GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

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Name of Organism:	***Ruditapes philippinarum* (Manilla Clam)**
Objectives:	Assess the risks associated with this species in GB
Version:	Original draft 29/06/11
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N	QUESTION	RESPONSE	COMMENT
1	What is the reason for performing the Risk Assessment?		Request made by GB Programme Board
2	What is the Risk Assessment area?	Great Britain	
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?		
	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?	YES (Give the full name & Go to 7)	Phyla: Mollusca; Class: Bivalvia; Order: Veneroida; Family: Veneridae; Genus/species: *Venerupis philippinarum* (A. Adams & Reeve, 1850). **NOTE:** Also placed in subgenus *Ruditapes. (* Synonyms include: *Tapes philippinarum, Ruditapes philippinarum, Venerupis semidecussata, Tapes semidecussata*) (Carlton, 1992). *Ruditapes philippinarum* is currently thought to be the most appropriate name for this species.
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)	Byers (2005) found no evidence that Manila clams at densities of 88-222 clams m^{-2} had any direct negative imacts on the littleneck clam Protothaca staminea in Puget Sound, Washington. However, by serving as a more accessible food resource, *R. philippinarum* may boost regional crab abundance and productivity, thereby influencing nearshore community structure and food web dynamics (Byers, 2005). Bartoli *et al.* , (2001) report that cultivation of R*. philippinarum* at densities of 2000–2500 individuals m^{-2} in the Mediterranean has had pronounced effects on: biogeochemical cycles, the abundance of microplankton, zooplankton and macrolagal growth. Pranovi *et al.* (2006) describe a sharp reduction, both in terms of distribution area and density, of all other filter feeder bivalves following the invasion of *R. philippinarum* in the Venice Lagoon. In France the native clam *Venerupis decussata* was displaced by *R. philippinarum* , which represented 97% of clam biomass in Arcachon Bay 20 years after initial introduction (ICES, 2008). However, population densities in the risk assessment area are significantly lower, (maximum abundance reported in any one sample in Poole Harbour 156 clams m^{-2}, Humphreys *et al* , 2007), and thus impacts on native species, habitats or ecosystems would be less likely.
8	Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems?		
9	Does the organism occur outside effective containment in the Risk Assessment area?	YES (Go to 10)	*R. philippinarum* was introduced into Poole Harbour for aquaculture in1988 (Langston *et al* , 2003) but had naturalised by 1994 and established reproducing populations on both north and south shores of the harbour when investigated by Jensen *et al.* , 2004. Established populations also occur in parts of Southampton Water and the Medina Estuary, Isle of Wight (pers. comm). Present throughout parts of the Solent and some adjacent Harbours also found off the north Kent coast near Whitstable and also in Essex (Ian Laing *pers com*).
10	Is the organism widely distributed in the Risk Assessment area?	NO (Go to 11)	Despite trials of *R. philippinarum* aquaculture in other regions of the UK (including the Exe Estuary, Devon), no successful establishment has been reported adjacent to aquaculture sites other than in Poole Harbour, Dorset (Jensen *et al.* , 2004). Populations also occur in Southampton Water and the Medina Estuary, Isle of Wight (pers comm).
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)	*R. philippinarum* inhabits fine - coarse sediments in the intertidal and upper sub-littoral zones (Bourne, 1982; Byers, 2005; Jensen *et al.* , 2005). Suitable habitats within the risk assessment area include large shallow inlets and bays, mudflats and sandflats, coastal lagoons and estuaries.
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)	*R. philippinarum* is native to Indo-Pacific coastal areas within a latitudinal range of 25-45 °N (Jensen *et al.* , 2004), but is now widespread throughout the western world. Established populations occur in the USA, Canada, Spain, Italy, France (Laing & Utting, 1994). This distribution includes ecoclimatic zones comparable with those of the risk assessment area although British seawater temperatures are somewhat lower. Water temperatures (5 m depth) at station L4 of the Western Channel Observatory (WCO) (south of Plymouth, UK) for the period 2002-2009 range from 7 - 18 °C (WCO, 2009). A naturalised population has become established within Poole Harbour, Dorset. This was thought to be a unique occurence in British waters, facilitated by a combination of favourable environmental conditions including warm seawater temperatures (up to 27 °C) in summer (Jensen *et al.* , 2004), but reproducing populations have since been found in Southampton Water and the Medina Estuary where conditions are more typical of an estuarine environment. Comparable ecoclimatic zones within the risk assessment area are likely limited to the south coast of England.
