

Information about GB Non-native Species Risk Assessments

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

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

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

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

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

Common misconceptions about risk assessments

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

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

Period for comment

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

*risk assessments are posted online at:

<https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=51>

comments should be emailed to nnss@fera.gsi.gov.uk

GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME
For more information visit: www.nonnativespecies.org

Name of Organism:		Japanese skeleton shrimp - <i>Caprella mutica</i>	
Objectives:		Assess the risks associated with this species in GB	
Version:		FINAL 21/03/11	
N	QUESTION	RESPONSE	COMMENT
1	What is the reason for performing the Risk Assessment?		Request from the GB Programme Board
2	What is the Risk Assessment area?	GB	
3	Does a relevant earlier Risk Assessment exist?	NO OR UNKNOWN (Go to 5)	
4	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?		
A	Stage 2: Organism Risk Assessment SECTION A: Organism Screening		
5	Identify the Organism. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?		Animalia, Arthropoda, Crustacea, Amphipoda, Caprellidea, <i>Caprella mutica</i> Schurin 1935
6	If not a single taxonomic entity, can it be redefined?		
7	Is the organism in its present range known to be invasive, i.e. to threaten species, habitats or ecosystems?	YES (Go to 9)	<i>C. mutica</i> has not been proven to directly threaten habitats or ecosystems. However, it is one of the largest known caprellid amphipods; mature males attain body lengths of up to 50 mm (Nishimura 1995) and populations can attain densities > 300,000 individuals m ⁻² (Ashton 2006). <i>C. mutica</i> is an aggressive species, out-competing native caprellid amphipods for space, even at low densities in laboratory and field based studies (Shucksmith, in press). <i>C. mutica</i> is frequently associated with man-made structures and is found in abundance on boat hulls, navigation/offshore buoys, offshore wind farms, floating pontoons and aquaculture infrastructure, but has also been found amongst driftweed in the Risk Assessment Area. It is highly likely that its dispersal is associated with vessel movements whilst attached to hull fouling. It is known to readily consume diatoms, dinoflagellates, copepods and other caprellid species (Cook <i>et al.</i> submitted). Whilst the wider environmental implications of <i>C. mutica</i> have not yet been confirmed, it is likely that it has an important impact on benthic and plankton communities (Cook <i>et al.</i> submitted).
8	Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems?	YES or UNCERTAIN (Go to 9)	<i>C. mutica</i> was first described from sub-boreal areas of north-east Asia in 1935 (Schurin 1935). The first reports of <i>C. mutica</i> outside its native habitat were from the Pacific and Atlantic coasts of North America in the 1970s (Carlton 1979) and within 40 years it has spread to both northern and southern hemispheres (Ashton <i>et al.</i> 2007b). <i>C. mutica</i> can attain densities > 300,000 individuals m ⁻² (Ashton 2006). Juvenile, immature <i>C. mutica</i> typically range in body length from 0.81 to 7.95 mm (Ashton 2006), are translucent making them extremely difficult to detect and typically spend less than 2 hours with the
9	Does the organism occur outside effective containment in the Risk Assessment area?	YES (Go to 10)	Individuals can easily disperse from areas where populations are established, either <i>via</i> (1) hull fouling on recreational or aquaculture related vessels; (2) attachment to drifting macroalgae and/or (3) in ballast water. Although <i>C. mutica</i> is relatively sessile, it can move short distances by rapid body undulations as a result of disturbance or of antagonistic interactions (Cook
10	Is the organism widely distributed in the Risk Assessment area?	YES & the Future is not being considered (Go to 20)	The range is increasing in Britain (Cook <i>et al.</i> 2007; unpublished data Elizabeth Cook, Scottish Association for Marine Science, January 2009).
11	Does at least one species (for herbivores, predators and parasites) or suitable habitat vital for the survival, development and multiplication of the organism occur in the Risk Assessment area, in the open, in protected conditions or both?	YES (Go to 12)	A wide range of suitable habitat is available in Britain, particularly with the increasing development of our coastlines as this species favours artificial structures. Sites that are relatively enclosed, with minimal water flow and enhanced freshwater input are less favoured (Jahnke <i>et al.</i> , submitted; Cook pers. obs.).
12	Does the organism require another species for critical stages in its life cycle such as growth (e.g. root symbionts), reproduction (e.g. pollinators; egg incubators), spread (e.g. seed dispersers) and transmission, (e.g. vectors)?	NO (Go to 14)	
13	Is the other critical species identified in question 12 (or a similar species that may provide a similar function) present in the Risk Assessment area or likely to be introduced? If in doubt, then a separate assessment of the probability of introduction of this species may be needed.		
14	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?	YES (Go to 16)	<i>Caprella mutica</i> is indigenous to north-east Asia, but has been very widely distributed across biogeographic regions on the Pacific and Atlantic coasts of the USA, Alaska, Canada, across Europe from Belgium to Norway, including the UK and Ireland. It has not been found in the Baltic or the Mediterranean to date (Cook <i>et al.</i> 2007); in Britain there are records from sites throughout the Risk Assessment Area, although it is not found in sites which experience salinities of < 15 psu. The whole of the Risk Assessment area is within the ecoclimatic zone for <i>Caprella mutica</i> .
15	Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment area?	YES (Go to 16)	Found to be present in extremely high densities (> 300,000 ind. m ⁻²) at commercial fin- and shellfish farms and in certain marinas in the summer months in Scotland (Ashton 2006; Cook <i>et al.</i> submitted). Juvenile and ovigerous <i>C. mutica</i> are also present throughout the year on the west coast of Scotland on fish farm cages, which may indicate either continuous reproduction in this species or delayed growth of over-wintering juveniles (Ashton 2006).

