. The more precautionary assessment is recorded but it should be noted that extraction types and spatial scales will determine sensitivity.

Abrasion/disturbance of the surface of the substratum or seabed	Low Q: High A: Low C: Medium	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

No evidence was found for abrasion impacts on *Gammarus insensibilis*. However, a number of studies have assessed the effects of trampling on other amphipods and these assessments are used as a proxy.

Comparisons between shores with low and high levels of trampling found that the amphipod *Bathyporeia pelagica* is sensitive to human trampling (Reyes-Martínez *et al*., 2015). Changes in abundance of talitrid amphipods on urban beaches subject to high levels of recreational use was also observed by Bessa *et al*. (2014), this study compared abundances between samples taken ten years apart and thus the trends observed were not directly attributable to trampling vs beach cleaning or other pressures although they illustrate a general trend in density patterns as recreational use increases. Ugolini *et al*. (2008) carried out a controlled trampling experiment on *Talitrus saltator*. Plastic cylinders of 110 cm diameter (area 0.95 m^2) were placed in the sand and all individuals trapped and counted, and 400 steps were made in a cylinder in 15 minutes after the amphipods had reburied. The trampling rate was based on observed number of beach users and therefore represents a realistic level of exposure. Alive sandhoppers were counted at the end of the experiment and 24 hours after. Trampling significantly reduced the abundance of the amphipods and after 24 hours the percentage of surviving amphipods dropped to almost zero, while survival rates of control (untrampled) amphipods were unaffected. Abrasion and compaction can, therefore, kill buried amphipods within sediments.

Abrasion may also break up mats of *Chaetomorpha linum* and fragment individuals, however, broken parts will keep growing and this characteristic supports the development of extensive mats (Gates, 2006).

Sensitivity assessment. Based on evidence from other species the resistance of *Gammarus insensibilis* to a single abrasion event is assessed as 'Low'. Resilience is assessed as 'Medium', based on recruitment from the surviving population. Sensitivity is therefore assessed as 'Medium'.

Penetration or disturbance of the substratum subsurface	None Q: Low A: NR C: NR	Very Low Q: Low A: NR C: NR	High Q: Low A: Low C: Low

No evidence was found for penetration and disturbance impacts on the key characterizing species. Based on the abrasion assessment, direct exposure to penetration and abrasion pressure is considered likely to result in high levels of mortality and burial and breakup of the mats of *Chaetomorpha linum* which provide shelter and food to *Gammarus insensibilis*. Resistance is, therefore, assessed as 'None' and resilience as 'Very low' so that sensitivity is assessed as 'High'.

Changes in suspended solids (water clarity)	Medium Q: Low A: NR C: NR	High Q: Low A: NR C: NR	Low Q: Low A: Low C: Low

Changes in suspended solids are not likely to directly affect this *Gammarus insensibilis*. Indirect effects may arise where the productivity and extent of *Chaetomorpha linum* or other vegetation are altered due to increased turbidity. Reductions in growth are likely to be compensated by the high growth rates exhibited by *Chaetomorpha linum* and the shallow depth of lagoons which mitigates light reduction at depth.

Sensitivity assessment Resistance of *Gammarus insensibilis* is assessed as 'Medium', based on possible impacts on the productivity of *Chaetomorpha linum* and other vegetation that may reduce food supply and shelter. Resilience is assessed as 'High' so that sensitivity is assessed as 'Low'.

Siltation, which may be associated with increased suspended solids is assessed separately.

Smothering and siltation rate changes (light)	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

No evidence was found to assess the re-emergence of *Gammarus* spp. following the deposition of fine sediments. Some amphipods are more adapted to burrowing in unstable sand sediments such as the Haustoriinae and Pontoporeiinae. In experiments, the Haustoriid species *Parahaustorius longimerus* was able to regain the surface more effectively when buried under sand (terminal depth 85 cm) than silt/clay mixtures which reduced migration to the surface and increased mortality (Maurer *et al*., 1981).

The limited water movements in an enclosed lagoon would result in the deposit remaining in-situ, or if re-suspended it is likely to be redeposited in the lagoon. When buried beneath 5cm of fine sediments a proportion of the buried *Gammarus insensibilis* may be able to burrow and regain the surface. However, the algal mat of *Chaetomorpha linum* or other vegetation that amphipods feed on and shelter within would remain buried leading to indirect effects through feeding and increased exposure to predators.

Sensitivity assessment. Resistance is assessed as ‘Low’ (loss of 25-75% of the population). Resilience is assessed as ‘Medium’ and sensitivity is, therefore, ‘Medium’. Sensitivity to deposition events that affect only a small proportion of the lagoon will be lower as recovery is likely to be more rapid.