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)	*R. philippinarum* was introduced into Poole Harbour as a specific fishery resource but within five years had naturalised and spread throughout the harbour, both within and outside of the aquaculture beds (Jensen *et al.* , 2005). Naturalisation did not occur when similar trials were performed in the Exe Estuary (Jensen *et al.* , 2004).
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)	*R. philippinarum* is native to Indo-Pacific coastal areas within a latitudinal range of 25-45 °N (Jensen et al., 2004) but is now established in many western countries. This has occured through both accidental introduction with oyster seed (to North America and Canada) and intentional introduction as broodstock in several European countries including France, Spain and Italy (Laing & Utting, 1994). Anecdotal evidence suggests that the Manila clam has been introduced to new areas along the south coast of England by local fishers hoping to establish new fisheries (Anon' reviewer pers' comm').
17	Can the organism spread rapidly by natural means or by human assistance?	YES (Go to 18)	*R. philippinarum* has spread successfully throughout the intertidal zone of Poole Harbour since introduction in 1988 (Jensen *et al.* , 2004). Populations of the Manila clam found in Southampton water are thought to have been transported from Poole Harbour (Cooke & Jensen, 2009). In British Columbia, *R. philippinarum* has spread extensively since accidental introduction in the 1930s with Pacific oyster seed (Bourne, 1982). Spread of the pelagic larvae is aided by currents. Following introduction to the Venice Lagoon, *R. philippinarum* has spread along the Adriatic coast at a rate of 30 km year^{-1} (Breber, 2002).
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)	Uncertain. No evidence of economic, environmental or social harm was found with the exception of one report regarding the invasion of Manila clams in the Venice lagoon. Here, it was reported by Pranovi *et al.* , 2006 that a sharp reduction, both in terms of distribution area and density, of all other filter feeding bivalves occured following the introduction of *R. philippinarum* . Significantly lower population densities occur within the risk assessment area than in the Venice Lagoon, and no direct evidence was found to suggest that the Manila clam presents a substantial risk to species or habitats in GB. However if this species were to attain greater population densities then the native clam *Ruditapes decussatus* may be at risk from competition, as has occured in Arcachon Bay, France (ICES, 2008).
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	LOW - 0	(1) Intentional introduction for aquaculture (Introduced to several European countries for this purpose (Soudant *et al.* , 2004)). (2) Accidental transfer with other species associated with aquaculture (Unintentionally introduced to British Columbia with Pacific oyster seed (Bourne, 1982)). (3) There is anecdotal evidence that fishers introduce clams into new areas along the south coast of England to see whether thay can establish a new fishery; these attempts may be as crude as putting adult clams over the side of boats (Anon' reviewer pers' comm'). (4) Natural spread - *R. philippinarum* larvae are pelagic for 3-4 weeks, allowing transport by tidal or wind driven currents (Bourne, 1982). (5) Transport via ballast water.
1.2	Choose one pathway from the list of pathways selected in 1.1 to begin the pathway assessments.	Intentional introduction for aquaculture, combined with natural spread		The principal pathway of entry into European waters has been intentional introduction for aquaculture. Following initial introduction, natural spread has occurred (Breber, 2002).
1.3	How likely is the organism to be associated with the pathway at origin?	very likely - 4	LOW - 0	The farming of clams involves the laying of juvenile spat under netting on an otherwise natural coastal/estuarine mudflat (Jensen *et al.* , 2005).
1.4	Is the concentration of the organism on the pathway at origin likely to be high?	very likely - 4	LOW - 0	This would depend on the scale of aquaculture intended. Clams on cultivated lots occur at densities of 1,000 m^{-2} or more (Humphreys *et al.,* 2007).
