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	***Crassostrea gigas* - Pacific Oyster**	
	Objectives:	Assess the risks associated with this species in GB	
	Draft:	Final (20/9/10)	
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 coastline, in particular the south and south east coast of England, but also the south west of England, Wales and the North West.	Habitats comparable to those in the Wadden Sea are considered most at risk, including intertidal mudflats and sand flats and shellfish beds. Also considered at risk are areas of intertidal biogenic reef. Note references to the Wadden Sea reflect its similar habitats and species, although UK habitats directly comparable to the Wadden Sea area are limited.
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:Ostreoida, Family:Ostreidae, Genus/species: Crassostrea gigas There is currently some debate over whether or not C. angulata (the Portuguese oyster) is in fact the same species. Whilst the 2 species are often considered synonomous, recent research suggests that both are separate species of Asian origin (Batista et al 2006).
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?	NO or Uncertain (Go to 8)	
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)	marine invertebrate spreadsheet score of 42
9	Does the organism occur outside effective containment in the Risk Assessment area?	YES (Go to 10)	
10	Is the organism widely distributed in the Risk Assessment area?	YES & Future conditions/management procedures/policies are being considered (Go to 19)	
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)	Suitable habitats exist for C.gigas throughout the UK although current environmental conditions and other biotic and abiotic factors are likely to exclude settlement in some areas.
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)	
15	Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment area?	NO (Go to 20)	
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)	
17	Can the organism spread rapidly by natural means or by human assistance?	YES (Go to 18)	
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)	
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		

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?	moderate number - 2	LOW - 0	Further aquaculture introductions. A study (Child et al 1995) has shown that some spat settlement in the southwest of England has come from French stock. Authors suggest a number of possible vectors of this stock including transport by current systems, discarded food waste transport on ship's hulls and intentional (illegal) introductions.
1.2	Choose one pathway from the list of pathways selected in 1.1 to begin the pathway assessments.	B.6 aquaculture/mariculture		
1.3	How likely is the organism to be associated with the pathway at origin?	very likely - 4	LOW - 0	Following initial iimportation of a small number of individuals from Canada to the UK in 1965 (Drinkwaard 1999) C.gigas is now bred in 3 UK hatcheries and oyster seed is distributed widely to sites around the UK and Ireland where on-growing takes place in open systems. This involved the release of 206 million individuals in 2005 and 708 million in 2006, (Cefas 2007).
1.4	Is the concentration of the organism on the pathway at origin likely to be high?	very likely - 4	LOW - 0	In 2006, 708 million individual spat were distributed from hatcheries around the UK and Ireland (Cefas 2007). Relative to existing feral populations and in terms of proximity to conspecifics, oysters in culture represent high concentrations of individuals. However, the level of concentration varies between sites and stages of development/ size. The majority of UK growers produce around 5 tonnes of oysters per annum with only a few producing over 10 tonnes (Anonomous reviewer pers com).
1.5	How likely is the organism to survive existing cultivation or commercial practices?	likely - 3	LOW - 0	Spatfall has been witnessed outside of the commercial fishing areas. Natural spatfall found in several UK sites. (Child et al 1995, Drinkwaard 1999)
1.6	How likely is the organism to survive or remain undetected by existing measures?	likely - 3	MEDIUM -1	As a benthic species cohabiting with other marine bivalves chemical controls are deemed inappropriate. Recent studies have shown that early culling of settled individuals and destruction of both valves using a hammer before establishment occurs may be effective at preventing establishment (particularly in areas where spawning does not take place every year) with minimal impact on surrounding biological assemblages (Guy & Roberts 2010).
1.7	How likely is the organism to survive during transport /storage?	likely - 3	MEDIUM -1	Farmed oysters can survive several days during transportation to consumers/the market place. In the natural environment C.gigas survives tidal exposure.
1.8	How likely is the organism to multiply/increase in prevalence during transport /storage?	unlikely - 1	MEDIUM -1	Requires submersion within water and conspecifics to spawn.