Smothering and siltation rate changes (heavy)	None Q: Low A: NR C: NR	Very Low Q: Low A: NR C: NR	High Q: Low A: Low C: Low

Lagoons are typically shallow and less than 1 metre deep (Barnes, 1994). As lagoons are separated from the sea by barriers, tidal currents and wave action are limited so that sediments are unlikely to be rapidly remobilised and removed as they might be in open habitats. A deposit at the benchmark thickness could substantially fill a lagoon, reducing the depth and altering the habitat. The deposit is likely to smother the amphipods and the algal mat of *Chaaetomorpha linum* and other vegetation that they feed on and shelter in.

Sensitivity assessment. A deposit of 30cm thickness is likely to smother all *Gammarus insensibilis* that are exposed and to bury the habitat and vegetation which provides shelter and food. Resistance is therefore assessed as ‘None’ and sensitivity as ‘Very low’, so that sensitivity is assessed as ’High’. Sensitivity to deposition events that affect only a small proportion of the lagoon will be lower as recovery is likely to be more rapid.

Litter	Not Assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR	Not assessed (NA) Q: NR A: NR C: NR

Not assessed.

Electromagnetic changes	No evidence (NEv) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No information was found on orientation using geomagnetic fields by *Gammarus insensibilis*. However, for some amphipods, there is evidence for geomagnetic orientation being inhibited or disrupted by the presence of electromagnetic fields or by changing magnetic fields. Arendse & Barendregt (1981) manipulated magnetic fields to alter the orientation of the talitrid amphipod *Orchestia cavimana*. Deep-water amphipods, *Gondogenia arctica*, have been shown to be sensitive to even weak electromagnetic fields which cancel magnetic orientation (Tomanova & Vacha, 2016). Loss of orientation was observed at a radio frequency electromagnetic field of 2 nT (0.002 µT) (Tomanova & Vacha, 2016).

No assessment was made of the sensitivity of *Gammarus insensibilis* due to the lack of evidence for this species.

Underwater noise changes	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No evidence was found to assess this pressure.

Introduction of light or shading	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR	No evidence (NEv) Q: NR A: NR C: NR

No specific evidence was found to assess the sensitivity of *Gammarus insensibilis* to this pressure and no assessment has been made. However, it is noted that orientation by light has been well studied for other amphipods (particularly the strandline dwelling species, *Talitrus saltator*). Intertidal amphipods orientate themselves by a range of factors that include (but are not limited to) visual cues based on solar or astronomic cues and the geomagnetic field (Scapini, 2014). Activity patterns are also linked to internal biological clocks that respond to diel, tidal, lunar and seasonal cycles so that animals are active during the most suitable time of day or night (Scapini, 2014). The introduction of light or an increase in shading could, therefore, alter behavioural patterns and navigation.

Photoperiod (day length) has been noted to alter sex ratios in the congener *Gammarus duebeni*. Exposure to short days (<13-14h light) results in female dominance while a longer photoperiod (>13-14 h light) led to a population dominated by males.

Barrier to species movement	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

The lagoon habitats in which *Gammarus insensibilis* are found are enclosed by sediment barriers which reduce wave action and water flow, barriers (either natural or man-made) can, therefore, be considered an essential habitat component of lagoons. *Gammarus insensibilis* have benthic dispersal strategies (via brooding), water transport is not a key method of dispersal over wide distances, as it is for some marine invertebrates that produce pelagic larvae. Barriers may result in habitat fragmentation and changes to barrier systems within lagoons may alter tidal flushing resulting in changes in salinity. For example, *Gammarus insensibilis* has been lost from Widewater, West Sussex, where a reduction in sea-water input has resulted in hypersaline conditions during the summer months. Within the Keyhaven-Lymington lagoon system, *Gammarus insensibilis* has been lost from the western Keyhaven-Pennington section, following sea wall reconstruction which resulted in markedly hyposaline conditions, especially in winter (M. Sheader, pers. comm., previous MarLIN review)). As these effects arising from barriers are indirect they are assessed through the relevant changes in salinity pressures.

Sensitivity assessments. Barriers within lagoons are unlikely to result in direct effects on

Gammarus insensibilis populations. Resistance is therefore assessed as 'High' and resilience as 'High', by default, so that *Gammarus insensibilis* is considered to be 'Not sensitive'. Barriers may result in indirect effects where habitat conditions such as temperature and salinity are affected (see relevant pressures). At the pressure benchmark, habitats are not impermeable so habitat fragmentation with concomitant effects of genetic diversity and prevention of recovery where populations in habitat fragments are lost are not considered.

Death or injury by collision	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Not relevant' to seabed habitats and associated species. NB. Collision by interaction with bottom towed fishing gears and moorings are addressed under 'surface abrasion'.

Visual disturbance	High Q: Low A: NR C: NR	High Q: High A: High C: High	Not sensitive Q: Low A: Low C: Low

It is likely that *Gammarus insensibilis* could detect movement and would react by burrowing into mats of the green algae *Chaetomorpha linum*, that this species is often associated with, or taking other evasive action. This disturbance may interrupt feeding and other behaviour but may not lead to lethal effects. Resistance is assessed as 'High' and resilience as 'High' so that *Gammarus insensibilis* is considered to be 'Not sensitive'.