1.5	How likely is the organism to survive existing cultivation or commercial practices?	very likely - 4	LOW - 0	*R. philippinarum* is successfully cultivated and harvested commercially in many regions worldwide. Because spat can be grown and supplied from hatcheries where environmental conditions are manipulated, clam farming can be achieved outside of the natural reproductive range (Jensen *et al.* , 2005).
1.6	How likely is the organism to survive or remain undetected by existing measures?	likely - 3	LOW - 0	Unlikely to be detected in larval or juvenile stages. Adult *R. philippinarum* remain buried in the sediment and so would not be detected without disturbing the local environment. *R. philippinarum* is superficially similar in shape and size to the native chequered carpet shell *Ruditapes decussatus,* causing potential difficulties in identification.
1.7	How likely is the organism to survive during transport /storage?	likely - 3	LOW - 0	The very nature of farming *R. philippinarum* involves spat production in hatcheries and subsequent transport to suitable farming sites.
1.8	How likely is the organism to multiply/increase in prevalence during transport /storage?	N/A		
1.9	What is the volume of movement along the pathway?	moderate - 2	MEDIUM -1	At present, there is one large commercial hatchery in England (one has recently closed) and one in the Channel Isles, each of which have the capacity to produce up to 200 million bivalve (mostly *Crassostrea gigas* and *R. philippinarum*) seed per year, for home and export markets. (Utting, 1999).
1.10	How frequent is movement along the pathway?	often - 3	MEDIUM -1	Farming may be a continuous process. Natural spawning occurs from June - September but requires a minimum seawater temperature of 14/15 °C (Bourne, 1982; Drummond *et al.* , 2006)
1.11	How widely could the organism be distributed throughout the Risk Assessment area?	moderately widely - 2	MEDIUM -1	*R. philippinarum* inhabits fine - coarse sediment in the intertidal and upper sublittoral zones (Jensen *et al.,* 2005). Suitable habitats within the risk assessment area include large shallow inlets and bays, mudflats and sandflats, coastal lagoons and estuaries. However, at present it appears that seawater temperatures are too low in most of the UK for successful reproduction and establishment to occur. Water temperatures (5 m depth) at station L4 of the Western Channel Observatory (WCO) (south of Plymouth, UK) for the period 2002-2009 range from 7 - 18 °C (WCO, 2009). If seawater temperatures rise as predicted with a warming climate however, then barriers to establishment would be reduced. Jensen *et al.* (2004) suggests that naturalization in Poole Harbour was only possible due to localised, favourable environmental conditions, but the discovery of established populations in Southampton Water and the Medina Estuary conflicts this theory, as the latter locations are more typical estuarine environments. The south coast of England may represent the northernmost limit for this species.
1.12	How likely is the organism to arrive during the months of the year most appropriate for establishment ?	likely - 3	LOW - 0	*R. philippinarum* spat is grown in hatcheries and introduced into the marine environment once it has reached a lifestage whereby it can survive. The following temperature limits are reported for essential reproductive activity: 8 °C for gonadal activity, 12 °C for gamete ripening and 14 °C for spawning (Drummond *et al.* , 2006). Water temperatures (5 m depth) at station L4 of the Western Channel Observatory (WCO) (south of Plymouth, UK) for the period 2002-2009 range from 7 - 18 °C (WCO, 2009).
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	LOW - 0	Spat grown in hatcheries is directly transferred to suitable marine habitat. Anecdotal evidence suggests that local fishers deliberately plant clams in new locations in attempts to establish new fisheries (Anon' reviewer pers' comm').

1.14	How likely is the organism to be able to transfer from the pathway to a suitable habitat?	likely - 3	LOW - 0	Spat grown in hatcheries are introduced to coastal/estuarine mudflats. Natural spread from aquaculture nets to wild habitat is likely to occur, as evident in Poole Harbour. Anecdotal evidence suggests that local fishers deliberately plant clams in new locations in attempts to establish new fisheries (Anon' reviewer pers' comm').