1.9	What is the volume of movement along the pathway?	moderate - 2	HIGH -2	According to the Shellfish Association GB figures, the UK produced 1016 tonnes of farmed pacific oysters in 2004, in 2006, 708 million spat were distributed from UK hatcheries to sites around UK and Ireland (Cefas 2007) A female has the potental to spawn 50-60million eggs (NIMPIS, 2002) Mortaility is extremely high at the larval phase and is likely comparable to the >90% mortality rates observed in C. virginica (Gosselin & Qian 1997). Levels of larval mortality are largely dependant on environmental conditions, in particular food availability and temperature (Rico-Villa et al 2009) Settlement success will also be dependant on environmental conditions and availability of suitable settlement habitat. In more northerly locations and in years where water temperatures fluctuate widely the success of larval settlement is likely to be reduced (Syvret et al 2008 and anonomous reviewer pers com). It should be noted that spawning by oysters in an on growing situation is looked upon unfavourably by the industry due to reduced product quality and other negative impacts to the industry associated with wild spat settlement. Some growers therefore take actions to discourage spawning (Anonomous Peer revier pers com). The high level of uncertaintyy reflects the need for far more research into potential for larval success and movement in the risk assement area.
1.10	How frequent is movement along the pathway?	often - 3	LOW - 0	Frequency of oyster farming is continuous. Spawning occurs only when water temperatures exceed 18 ^{0}C (Mann 1979) and recruitment is likely to be sporadic and limited to unusually warm summer temperatures (Diederich et al 2005).
1.11	How widely could the organism be distributed throughout the Risk Assessment area?	widely - 3	MEDIUM -1	Suitable habitats exist for C.gigas throughout the UK with 290000 hectares of mudflats/sandflats, 283060 hectares of shallow bays and inlets some of which are likely to include suitable habitat for C.gigas settlement. C.gigas are also likely to inhabit rocky shores and man-made hard structures, which are widely spread around the UK. A variety of Biotic and Abiotic factors will affect the successful spawning and recruitment of *Crassostrea gigas* ,including temperature (including biological resource debt resulting from prolonged exposure to cold winter conditionsr), trophic interactions and nutrient availability, adverse hydrodynamics and pollution (e.g TBT). Syvret et al (2008) undertook analysis of risk of natural recruitment of C. gigas for regions of the British Isles. Based on his results, Scotland and the North-East of England are considered low risk. Northern Ireland, Wales and South West England are considered moderate risk and South and South East England are considered to be high risk.
1.12	How likely is the organism to arrive during the months of the year most appropriate for establishment ?	very likely - 4	LOW - 0	Organism is already present within the marine environment and as such is present during times of optimal environmental conditions required for spawning and natural spatfall.
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?	likely - 3	MEDIUM -1	Introduction of C.gigas for aquaculture into new sites where conditions are suitable for reproduction is likely to lead to spatfall and is likely to contribute to the establishment of further populations. Elsewhere in North West Europe, spread of feral populations of C.gigas have been documented on numerous occasions following release of Spat for culture (Troost 2010). Processing and consumption is unlikely to aid transfer although it has been suggested that discards from the food industry are a potential vector of introduction (Child et al 1995) .
1.14	How likely is the organism to be able to transfer from the pathway to a suitable habitat?	likely - 3	MEDIUM -1	Dependant on suitable environmental conditions such as temperature. These optimal temperature conditions have already occurred in and aided transfer along the North West Coast of Europe from Denmark to Portugal, and several sites in the South West of the UK (See for example Troost 2010 & Child et al 1995)

	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?	similar - 3	LOW - 0	Spreading within the estuarine marine environment to other estuaries nearby.
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	MEDIUM -1	Salinity gradients will vary within estuaries. C.gigas is tolerant of wide ranges of salinity (Chu et al.,1996) Habitats exist throughout the risk assesment area with abiotic conditions similar to areas in North West Europe, where C. gigas has become established. However, certain factors, including polution and hydrodynamic regimes may influence establishment in some areas. Suitable substrata are varied with C.gigas being found on rocky shores as well as more traditional oyster/mussel reefs.