16	Has the organism entered and established viable (reproducing) populations in new areas outside its original range, either as a direct or indirect result of man's activities?	YES (Go to 17)	First recorded on a fish farm near Oban in 2000, after a detailed survey of the west coast of Scotland in May 2004. Contact with other UK researchers has meant a further 37 sites were identified in the Risk Assessment Area (Ashton <i>et al.</i> 2007) and an additional 12 marinas throughout the 'Area' have been found to contain <i>C. mutica</i> (Cook, pers. obs.; Arenas <i>et al.</i> 2006). It is highly likely that the unintentional introduction of this species into the Risk Assessment Area and its movement within this region was either via shipping related activities or through the importation of Pacific oysters (<i>Crassostrea gigas</i>) from British Columbia in the 1960s and later directly from Japan in the 1970s (Cook <i>et al.</i> 2007).
17	Can the organism spread rapidly by natural means or by human assistance?	YES (Go to 18)	<i>Caprella mutica</i> is spreading by natural means via drift macroalgae (Ashton, 2006). Unintentional human dispersal, however, is probably the most important means of spread via attachment to hull fouling (Cook, pers. obs.), movement of infested nets, ropes, buoys and incorporation in ballast water.
18	Could the organism as such, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment area?	YES OR UNCERTAIN (Go to 19)	Harm is uncertain in the field. Rapid decline in populations of the native caprellids <i>Caprella linearis</i> and <i>Pseudoprotella phasma</i> in laboratory conditions was principally due to direct displacement of the native species even when the density of <i>C. mutica</i> was 10 times lower than the native caprellids (Shucksmith <i>et al.</i> , in press). Impacts on other species and habitats have not been investigated to date, yet it is known that <i>C. mutica</i> will consume diatoms, dinoflagellates and copepods (Cook <i>et al.</i> submitted). Feeding trials with <i>Artemia nauplii</i> have also revealed feeding rates of approximately 20 <i>Artemia</i> hr ⁻¹ for males and 13 <i>Artemia</i> hr ⁻¹ for females. Feeding rates remain constant over a period of 24 hours indicating continuous feeding throughout the day and night (K. Boos, pers. comm., AWI). The implications of feeding rates on plankton productivity, particularly during the summer months when <i>C. mutica</i> abundance is at its greatest are unknown.
19	This organism could present a risk to the Risk Assessment area and a detailed risk assessment is appropriate.	Detailed Risk Assessment Appropriate GO TO SECTION B	
20	This organism is not likely to be a harmful non-native organism in the Risk Assessment area and the assessment can stop.		