	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?	moderately similar - 2	LOW - 0	Distribution of *R. philippinarum* worldwide include several regions with fairly similar climatic conditions including the Pacific coast of Canada and the Brittany coast of France. The seawater temperature in these regions would however be slightly higher. *R. philippinarum* is native to Indo-Pacific coastal waters within latitudes of 25 - 45 °N (Jensen *et al.* , 2004) and the following temperature limits are reported for essential reproductive activity: 8 °C for gonadal activity, 12 °C for gamete ripening and 14 °C for spawning (Drummond *et al.* , 2006). Dang *et al* (2010) state that Manila clam eggs require 1–2 days at a temperature of 13–16 °C to hatch, followed by an optimal temperature of 25 °C and salinity of 20–30 ppt for larval survival. Water temperatures (5 m depth) at station L4 of the Western Channel Observatory (WCO) (south of Plymouth, UK) for the period 2002-2009 range from 7 - 18 °C (WCO, 2009). Within the risk assessment area, such climatic conditions are most likely to occur on the south coast.
1.16	How similar are other abiotic factors that would affect establishment in the Risk Assessment area and in the area of present distribution?	similar - 3	LOW - 0	Salinity, pH, water quality and currents are similar in the risk assessment area.
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.	moderate number - 2	LOW - 0	Suitable habitats would include large shallow inlets and bays, mudflats and sandflats, coastal lagoons and estuaries, but are probably limited by temperature to southern England. According to Humphreys *et al.* (2007) *R. philippinarum* attains its highest abundances in eutrophic, sheltered environments. As a filter feeding organism, availability of food is unlikely to be limiting, however periodic large scale spring mortalities are speculated to be due to weak condition over winter such that many don't make it to the spring phytoplankton bloom (Humphreys *et al* , 2007).
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?	frequent - 3	LOW - 0	These habitats are widespread around the UK, covering ~ 2101515 ha (JNCC, 2009). Suitable habitat will however probably be limited to southern areas where water temperatures are higher.
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?	likely - 3	LOW - 0	Competition from existing species has not prevented the successful establishment of the Manila clam in Poole Harbour, Dorset. In the Venice Lagoon, Italy, the grooved carpet shell *Ruditapes decussatus* (which occupies a very similar ecological niche) reduced greatly in abundance and distribution following the successful establishment of *R. philippinarum* (Pranovi *et al.* , 2006).
1.21	How likely is it that establishment will not be prevented by natural enemies already present in the Risk Assessment area?	moderately likely - 2	MEDIUM -1	Potential predators include crabs, starfish, benthic fish and wading birds. Byers (2005) reported greater predation by crabs on *R. philippinarum* than on similar native bivalves, and suggests that *R. philippinarum* has a high susceptibility to excavating crab predators due to a relatively shallow burial depth. However, this predation did not prevent successful establishment and population growth.
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?	likely - 3	LOW - 0	Laing & Utting (1994) suggest that the rearing of triploid *R. philippinarum* may be worthwhile as triploid animals show reduced fecundity. Trials by MAFF during the 1980s found that whilst triploid clams demonstrated reduced fecundity, sterilization was not reliably achieved (Jensen *et al.* , 2005). Farming under nets appears not to prevent spread and establishment, as evident from the naturalisation and spread of *R. philippinarum* in Poole Harbour Jensen *et al* , 2004).
1.24	How often has the organism been recorded in protected conditions, e.g. glasshouses, elsewhere?	N/A		
1.25	How likely is the reproductive strategy of the organism and duration of its life cycle to aid establishment?	likely - 3	LOW - 0	*R. philippinarum* larvae are pelagic for 3-4 weeks, enabling drift and spread to further areas of suitable habitat. When conditions are favourable, *R. philippinarum* exhibits a fast growth rate, extended breeding season and high fecundity (Pranovi *et al.* 2006). Drummond *et al* (2006) reported that (referring to *R. philippinarum* in Irish waters) gametes appeared to be resorbed into the gonad when temperatures were too low for successful spawning.