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	As a benthic bivalve there are many suitable habitats, the primary habitats for forming reefs are seen to be shallow intertidal mudflats as per the Wadden sea. C. gigas may live both in intertidal and subtidal habitats. In the Wadden Sea, it mainly lives in the intertidal in the same zone as blue mussels. Pacific oyster larvae may settle on all kind of natural and artificial hard substrates as mollusc shells, living molluscs, wood, stones, concrete and others.
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	
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	MEDIUM -1	C.gigas is seen to outcompete both the native oyster (O.edulis) and the blue mussel (M.edulis), and has been found to reduce suitable habitat for cockles(Diedrich, 2006). Competition for space and and resources may be caused by another invasive species, the slipper limpet *Crepidula fornicata* . There is also anecdotal evidence that settlement of the blue mussel (M. edulis) and barnacles on C.gigas in cultivation occurs to levels whcih may inhibit the life functions of individual oysters or smother stocks. (anonomous peer reviewer pers com)
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	There is some conflicting information between Australian reports (NIMPIS, 2002; Shatkin et al., 1997) and European reports (Wadden Sea). Pacific oysters are consumed by a variety of marine animals as Asteroid echinoderms, boring gastropods, boring bivalves, spionid polychaetes. Carcinus maenas in the intertidal, benthic feeding fish, lobsters in the subtidal zone, black ducks, eider ducks, and wading birds (NIMPIS, 2002). Predation is likely to be far higher in newly settled juvenilles, so much so that the industry now seeks to purchase seed stock at the largest economic size to reduce predation (anonomous reviewer pers com). In the Wadden Sea, predation from birds seems to be very limited. Unlike blue mussels, oyster are only consumed by a few bird species (herring gulls and the oyster catcher)(reviewed in Troost 2010). Juvenilles apparently have far more natural enemies, including the shore crab (Carcinus maenus) which will take individuals up to 40mm and common starfish (Asterias rubens) takign indicviduals up to 60 mm although in laboratory studies both have been shown to feed preferentially on mussels (m. edulis) predatory gastropods are also known to consume juvenile oysters and another invasive non-native species, the American oyster drill (Urosalpinx cineria), known to be present in the UK in a limited geographical range is a particularly voracious predator of young oysters (Troost 2010). In the Wadden Sea, it is considered that a reduced number of natural predators compared to the native range supports the 'enemy release hypothesis' (Troost 2010) a similar situation is likely to be the case in the UK. Infestations by the polychate worm Polydora ciliata have adverse impacts on the biology of C.gigas and may increase vulnerability to predators and impare othe rlife procceses (Chambon et al 2007). In cultivation practices, removal of fouling and predator species is the main husbandry task, suggesting that unprotected stock may be more vulnerable (Anonomous referee pers com)Energy flow of an oyster reef is anticipated to be highly different from mussel beds and not directed to higher trophic levels. Oyster reefs are apparently of little value for mussel eating birds and especially eider ducks Somateria mollissima cannot make use of adult oysters (Diedrich, 2006; Nehls & Buttger, 2007;). Pathogens and parasites impacting stocks in Europe have not currently arrived in UK waters, but if they did, risks to faral and farmed C. gigas would be high (Anonomous reviewer pers com)
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	Existing controls are predominantly detrimental to other marine organisms in the area. Current husbandry practices are unlikely to prevent establishment. Internationally the use of triploidy has been effective, but UK experience has shown the techniqe is not always effective and may have marketability implications for the product (Anonomous referee pers com). Management of feral stocks by harvesting may also be effective at controlling feral populations (Anonomous referee pers com) but would only be limited to specific sites and conditions. Current existing controls have failed to prevent establishment in some areas.