B SECTION B: Detailed assessment of an organism's probability of entry, establishment and spread and the magnitude of the economic, environmental and social consequences				
Probability of Entry		RESPONSE	UNCERTAINTY	COMMENT
1.1	List the pathways that the organism could be carried on. How many relevant pathways can the organism be carried on?	many - 3	MEDIUM -1	Known pathways are: 1. accidental introduction with hull fouling - proven; 2. inter-regional spread via aquaculture transfers, predominantly shellfish - potential but not proven; 3., accidental introduction with ballast water - proven for caprellids, but not specifically for <i>C. mutica</i> ; 4. natural dispersal via drift macroalgae - proven; 5. occasional movement by large installations (e.g. oil rigs, fish farm cages) - proven.
1.2	Choose one pathway from the list of pathways selected in 1.1 to begin the pathway assessments.			Accidental introduction with hull fouling.
1.3	How likely is the organism to be associated with the pathway at origin?	very likely - 4	LOW - 0	A high proportion of marinas, harbours and aquaculture related sites within the Risk Assessment Area and adjacent regions are known to have <i>Caprella mutica</i> (Cook <i>et al.</i> 2007). In the donor area, this species is typically reported from aqua(algi)culture facilities in sheltered bays, in the littoral zone to a depth of 13 m, where it inhabits a variety of macroalgal species. Distribution in ports/harbours in the donor region is unknown.
1.4	Is the concentration of the organism on the pathway at origin likely to be high?	very likely - 4	LOW - 0	The density of <i>C. mutica</i> , particularly in the summer months (July to October), can be extremely high (ranging from 10s to 100,000s ind m ⁻²) in marinas and aquaculture installations in the Risk Assessment Area. Recreational boat hulls have been observed with over 1,000 ind m ⁻² (Cook, pers. obs.). <i>C. mutica</i> have been known to remain attached on boat hulls over a prolonged voyage (5-6 hours) at max. 14 knots (Cook, pers. obs.). The hull does require some initial fouling of organisms (mussels, barnacles, macroalgae, hydroids, bryozoans) for the successful attachment and transfer of <i>C. mutica</i> . The concentration of <i>C. mutica</i> , however, on vessel hulls in the native range is
1.5	How likely is the organism to survive existing cultivation or commercial practices?	very likely - 4	MEDIUM -1	At present, commercial and recreational vessels are dry-docked at intervals ranging from < 12 months to ~5 years for fouling to be removed from the hulls. If cleaning is thorough, particularly areas on commercial vessels which are more difficult to access (i.e. sea chests, propeller shafts) and the fouling is completely removed then there will be a high chance that <i>C. mutica</i> will not survive. This however would need further investigation, as the effectiveness of current hull cleaning methods in the complete removal of this species has not been tested. There are also a proportion of vessels that do not get cleaned at regular intervals and could also be responsible for the transfer of this species.
1.6	How likely is the organism to survive or remain undetected by existing measures?	likely - 3	MEDIUM -1	<i>Caprella mutica</i> are moderately likely to be detected as adults on vessel hulls if inspectors are vigilant for this species and it is relatively straightforward to identify them from the other caprellid species found in the Risk Assessment Area. Juveniles would be impossible to observe from a visual inspection of hull fouling and detailed microscopic examination of a scrape sample would be required, although it is extremely difficult to categorise caprellids at species level under approx. 4mm in body length (K. Boos, pers. comm., AWI). However, at present, no formal inspection procedure is in place to detect the introduction of <i>C. mutica</i> or any other non-native species on vessel hulls in the UK.
1.7	How likely is the organism to survive during transport /storage?	likely - 3	MEDIUM -1	<i>C. mutica</i> are known to survive transport via recreational boat hulls (Cook, pers. obs.).
1.8	How likely is the organism to multiply/increase in prevalence during transport /storage?	likely - 3	MEDIUM -1	<i>Caprella mutica</i> could theoretically mate in transit, particularly since a large majority of vessel movements take place during the summer months when reproductive activity is at its greatest. This remains unproven though at present.
1.9	What is the volume of movement along the pathway?	moderate - 2	HIGH -2	Recreational and commercial (fishing) vessels (n=5) have been examined once dry-docked and 100s ind m ⁻² of <i>Caprella mutica</i> were attached to the hull fouling (E. Cook, pers. obs., SAMS). This is only a very small sample size and further investigations are necessary to indicate the volume of <i>C. mutica</i> that are transported via this vector.
1.10	How frequent is movement along the pathway?	very often - 4	HIGH -2	The British Marine Federation estimates that there are approx. 560,000 boats (over 2.5m length) owned either privately or commercially in the UK (based on 2006 figures). A survey of the 10 largest marinas in Scotland in 2006 found that 59% of recreational boats surveyed had macrofouling (sufficient for the attachment of <i>C. mutica</i>) on their hulls (Ashton <i>et al.</i> 2006). This could equate to over 330,000 vessels (if levels of fouling were found to be the same throughout the UK) in the Risk Assessment Area having the potential to act as a vector for <i>C. mutica</i> . If it is assumed that the average overall length of these vessels is 12.2 m (40'), then the 'wetted surface area' (available for caprellid attachment) would be (overall length=12.2)*(Beam length = 3.4m)* (0.85) = 35.3 m ² . Based on a density of 100 caprellids m ⁻² , this would equate to approx. 3,530 caprellid per vessel and to potentially a total of 1.17 billion caprellids (3,530*330,000) being transported throughout the Risk Assessment Area via this vector at any given time. However, this may be a considerable underestimate as populations of <i>C. mutica</i> have been known to reach densities of over 300,000 m ² during the summer months.
1.11	How widely could the organism be distributed throughout the Risk Assessment area?	very widely - 4	LOW - 0	All coastlines supporting artificial substrate (navigation buoys, moorings, marinas, harbours, aquaculture installations) throughout the Risk Assessment Area could be colonised by <i>Caprella mutica</i> , with the exception of water bodies (estuaries, heads of sea lochs, enclosed marinas/harbours with significant riverine input) where salinity fluctuates below 15 psu on a regular basis. These potential sites for colonisation include; approx. 640 buoys/beacons (Trinity House & Northern Lighthouse Board 2009), over 250 sites active for finfish and 330 for shellfish production in Scotland alone (FRS, 2007) and over 150 purpose built harbours/marinas. In addition, there are the 10,000s of swinging moorings throughout the Risk Assessment Area that would also provide suitable substrate for this species.