1.26	How likely is it that the organism's capacity to spread will aid establishment?	likely - 3	LOW - 0	It was originally thought that *R. philippinarum* would be unable to establish in British waters due to low seawater temperatures. The populations in Poole Harbour, Southampton Water and the Medina Estuary suggests that if favourable conditions exist, *R. philippinarum* are capable of natural spread and establishment. *R. philippinarum* larvae are pelagic for 3-4 weeks, enabling drift and spread to further areas of suitable habitat.
1.27	How adaptable is the organism?	moderately adaptable - 2	MEDIUM -1	Robert *et al.* , (1993) report that *R. philippinarum* is tolerant to wide ranges of temperature and salinity but not to sharp variations therein. This species has naturalised in several regions where it had originally been introduced for aquaculture.
1.28	How likely is it that low genetic diversity in the founder population of the organism will not prevent establishment?	likely - 3	MEDIUM -1	Yiping *et al.* (2005) suggest that the genetic diversity of *R. philippinarum* in China is high, and no evidence was found to suggest that subsequent populations would show low genetic diversity.

1.29	How often has the organism entered and established in new areas outside its original range as a result of man's activities?	many - 3	LOW - 0	*R. philippinarum* was introduced to the Pacific coast of North America and Canada with Pacific oysters from Japan, and to several European countries (including France, Spain, Italy, Portugal and the UK) for aquaculture purposes (Flassch & Leborgne, (1992).
1.30	How likely is it that the organism could survive eradication campaigns in the Risk Assessment area?	likely - 3	LOW - 0	As a burrowing species, eradication measures would involve dredging to remove *R. philippinarum* . No information was found to suggest that this method would be successful in eradicating the species, and furthermore such action would involve considerable expense and significant damage to the local environment and associated species.
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)?	likely - 3	LOW - 0	*R. philippinarum* is a highly valuable species of commercial aquaculture and so introductions are likely to continue. Anecdotal evidence suggests that some southwest fishers deliberately plant clams in new locations to try to establish new fisheries (Anon' reviewer pers' comm'). Transport of larvae via ballast water, or natural spread of pelagic larvae may also continue to introduce transient populations.

	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	In Italy, *R. philippinarum* was first introduced in 1983 to Venice Lagoon (Humphreys *et al.* , 2007). Its range extended southwards at 30 km per year and it now thrives in all the lagoons along the northern Adriatic coast (Breber 2002). *R. philippinarum* is unlikely to spread this swiftly within the risk assessment area as conditions are less favourable. *R. philippinarum* was introduced to Poole Harbour in 1988 and in 2004 was found to be abundant on both the north and south shores of the harbour (Jensen *et al.* , 2004). The Manila clam was also found in Southampton Water during the early 2000s and had spread to the Medina Estuary by 2011 (Anon' reviewer pers' comm'). If seawater temperature increases as it is predicted to, then the ability to spread by natural means will be enhanced.
2.2	How rapidly is the organism liable to spread in the Risk Assessment area by human assistance?	rapid - 3	LOW - 0	Expansion of current aquaculture sites would accelerate the rate of spread. Caldow et al. (2007) report that *R. philippinarum* is now abundant in Southampton waters, 50 km east of Poole Harbour. It is unknown whether this has occurred through natural spread or through human assistance. Anecdotal evidence suggests that local fishers deliberately plant clams in new areas to try to establish new fisheries (Anon' reviewer pers' comm').
2.3	How difficult would it be to contain the organism within the Risk Assessment area?	difficult - 3	LOW - 0	It would be very difficult to prevent the spread of pelagic larvae. Clam farming does not operate within a closed system.