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?	very likely - 4	LOW - 0	As in other bivalves, Pacific oysters have pelagic larvae spending 3 to 4 weeks in a free-swimming phase. In the right conditions some authors have postulated that larvae may be capable travelling distances of up to 1300km (Global Invasive Species Database 2005 & Stenzel 1961 cited in Ozaka & Fujio 1985) however such distances would be very unlikely in GB waters. Studies in the German Wadden Sea found larval dispersal distances between 0 and 50 km (Brandt et al 2008).
1.26	How likely is it that the organism's capacity to spread will aid establishment?	very likely - 4	LOW - 0	Whilst the thermal conditions in Northern Europe were thought to be beyond optimal for C.gigas, natural spatfall has occurred. Therefore it is very likely that the organisms ability to spread via spawning will aid establishment(Spencer et al., 1994).
1.27	How adaptable is the organism?	adaptable - 3	MEDIUM -1	Once adult C.gigas can survive in a wide range of temperature, salinity, dissolved oxygen, and pH conditions (Eno et al., 1997; NIMPIS, 2002). Larvae are less adaptable and more vulnerable to extreme/ changing environmental conditions (Miossec et al 2009, Anonomous reviewer pers com).
1.28	How likely is it that low genetic diversity in the founder population of the organism will not prevent establishment?	unlikely - 1	MEDIUM -1	There are a number of founder poulations and it is thought that natural spat from France has settled in UK waters (River Teign)(Child et al., 1995).
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	Throughout the North Sea, Wadden Sea, and Atlantic coasts C.gigas has been able to establish itself as a result of natural spatfall within mariculture (Nehls & Buttger, 2007; NIMPIS, 2002).
1.30	How likely is it that the organism could survive eradication campaigns in the Risk Assessment area?	likely - 3	LOW - 0	The majority of eradication campaigns would involve destruction of the organism in the environment and it is likely that this would result in environmental degradation, including non target 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	Given the correct environmental conditions i.e. temperature and substrata, it is very likely that C.gigas will spread through natural migration or anthropogenic activities.

	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	This is very dependant on optimal temperature conditions (Song et al., 2007), but in recent years and using case studies such as the Wadden Sea and the Yealm estuary the spread is likely to be increasingly rapid.The spread of the Pacific oyster in the Wadden Sea follows the classic pattern of biological invasions with a long phase of stagnancy followed by a fast increase (Diedrich et al., 2005; Nehls & Buttger, 2007; Spencer et al.,1994). A small founder generation has to reach a certain size before a fast growth is possible. However, in the case of the Pacific oyster, it is likely that the recent spread is facilitated by changing environmental conditions, especially an increase in summer temperatures (Nimpis, 2002).
2.2	How rapidly is the organism liable to spread in the Risk Assessment area by human assistance?	slow - 1	HIGH -2	This is largely dependant on the licencing of further oyster farms and movement of spat and half grown adults.
2.3	How difficult would it be to contain the organism within the Risk Assessment area?	very difficult - 4	LOW - 0	Controlling release of natural spatfall will involve closed systems, which is not currently used by the vast majority of shellfish farming. Or would involve the use of triploidy within the species, this is unlikely to to affect areas where C.gigas is already established.
2.4	Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism.			Areas with suitable substrate, temperature, and salinity conditions and potentially endangered by C.gigas. This includes areas used for wild harvest of cockles, mussles and native oysters.