1.12	How likely is the organism to arrive during the months of the year most appropriate for establishment ?	very likely - 4	MEDIUM -1	<i>Caprella mutica</i> is most likely to become established in the summer months. Fecund females and juveniles have been found throughout the winter months, but exponential population growth typically occurs between July and September and this is generally when vessel traffic, particularly recreational, is at its greatest (Ashton, 2006).
1.13	How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) or other material with which the organism is associated to aid transfer to a suitable habitat?	very likely - 4	MEDIUM -1	It is highly likely that a proportion of the <i>Caprella mutica</i> population that has become established on a vessel hull will survive a short passage at a moderate speed. In 2006, a fishing vessel was dry-docked in Dunstaffnage Marina; this vessel had 1000s of <i>C. mutica</i> on its hull and had travelled approx. 25 miles at an average speed of 12 knots to reach the marina (G. Ashton, pers. comm.). The vessel was moored for a short time prior to dry-docking in one of the marina berths, which are known to support populations of <i>C. mutica</i> and it is highly likely that this species was able to spread to the adjacent pontoon floats during this period.
1.14	How likely is the organism to be able to transfer from the pathway to a suitable habitat?	very likely - 4	LOW - 0	If movement is with hull fouling, this pathway is highly likely to move <i>C. mutica</i> into a suitable habitat.

	Probability of Establishment	RESPONSE	UNCERTAINTY	COMMENT
1.15	How similar are the climatic conditions that would affect establishment in the Risk Assessment area and in the area of current distribution?	very similar - 4	LOW - 0	<i>Caprella mutica</i> are known to be tolerant of climatic conditions in all parts of Risk Assessment area and indeed can survive in hotter summers and colder winters in other parts of their indigenous and introduced range. Colder regions include Netherlands, Norway and Germany (Cook <i>et al.</i> 2007) and most recently Alaska (Ashton <i>et al.</i> 2008). Warmer regions include France (Le Havre) and its tolerance to a wide range of temperatures suggests that this species would be able to expand its range southwards along French and Iberian coastlines (Cook <i>et al.</i> 2007). A population of <i>C. mutica</i> has been continuously monitored, monthly (2004-2007) and bimonthly (2007-2009) now for 5 years in a sea loch (Lynne of Lorne) on the west coast of Scotland, and appears to be tolerant to the year-round conditions experienced in this region (Ashton, 2006; E. Cook, SAMS, pers. obs.).
1.16	How similar are other abiotic factors that would affect establishment in the Risk Assessment area and in the area of present distribution?	very similar - 4	LOW - 0	<i>Caprella mutica</i> has been found in marine environments throughout the Risk Assessment Area and in other parts of Europe (7 countries so far, Cook <i>et al.</i> 2007). It is unlikely that temperature will be limiting in the Area as this species can tolerate temperatures as low as -1.9 °C and as high as 28 °C (Ashton <i>et al.</i> 2007) and can reproduce at temperatures ranging from 4 to 26 °C (K. Boos, pers. comm., AWI). Salinity may be a limiting factor to the dispersal of this species, particularly in estuarine and fjord-like environments. On an annual Scottish marina survey, <i>C. mutica</i> is absent from one marina (Inverkip) which can experience salinities as low as 4 psu on the ebb tide due to high riverine input (Jahnke <i>et al.</i> submitted). This species has also not been found on fin- or shellfish farm in Loch Etive, west coast of Scotland which experiences lower salinities on the ebb tide (E. Cook, pers. obs.). The LC50 of male and female <i>C. mutica</i> over a 48 hour period was found to be 18.7 ± 0.3 psu. All animals were found to be dead after 48 hours at salinities lower than 15 psu in laboratory studies (Ashton <i>et al.</i> 2007), which would explain the field observations. It is not known how tolerant <i>C. mutica</i> is to reduced levels of dissolved oxygen, but breeding activity of <i>Caprella equilibria</i> was found to decrease at higher temperatures and in oxygen deficient waters (Sconfiatti & Luparia, 1995). However, caprellids have been known to survive in ballast tanks (Gollasch <i>et al.</i> 2002), so are presumably tolerant to the conditions experienced on trans-oceanic passages. In contrast, <i>Caprella mutica</i> is intolerant to aerial exposure and will die within an hour of emergence from water (E. Cook, pers. obs.). However, cool, damp conditions typically found in anchor lockers or bundles of mooring line/fish farm netting are likely to prolong their survival out of water (E. Cook, pers. obs.).
1.17	How many species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism species are present in the Risk Assessment area? Specify the species or habitats and indicate the number.	very many - 4	LOW - 0	<i>Caprella mutica</i> has been recorded throughout the Risk Assessment Area, predominantly on artificial substrates including marina pontoon floats, fin- and shellfish farm nets and culture lines, moorings, offshore windfarms, boat hulls and on natural substrate including drifting mats of macroalgae (Ashton, 2006; Shucksmith, 2007; K. Boos, pers. comm., AWI).
1.18	How widespread are the species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism in the Risk Assessment area?	widespread - 4	LOW - 0	Potentially suitable habitats are widespread around the coastline of the Risk Assessment area.
1.19	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?	N/A		
1.20	How likely is it that establishment will not be prevented by competition from existing species in the Risk Assessment area?	very likely - 4	LOW - 0	Native caprellids are unable to compete with <i>Caprella mutica</i> , the non-native species displacing the native species even at very low densities (Shucksmith, 2007; Shucksmith <i>et al.</i> , in press).
1.21	How likely is it that establishment will not be prevented by natural enemies already present in the Risk Assessment area?	very likely - 4	LOW - 0	Native predators including the shore crab <i>Carcinus maenas</i> and the Goldsinny wrasse <i>Ctenolabrus rupestris</i> have both been found to consume significant numbers of <i>C. mutica</i> , particularly the larger males in laboratory experiments, suggesting that the success of this species on many artificial habitats and floating mats of macroalgae is due to their isolation from benthic predators (K. Boos, pers. comm., AWI). Wild and farmed finfish including perch, dab and Atlantic salmon have been found to consume significant quantities of caprellids (see review by Woods, in press); however, these species have not prevented the establishment of populations of <i>C. mutica</i> throughout the Risk Assessment Area.
1.22	If there are differences in man's management of the environment/habitat in the Risk Assessment area from that in the area of present distribution, are they likely to aid establishment? (specify)	N/A		
1.23	How likely is it that existing control or husbandry measures will fail to prevent establishment of the organism?	very likely - 4	LOW - 0	Existing methods of cleaning or replacing aquaculture related infrastructure (e.g. moorings/netting) and cleaning vessel hulls do not take into consideration that they are highly likely to facilitate the spread of <i>Caprella mutica</i> .
1.24	How often has the organism been recorded in protected conditions, e.g. glasshouses, elsewhere?	frequent - 3	LOW - 0	<i>Caprella mutica</i> was found at 17 of the 30 finfish aquaculture sites (59%) visited in a survey on the west coast of Scotland in May 2004 (Ashton <i>et al.</i> 2007). <i>C. mutica</i> has also been observed on culture lines at shellfish aquaculture sites on the west coast of Scotland (E. Cook, pers. obs., SAMS).
1.25	How likely is the reproductive strategy of the organism and duration of its life cycle to aid establishment?	very likely - 4	LOW - 0	<i>Caprella mutica</i> reproduces successfully between 4 and 26 °C. The greatest number of consecutive broods (x8) has been recorded for caprellids held at 16 °C and the average number of live hatchlings produced at each brood was 30 (K. Boos, pers. comm., AWI). More than 300 eggs, however, have been recorded for a single clutch in <i>C. mutica</i> collected from native (Fedotov, 1991) and non-native (Ashton, 2006) populations. It is highly likely, therefore, that a single ovigerous female is sufficient to found a population, particularly in the summer months throughout the Risk Assessment Area.