2.4	Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism.		MEDIUM -1	Suitable habitats occur throughout the southern part of the risk assessment area and include large shallow inlets and bays, mudflats and sandflats, coastal lagoons and estuaries on the south coast. According to Humphreys *et al.* , (2007) *R. philippinarum* attains its highest abundances in eutrophic, sheltered environments. Seawater temperatures in many parts of the UK are thought to be too low for widespread successful establishment of *R. philippinarum* . Cultivation of *R. philippinarum* in other parts of the UK have not resulted in naturalized populations. *R. philippinarum* is now known to be abundant in mudflats within Southampton waters (Caldow *et al.* , 2007) and it has also recently been found in the Medina Estuary (Anon' reviewer pers' comm'). This would suggest that the species may be capable of adapting to local conditions, and could establish in areas with similar conditions. Furthermore, if seawater temperatures rise as predicted (Hulme *et al.* , 2002) then barriers to establishment could be reduced.

	Impacts	RESPONSE	UNCERTAINTY	COMMENT
2.5	How important is economic loss caused by the organism within its existing geographic range?	minimal - 0	LOW - 0	No evidence of economic loss caused by *R. philippinarum* was found. *R. philippinarum* is a highly valuable commercial species. It now represents one of the major cultured species in the world (2.36 million tonnes in 2002 (FAO, 2009)).
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?	minimal - 0	MEDIUM -1	The figures are based on (A) - overall area of sandflats and mudflats (733100 ha), estuaries (308355 ha), shallow bays and inlets (764560 ha) and coastal lagoons (5500 ha) in UK waters (JNCC, 2009:http://www.jncc.gov.uk/page-4166). These habitats are potentially suitable sites for establishment of *R. philippinarum* (B) - Due to the successful establishment of *R. philippinarum* in other geographical regions, all suitable areas in southern Britain are considered 'at risk' for the purposes of this assessment although uncertainty is high. High densities of *R. philippinarum* are most likely in shallow, sheltered, eutrophic waters. (C-) *R. philippinarum* is abundant throughout Poole Harbour (~4000 ha) and in Southampton water (D) Total value of UK clam and cockle production in 2006 was £63,000 (FAO, 2009). (E, F) Estimated final proportion of the resource value at risk is based on lack of scientific evidence to suggest economic impact. There is no evidence to suggest that ecological conditions in the risk assessment area are suitable for populations to build up to levels where significant economic damage is caused. (G) There are no proven methods of control or eradication for this species. Dredging for infaunal populations would involve unacceptable environmental harm. Large epifaunal individuals may be recognised and collected but this method would be extremely time consuming and present logistical difficulties.
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?	minimal - 0	LOW - 0	No evidence was found to suggest that producer profits would be negatively affected.
2.8	How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area?	minimal - 0	LOW - 0	No evidence was found to suggest that consumer demand would be impacted, although a shift in consumer demand from the native clam *R. decussatus* to *R. philippinarum* may occur.
2.9	How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets?	unlikely - 1	LOW - 0	No evidence was found to suggest this, however demand for native clams may be reduced. In Ireland, low domestic demand for *R. philippinarum* prompted the producers to export their fresh products to France and Spain (FAO, 2009), and part of the Poole Harbour catch is exported to France
2.10	How important would other economic costs resulting from introduction be? (specify)	minimal - 0	LOW - 0	No evidence was found to suggest economic costs would be incurred following establishment of *R. philippinarum* .
2.11	How important is environmental harm caused by the organism within its existing geographic range?	minor - 1	LOW - 0	Possible species displacement has been a concern but there is little firm evidence to make conclusions. The only report of significant environmental impacts is from Pranovi *et al.* (2006) who suggest that *R. philippinarum* has altered ecosystem functioning in the Venice Lagoon, Italy. Following its introduction into the Venice Lagoon, *R. philippinarum* achieved widespread abundance whilst abundance and distribution of other, native bivalves was significantly reduced. However it is possible that this reduction is due to indirect effects from intense dredging activity rather than from direct competition (Pranovi *et al.* , 2006). Sorokin *et al* (1999) describe the 'high' environmental impacts of harvesting equipment used in the Venice Lagoon. If similar gears were used in the risk assessment area then similar adverse environmental impacts may also be expected. Byers (2005) reported no direct effect on native bivalve species even where high densities of *R. philippinarum* occured in Washington, USA. There is no evidence that *R. philippinarum* has affected the distribution or abundance of native bivalves in Poole Harbour.