Biological Pressures

	Resistance	Resilience	Sensitivity
Genetic modification & translocation of indigenous species	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

Gammarus insensibilis are not cultivated or translocated. This pressure is therefore considered 'Not relevant' to this species. The green alga *Chaetomorpha linum* forms mats within lagoons and provides food and shelter to *Gammarus insensibilis*, changes to the green alga could potentially affect *Gammarus insensibilis*. However, no information was found on current production of *Chaetomorpha linum* in the UK and it is possible this species is not currently cultivated.

Introduction or spread of invasive non-indigenous species	Low Q: Low A: NR C: NR	Very Low Q: Low A: NR C: NR	High Q: Low A: Low C: Low

Invasion of rivers and freshwaters by the invasive non-indigenous amphipod *Gammarus triginus* has been documented, salinity may be too high in lagoons to support this species. The amphipod *Grandidierella japonica* is originally from Japan and is now found in Europe, including UK coastal waters (Ashelby, 2006). It has been recorded in lagoons in a Po delta lagoon in the northern Adriatic (Mediterranean Sea) (Munari *et al*., 2016).

Sensitivity assessment. Invasion of the lagoon by other amphipods may lead to competition for food, shelter or other resources. Resistance to invasive non-indigenous species is assessed as 'Low' and recovery as 'Very low' as once established INIS may not be readily removed so that effects can be considered permanent. Sensitivity is therefore assessed as 'High'.

	Resistance	Resilience	Sensitivity
Introduction of microbial pathogens	Medium Q: High A: High C: NR	High Q: High A: Low C: NR	Low Q: High A: Low C: Low

A number of parasites of Gammarid amphipods have been reported. In the Black Sea, *Gammarus insensibilis* is the intermediate host for a number of trematode parasites including *Maritrema subdolum*, *Microphallus hoffmanni*, *Microphallus papillorobustus* and *Levinseniella propinqua* (Kostadinova & Mavrodieva, 2005). In Gilkicker lagoon in the south coast of England, 84% of sampled amphipods were infected by microphallid trematode parasites. The infection had an effect on reproductive investment with a 36.6% reduction in weight-specific brood size associated with higher degrees of infection and respiration rates were also reduced in infected organisms (Gates, 2006). Trematodes also alter the behaviour of infected amphipods in order to increase predation by birds (the final host). Although parasites are likely to have some effects on populations within lagoons, the prevalence of infection and the persistence of populations suggest that the levels of parasitism are sustainable.

Sensitivity assessment. Based on the evidence from Gates (2006), resistance to parasites is assessed as ‘Medium’ and resilience as ‘High’ (following removal of parasites) so that sensitivity is assessed as ‘Low’

	Resistance	Resilience	Sensitivity
Removal of target species	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR	Not relevant (NR) Q: NR A: NR C: NR

This species is not targeted by commercial or recreational fishers or harvesters. This pressure is therefore considered ‘Not relevant’. Macroalgae may be harvested to provide food, fertiliser or other products such as cosmetics and biofuels. There is no evidence that the green alga *Chaetomproha linum* is harvested commercially from lagoons in the UK, however, should this species be removed it would reduce the food and shelter available to amphipods and other species (see 'removal of non-target species' pressure).

	Resistance	Resilience	Sensitivity
Removal of non-target species	Low Q: Low A: NR C: NR	Medium Q: Low A: NR C: NR	Medium Q: Low A: Low C: Low

Incidental removal of *Gammarus insensibilis* may occur where the algal mats of *Chaetomorpha linum* in the lagoon are removed. Macroalgae may be harvested to provide food, fertiliser or other products such as cosmetics and biofuels. There is no evidence that the green alga *Chaetomproha linum* is harvested commercially from lagoons in the UK, however, should this species be removed it would reduce the food and shelter available to amphipods and other species.

Sensitivity assessment. Resistance to removal as a non-target species is assessed as 'Low' (removal of 25-75% of population), resilience is assessed as 'Medium' as replenishment of population where losses were towards the higher end of the scale (75% of population) may require more than two years as this species produces limited amounts of brooded young. Sensitivity is therefore assessed as 'Medium'.

Importance review

Policy/legislation

Wildlife & Countryside Act	Schedule 5, section 9
UK Biodiversity Action Plan Priority	✔
Species of principal importance (England)	✔
Features of Conservation Importance (England & Wales)	✔

Status

National (GB) importance	Not rare/scarce	**Global red list (IUCN) category**	-

Non-native

Native	-		
Origin	-	**Date Arrived**	-

Importance information

Gammarus insensibilis has been protected under Schedules 5 and 8 of the Wildlife and Countryside Act 1981. Since 1988, it has been illegal in Britain to catch or handle the species without a specific licence from the national Nature Conservation agency.

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