1.26	How likely is it that the organism's capacity to spread will aid establishment?	very likely - 4	LOW - 0	<i>Caprella mutica</i> are relatively sedentary for the majority of the time and will generally only release their hold on the substrate when disturbed or as a result of agonistic interactions (Caine 1991). This ability to cling tightly to substrate has been suggested as an important factor in its success as an introduced species (Ashton 2006). They lack a planktonic stage in their lifecycle and their swimming ability is relatively poor. However, they are able to move across substrate extremely rapidly if necessary, by looper or inch-worm-like movements (Woods, in press). Rapid body undulations do allow <i>C. mutica</i> to swim short distances (< 5 m) (E. Cook, pers. obs., SAMS), and through a combination of swimming and drifting with the current it has been predicted, based on field experiments, that they could naturally disperse up to 1000m downstream of a source population (Ashton 2006). Rafting on drifting macroalgae or other floating material could greatly enhance natural dispersal and has been linked to dispersal over a wide geographic range (< 100 km up to > 5 000km) (Thiel & Haye 2006). In field studies, <i>C. mutica</i> was found attached to 26.9% of clumps of drifting macroalgae. Frequency was generally low (< 10 caprellids per clump), however, one clump of macroalgae contained 71 caprellids, including 37 females of which 10 were ovigerous (Ashton 2006). In addition, <i>C. mutica</i> is frequently associated with areas of high vessel activity (e.g. marinas, ports etc.) both on vessel hulls (Minchin & Holmes 2006; E. Cook, pers. obs., SAMS) and on pontoon floats adjacent to the moored vessels (Ashton <i>et al.</i> 2006), and living <i>Caprella</i> spp. have been found in ships' ballast tanks (Carlton 1985) and in sea-chests in a study in New Zealand (Coutts <i>et al.</i> 2003), suggesting that anthropogenic vectors would could also aid in trans-oceanic dispersal of this species. The dispersal of <i>C. mutica</i> has also been linked to the importation of the Pacific Oyster, <i>Crassostrea gigas</i> in the United States (Carlton 1987), but no evidence has been found to date that this was a mechanism of introduction to Europe. However, stock movement between sites within the Risk Assessment Area can not be ruled out as a potential vector for the dispersal of <i>C. mutica</i> .
1.27	How adaptable is the organism?	very adaptable - 4	LOW - 0	<i>Caprella mutica</i> is highly adaptable, tolerating a wide range of environmental conditions, including highly disturbed (e.g. ports/marinas) and organically enriched sites (e.g. finfish farms).
1.28	How likely is it that low genetic diversity in the founder population of the organism will not prevent establishment?	very likely - 4	LOW - 0	Populations of <i>Caprella mutica</i> have been found to contain a reduced genetic diversity compared to populations from the native range through direct sequencing of mitochondrial DNA (cytochrome c oxidase subunit I gene) (Ashton <i>et al.</i> 2008). The study found that populations on the Pacific coast of North America was the most divergent of the non-native populations, indicating independent introduction pathways for <i>C. mutica</i> to the Pacific and Atlantic coasts of North America. Two dominant haplotypes were identified in eastern and western Atlantic coastal populations, indicating dispersal routes across the Atlantic and along both coasts. Grouping of <i>C. mutica</i> populations into native, east Pacific, and Atlantic cohorts explained the most among-region variation (59%). The analysis identified several introductions from multiple sources are likely to be responsible for the observed global distribution of <i>C. mutica</i> , but the pathways were least well defined among the Atlantic populations. The reduced genetic diversity in founder populations compared with the native region has not been any constraint on widespread colonisation to date.
1.29	How often has the organism entered and established in new areas outside its original range as a result of man's activities?	very many - 4	LOW - 0	<i>Caprella mutica</i> has been recorded throughout the northern hemisphere including: the Pacific and Atlantic coasts of North America, Canada and the north-east Atlantic coasts of Europe. In the southern hemisphere, the two records are from New Zealand (Ashton <i>et al.</i> 2007b). Within Europe, a more recent detailed study on the distribution of <i>C. mutica</i> found that this species had spread from the initial sighting in the Netherlands in 1994 to 97 confirmed sites in Norway, Netherlands, Germany, Belgium, France, England, N. Ireland, Eire, Wales and Scotland (Cook <i>et al.</i> 2007). All the records are from areas of human activity (marinas, ports, aquaculture sites, offshore wind farms, oil rigs).
1.30	How likely is it that the organism could survive eradication campaigns in the Risk Assessment area?	very likely - 4	LOW - 0	No eradication campaigns undertaken to date for <i>Caprella mutica</i> . Extremely difficult in the marine environment to effectively eradicate any invasive species due to open nature of the environment. Ability of <i>C. mutica</i> to disperse naturally over a ~ 1 km area and the difficulty in visually observing the juveniles would potentially make eradication almost impossible.
1.31	Even if permanent establishment of the organism is unlikely, how likely is it that transient populations will be maintained in the Risk Assessment area through natural migration or entry through man's activities (including intentional release into the outdoor environment)?	very likely - 4	LOW - 0	Studies over the last 5 years, have shown that populations of <i>C. mutica</i> at marina sites can be transient on the west coast of Scotland, with caprellids typically present between May and October. It is highly likely therefore that anthropogenic activity (e.g. hull fouling) is re-introducing this species to these sites each year from established populations elsewhere (Ashton, 2006; E. Cook, pers. obs., SAMS).