2.12	How important is environmental harm likely to be in the Risk Assessment area?	minimal - 0	MEDIUM -1	It appears unlikely that *R. philippinarum* would cause significant environmental harm in the risk assessment area. Although unpublished surveys suggest that certain native bivalves were much more abundant before the introduction of *R. philippinarum* to Poole Harbour, the decrease is thought to be due to high TBT concentrations in the harbour during the 1980s (Jensen *et al.,* 2004). It is possible that the cumulative impact of increased competition and toxic effects of TBT contributed to this decline, however there is no evidence to support this suggestion. Although uncomfirmed, cumulative habitat damage may occur due to the pump-scoop method of harvesting clams. Preliminary investigations reported by Jensen *et al* (2005) did not suggest acute community disturbance but Parker & Pinn (2005), discussing pump-scoop dredging for cockles, suggest that there may be a chronic effect as the fishery season progresses, causing declines in abundance of non-target species. Furthermore, illegal fishing of shellfish is known to occur out of season, and dredging is identified as a concern in terms of damage to seagrass beds, effect on prey availability and displacement of birds in the short term (Natural England, 2010).
2.13	How important is social and other harm caused by the organism within its existing geographic range?	minimal - 0	LOW - 0	No evidence was found of social or other harm attributable to *R. philippinarum.*
2.14	How important is the social harm likely to be in the Risk Assessment area?	minimal - 0	LOW - 0	No evidence was found in the scientific literature to indicate that social harm would result from the establishment of *R. philippinarum* .
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?	moderately likely - 2	MEDIUM -1	Natural hybridization has been reported between the native European species *Ruditapes decussatus* and *R. philippinarum* (FAO, 2009). Further detail would be required to make an informed judgement regarding the effects of this on environmental, social or economic scenarios.

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?	moderately likely - 2	MEDIUM -1	Potential predators include crabs, starfish, benthic fish and wading birds. Byers (2005) reported greater predation by crabs on *R. philippinarum* than on similar native bivalves, and suggests that *R. philippinarum* has a high susceptibility to excavating crabs due to its relatively shallow burrowing depth. However, these predators appear to have had little impact on the abundance of *R. philippinarum* in its existing distribution. It is possible that predation may have contributed to this species' failure to become established in some places (for example the Exe Estuary), but no evidence was found to support this suggestion.
2.17	How easily can the organism be controlled?	difficult - 3	MEDIUM -1	No measures to control the spread of *R. philippinarum* have been suggested. Open access fisheries may inhibit population growth but would not prevent the spread of pelagic larvae.
2.18	How likely are control measures to disrupt existing biological or integrated systems for control of other organisms?	unlikely - 1	HIGH -2	No information was found.
2.19	How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms?	likely - 3	MEDIUM -1	Brown ring disease (BRD) *Vibrio tapetis* , in *R. philippinarum* has been reported from the coasts of France, Portugal, Spain, Italy, England and Ireland. BRD has been linked with mass mortalities in *R. philippinarum* beds along the west coast of France (Bower, 2007). A concern is that BRD also affects the native chequered carpet shell *R. decussatus* which is found along southern and western coast of Britain and Ireland (Carter, 2005).
2.20	Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur		LOW - 0	*R. philippinarum* attains its greatest abundances is sheltered, eutrophic environments (Humphreys *et al.* , 2007). Therefore, sandbanks/mudflats within sheltered bays, harbours and estuaries which receive nutrient inputs and where water temperatures are elevated, are most likely to provide suitable conditions for *R. philippinarum* . These sites will probably be limited by water temperatures to southern regions.

Summarise Entry	very likely - 4	LOW - 0	*R. philippinarum* has been introduced to the UK already as a comercial species for aquaculture. Spat is produced within hatcheries and transferred to natural coastal/estuarine mudflats. Given the appropriate conditions this species has demonstrated its ability to naturalise and establish reproducing populations.
Summarise Establishment	moderately likely - 2	MEDIUM -1	Whilst it has long been thought that seawater temperatures in the UK are too low for successful establishment of *R. philippinarum* , the naturalised population in Poole Harbour, and recent reports from 50 km east within Southampton waters and the Medina Estuary suggest that *R. philippinarum* may be adapting to local environmental conditions. It seems likely that this trend will continue given suitable local conditions (shallow, eutrophic, sheltered mudflats). Establishment is likely to be limited, as opposed to prevented, by water temperature. The following temperature limits are reported for essential reproductive activity: 8 °C for gonadal activity, 12 °C for gamete ripening and 14 °C for spawning (Drummond et al., 2006). Water temperatures (5 m depth) at station L4 of the Western Channel Observatory (WCO) (south of Plymouth, UK) for the period 2002-2009 range from 7 - 18 °C (WCO, 2009). Suitable habitat is widespread throughout southern regions of the risk assessment area and establishment is unlikely to be prevented by competition or natural enemies. If seawater temperatures rise as predicted, further establishment and spread are expected.
Summarise Spread	intermediate - 2	MEDIUM -1	Larvae are planktonic for 3-4 weeks, facilitating natural spread by tidal or wind driven currents, and accidental transport via ballast water. Further spread through intentional introduction is also likely due to the commercial value of this species. Given favourable conditions (particularly water temperature), natural spread could occur rapidly. Unintentional spreading could occur through associations with oyster seed (Bourne, 1982). Intentional introductions as prevously mentioned may increase the potential for spread.
Summarise Impacts	minor - 1	MEDIUM -1	Currently, population densities of Manila clam in the risk assessment area are significantly lower than in other invaded regions, and are likely to be limited by the cooler water temperatures in the risk assessment area. If *V. philippinarum* were to become more widespread, the magnitude of impacts would depend upon the densities attained by the species (Humphreys *et al.* , 2007). In the Venice Lagoon, Italy, abundance and distribution of native bivalves declined significantly following the *R. philippinarum* invasion (Pranovi *et al.* , 2006); yet Byers (2005) reported no direct effect on native bivalves in Washington even at very high clam densities. This suggests that effects may be site-specific and highly variable; therefore impacts within the risk assessment area would be difficult to predict without additional study. No evidence was found in the scientific literature to suggest that any adverse socio-economic impacts could be expected, as *R. philippinarum* is a valuable fishery resource worldwide.
Conclusion of the risk assessment	LOW - 0	MEDIUM -1	Entry and limited spread have already occurred, and are expected to continue. *R. philippinarum* is farmed in British waters as a valuable commercial aquaculture species. The Fish Health Inspectorate have 12 authorised farms showing as holding manila clams at the time of their last visit (usually with the last 12 months). This can be sites actively farming as well as farms where they naturally occur on their beds. These are on the Anglian coast (7) and South coast (5). Information from the FHI is that they do not feel this species is being 'farmed' and that natural production only appears to come from some of the sites on the south coast. Manila clams are still held by farms in Poole Harbour but are harvested from natural production of the beds rather than being actively 'farmed' (Debbie Murphy, Cefas, (2011) pers comm.). Suitable habitat is widespread in British waters but spread in the near future is liable to be limited to southern regions by low water temperatures. The potential for further spread and naturalisation exists and would be facilitated by rising seawater and air temperatures. The potential ecological impacts of establishment are unclear, and impacts appear to be variable and site-specific. Little evidence exists to suggest that environmental or socio-economic impacts would be significant.
Conclusions on Uncertainty		MEDIUM -1	Scientific literature on *R. philippinarum* seems for the most part reliable. It is interesting to note the discrepancy in the use of different scientific names for the Manila clam; authors used *Venerupis philippinarum* , *Ruditapes philippinarum* and *Tapes philippinarum.* Further molecular work is required to decide if they merit different genera (Humphreys, pers comm). Additional research into the invasive potential of this species would be welcome, particularly in the risk assessment area. Contrasting scenarios have been reported concerning the impacts upon native bivalves (for example Byers, 2005 & Pranovi *et al.* , 2006). Impacts appear highly variable and site-specific, hence it is difficult to form a conclusion on this matter without further specific study.

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