	Spread	RESPONSE	UNCERTAINTY	COMMENT
2.1	How rapidly is the organism liable to spread in the Risk Assessment area by natural means?	intermediate - 2	MEDIUM -1	Typical rates of spread by unaided dispersal are highly reliant on current speeds and water depth. Ashton (2006) found that <i>Caprella mutica</i> could disperse up to a distance of 1 km from an established population on a fin-fish farm which experience maximum current speeds of 21 cm s ⁻¹ , suggesting a potential dispersal rate of 0.7 km hr ⁻¹ . Dispersal via drifting macroalgae is also extremely difficult to predict. However, since the first recorded sighting of <i>C. mutica</i> in the Netherlands in 1994, within 14 years it has spread throughout the North Sea and Celtic Sea coasts and the English Channel (Cook <i>et al.</i> 2007).
2.2	How rapidly is the organism liable to spread in the Risk Assessment area by human assistance?	very rapid - 4	MEDIUM -1	<i>Caprella mutica</i> is already widely dispersed throughout the Risk Assessment Area and it is highly likely that this species is spread predominantly by human assistance (e.g. vessel activity, aquaculture movements). This human activity is difficult to predict, but spread of 100s kms over a few days would be possible depending on the vessel type and passage plan. It is highly likely that this species will be frequently sighted and become a dominant member of the fouling community, particularly in the summer months, on artificial structures throughout the Area over the next few years.
2.3	How difficult would it be to contain the organism within the Risk Assessment area?	very difficult - 4	LOW - 0	There is no possibility of containing <i>Caprella mutica</i> within the Risk Assessment Area now it is so widely established throughout Europe and the northern hemisphere.
2.4	Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism.		LOW - 0	Entire Risk Assessment Area, with the exception of estuaries and sea lochs which experience salinities below 15 psu.

	Impacts	RESPONSE	UNCERTAINTY	COMMENT
2.5	How important is economic loss caused by the organism within its existing geographic range?	major - 3	HIGH -2	No studies have looked at the impact of <i>Caprella mutica</i> on the economy to date. In the summer months, high densities of <i>C. mutica</i> have been known to block water intakes on the pumps for the feeding system on caged fish sites and have settled on mussel lines which should have been covered with juvenile mussels (<i>Mytilus edulis</i>) (E. Cook, pers. obs., SAMS). Unfortunately, no studies have been performed to date to show whether there is a relationship between the abundance of caprellids and the lack of mussel spat, however, the same observations have been made in Canada. There may also be an economic 'cost' to the aquaculture industry through having to clean the caprellids, which form a major part of the fouling biomass in the summer months, from the cage nets but this hasn't been calculated to date. The economic cost to the shipping and recreational boating community could also be quite high in the future if this species (and other non-native species) had to be disposed of to landfill rather than the current practice of allowing any fouling to return back into the marine environment.
2.6	Considering the ecological conditions in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, livestock health and production, likely to be? (describe) in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, likely to be?	moderate - 2	HIGH -2	Direct negative economic impacts of <i>C. mutica</i> on aquaculture or shipping/recreational boating activity are unknown.
2.7	How great a loss in producer profits is the organism likely to cause due to changes in production costs, yields, etc., in the Risk Assessment area?	moderate - 2	HIGH -2	Unknown, although there may be quite a considerable reduction in profits if vessel operators have to increase dry-docking frequency and cover the costs of hull fouling disposal. Landfill charges are currently at approx. £32 per ton and this is set to increase to £50 per ton by 2011 (BBC News, 2008), so this may have a significant effect on prices paid by vessel owners, particularly in the commercial sector.
2.8	How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area?	moderate - 2	HIGH -2	Unknown.
2.9	How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets?	very unlikely - 0	MEDIUM -1	It is highly unlikely that the presence of <i>Caprella mutica</i> on fin- and shellfish sites or in ports/marinas would reduce the asset value of the product (e.g. salmon, mussels) or influence whether vessel owners (including international vessels) would use that particular site.
2.10	How important would other economic costs resulting from introduction be? (specify)	moderate - 2	HIGH -2	The greatest impact is likely to be increased husbandry costs of more frequent removal (where possible) and cleaning of submerged structures that provide a suitable substrate for attachment by <i>Caprella mutica</i> .
2.11	How important is environmental harm caused by the organism within its existing geographic range?	major - 3	MEDIUM -1	No reports to the author's knowledge have been produced to suggest that <i>Caprella mutica</i> is causing any environmental harm either in its native range or in other regions outside the Risk Assessment Area.
2.12	How important is environmental harm likely to be in the Risk Assessment area?	major - 3	MEDIUM -1	<i>Caprella mutica</i> will be certainly having an effect on the environment, particularly in the summer months when densities can reach > 300,000 ind. m ⁻² . It is known to outcompete native caprellids for space in the field and in laboratory experiments (Shucksmith, 2008) and it will consume a wide variety of food types, including diatoms, dinoflagellates, copepods, gammarid amphipods, nematodes and polychaetes (see review by Woods, 2009; Cook <i>et al.</i> submitted). Consumption rates are also quite high, with a single <i>C. mutica</i> consuming an average of 15 <i>Artemia-nauplii</i> hr ⁻¹ in laboratory studies (K. Boos, pers. comm.). Effects on pelagic phyto- and zooplankton communities, particularly in the summer may therefore be significant, however, quantifying the effect of <i>C. mutica</i> on these communities is more difficult, due to the lack of research in this area.
2.13	How important is social and other harm caused by the organism within its existing geographic range?	moderate - 2	HIGH -2	Unknown. At present, <i>Caprella mutica</i> is not known to cause any social harm within existing geographic range, but as legislation is introduced to change current practices in disposal of biofouling waste, then this will have some impact on commercial and recreational vessel owners and the aquaculture industry.
2.14	How important is the social harm likely to be in the Risk Assessment area?	major - 3	HIGH -2	Unknown. Social harm is likely to be greatest though in areas of high vessel and/or aquaculture activity, particularly the south coast of England and west coasts of Ireland and Scotland.
2.15	How likely is it that genetic traits can be carried to native species, modifying their genetic nature and making their economic, environmental or social effects more serious?	unlikely - 1	MEDIUM -1	There has been no known hybridisation between <i>Caprella mutica</i> and any European species.
2.16	How probable is it that natural enemies, already present in the Risk Assessment area, will have no affect on populations of the organism if introduced?	very likely - 4	LOW - 0	Predation is highly likely on <i>C. mutica</i> in natural benthic habitats and will have a major role in preventing the spread of this species to more natural environments. Predation, however, has been shown to be highly ineffective on artificial structures which are typically raised off the seabed (K. Boos, pers. comm., AWI).
2.17	How easily can the organism be controlled?	very difficult - 4	LOW - 0	<i>Caprella mutica</i> typically mature within 20 days of hatching (~ 7mm body length) (K. Boos, pers. comm., AWI) and population density can increase dramatically from 100s of ind. m ⁻² to 10,000s ind. m ⁻² within an 8-week period, which generally falls between May - September on the west coast of Scotland (Ashton, 2006; E. Cook, pers. obs., SAMS). Attempts to control this species are more likely therefore to succeed over the winter months (November to April), when growth and reproduction rates are at their minimum and juvenile densities are at their lowest. Control methods, using traps, freshwater, aerial exposure and/or pheromones have not been trialled as yet. There is no disease known that is selective to <i>C. mutica</i> , although there is a parasitic copepod that lives within the brood pouch of certain caprellids and mimics the morphology of the eggs. Further investigations on the impact that this parasite may have on the success of <i>C. mutica</i> in colonising new habitats is planned for 2009 (E. Cook, pers. comm., SAMS). There are no biocides that are
2.18	How likely are control measures to disrupt existing biological or integrated systems for control of other organisms?	very unlikely - 0	MEDIUM -1	Control measures most likely to assist in the control of other marine organisms rather than disrupt them.

2.19	How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms?	moderately likely - 2	HIGH -2	It is unknown whether <i>C. mutica</i> carries any hosts (e.g. unaware of any studies into whether <i>C. mutica</i> is a vector for white spot), although it is possible that it carries the parasitic copepod mentioned in 2.17, or whether it provides food or acts as a vector for any other non-native species in the Risk Assessment Area.
2.20	Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur		LOW - 0	Areas where most economic and social impacts are most likely to occur are probably on the south coast of England and the west coasts of Ireland and Scotland. Areas where the greatest environmental impacts are likely to occur are areas which support marine Special Areas of Conservation.

Summarise Entry	very likely - 4	LOW - 0	<i>Caprella mutica</i> are already established throughout the Risk Assessment Area. The probability of further introductions of this caprellid is high. The most likely pathways are from existing established source populations within the Risk Assessment Area to areas currently unaffected. These pathways are, in descending order: 1. accidental introduction with hull fouling; 2. natural dispersal via drift macroalgae; 3. inter-regional spread via aquaculture transfers, predominantly shellfish; 4. accidental introduction with ballast water; 5. occasional movement by large installations (e.g. oil rigs, fish farm cages, vessels due to be decommissioned).
Summarise Establishment	very likely - 4	LOW - 0	<i>Caprella mutica</i> is highly tolerant of a wide range of temperatures and salinities and the Risk Assessment Area falls within this range. It is highly likely, therefore, that they will be able to survive and reproduce in a large proportion of the 'artificial' environments into which they are introduced. They are however, intolerant to salinity levels below 15 psu and there is the potential that native benthic predators are effective at preventing their establishment in 'natural' habitats, although this still requires investigation with field trials.
Summarise Spread	very rapid - 4	LOW - 0	<i>Caprella mutica</i> is capable of spreading throughout the Risk Assessment Area, with the exception of estuaries and sea lochs which experience salinities below 15 psu for extended periods. Spread is likely to be very rapid, particularly by anthropogenic vectors such as hull fouling, ballast water and translocation of shellfish between sites.
Summarise Impacts	moderate - 2	MEDIUM -1	<i>Caprella mutica</i> is likely to have an environmental and economic impact within the Risk Assessment Area (see below). The extent of this impact, however, is unknown at present and further investigation is required.
For pathway/policy risk assessment Assess the potential for establishment and economic/environmental/social impacts of another organism or stop			1. Potential localised extinction of native caprellid species due to competition; 2. potential impact on phyto- and zooplankton communities during summer months; 3. potential economic costs to the aquaculture (fin- and shellfish) industry, commercial shipping and recreational boating industry, particularly if frequency of cleaning (hulls and infrastructure) is increased and biofouling material has to be disposed of at landfill. 4. <i>C. mutica</i> is unlikely to have any overall affect on asset value of products, although social impacts maybe higher in regions of higher vessel and aquaculture activity if legislation is introduced to change current practices of biofouling disposal.
Conclusion of the risk assessment	MEDIUM -1	LOW - 0	<i>Caprella mutica</i> is already established throughout the Risk Assessment Area and is having an environmental impact. It is highly likely that the geographic range and abundance of this species will continue to increase via natural spread via drifting objects, including macroalgae and unintentional anthropogenic spread, via hull fouling, aquaculture activity and ballast water. Eradication is highly unlikely to succeed in areas where this species has become established. If detected early enough, it may be possible to eradicate a recent introduction of caprellids with submergence in freshwater or through aerial exposure for a few hours (although temperature and moisture content must be taken into consideration for this latter treatment). The author is unaware though of any control/eradication attempts for <i>C. mutica</i> . The priority now must be to prevent new regions from becoming colonised, particularly those of national and/or European conservation priority for native species and/or habitats.
Conclusions on Uncertainty		MEDIUM -1	There is low uncertainty on most aspects of the biology, distribution and potential pathways for dispersal of <i>Caprella mutica</i> as this has been relatively well studied over the last few years, although there is more uncertainty of calculating the rates of spread via the different pathways. There is a greater uncertainty about the best method of calculating the economic and social impacts of <i>C. mutica</i> , especially in relation to other factors that may come into effect in the future regarding the issue of hull fouling and the disposal of biofouling.

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