	Impacts	RESPONSE	UNCERTAINTY	COMMENT
2.5	How important is economic loss caused by the organism within its existing geographic range?	moderate - 2	HIGH -2	In the Wadden Sea C.gigas has affected mussel, native oyster and cockle beds, resulting in many studies to ascertain the economic impacts. Cockles are considered to be more resilient due to mobility but some evidence has been found that *C.gigas* alters both reefs and substrate (Diedrich, 2006). It is possible that oyster beds increase settlement opportunities for mussels although the extent to which this will benefit the mussel industry is unclear (Troost 2010). Feeding interactions and competition with native, commercially important bivalves is likely to be complex It is likely that the feeding mechanisms of C. gigas and structure will interfere with the feeding success of native bivalve species of comercial importance(Troost 2010). Again the possible economic significance of such impacts are unclear. Escaped spat and feral oyster populations may also reprasent a cost to the cultured oyester industry. At sites in France, feral oyster are trophic competitiors of farmed oysters (e.g. Cognie et al 2007)and in the UK, settlement of spat on farmed oysters and gears creates additional operational costs and may lead to reduced product quality
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?	minor - 1	MEDIUM -1	In the Wadden Sea the C.gigas invasion has been thought to affect mussle and cockle beds, resulting in losses in these commercial fisheries(Diedrich, 2006; Nehls & Buttger, 2007). Because of the morphology of the shell it has also affected tourism, the shells potentially damaging people because of the sharp edges.Given the current value of wild mussel fisheries of £2.0million, native oysters of £0.1million, and cockles of £10.1million (all values for wild harvest, 2004(shellfish.org.uk) economic loss could represent £12.2million per year in an absolute scenario.However, in terms of community structure no species losses were observed in a 2006 report (Diedrich, 2006). It also concluded that: Blue mussels are able to coexist with Pacific oysters in their reefs, and Pacific oyster reefs offer species of blue mussel beds an alternative habitat. Blue mussel fisheries in the Wadden may be affected by the spread of the Pacific oyster in the future for two reasons. First, Pacific oysters may settle on culture lots and overgrow the blue mussels. At present, it seems to be unlikely that this will be a major problem for the fisheries, as Pacific oysters apparently rarely settle on young blue mussels and in general do not settle in high densities in the subtidal. As blue mussel cultures are stocked with young seed mussels and are located always in the subtidal it seems at present to be unlikely, that they might be overgrown by Pacific oysters. Second, oyster may be present on seed mussel beds and make it impossible to fish purely for blue mussels.
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?	minor - 1	MEDIUM -1	Although reports are contradictory in the ability of C.gigas to substantially alter the environment through out-competition, or to minimise commercial stocks, there is a risk that overtime mussel seedbeds will be difficult to fish because of the presence of oysters. There is also a risk that cockle beds will be affected, through the substrate changing to oyster reefs from mud/sand flats resulting in economic consequences for cockle fishers.
2.8	How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area?	minor - 1	HIGH -2	No evidence has been found to suggest whether or not consumer demand for shellfish products will be affected and this is an area which warrents further study. In terms of consumer demand for recreational activities in coastal and marine areas, ICES (Miossec et al 2009) suggest that the presence of C.gigas can affect recreational activities in possitive and negative ways and that it's sharp shells make it a nuisance to many recreational activities and lead to injury.
2.9	How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets?	unlikely - 1	HIGH -2	The cockle fishery is predominantly for export, and as such should this fishery be effected it will result in negative consequences for export markets. Native oysters and mussels that are for export may also be affected. Similar to 2.6, these statements are based on an absolute scenario and for the reasons described in section 2.6, based on current information, serious impacts on export markets are considered unlikely. Oppertunities may exist to market products derrived from feral oyster harvesting overseas, for example to Asian countries if legislation allows (Anon Referee pers com 2010).
2.10	How important would other economic costs resulting from introduction be? (specify)	minor - 1	HIGH -2	Other economic costs are likely to be recreation based. Impacts on the amenity value of shore areas (Miossec et al 2009) may reduce recreational activitiy and tourism in some areas although negative impacts may be offset by potential possitive impacts. It is likely that there will be possitive impacts to the oyster farming industry resulting from introduction and sale and export of oysters.
2.11	How important is environmental harm caused by the organism within its existing geographic range?	moderate - 2	MEDIUM -1	C.gigas is a trophic competitor for other bivalves, in the context of end-member supply limitation (Decottignes et al., 2007).Other non-native species have been introduced as a result of C.gigas introduction elsewhere in the . In Sylt, Wadden Sea previously known mussel beds have now been transformed to oyster reefs within the intertidal. Pacific oysters are today found in all parts of the Wadden Sea. They form dense layers which have all characteristics of reefs on former beds of the blue mussel Mytilus edulis and settle on all other kind of hard substrates. Within the Yealm estuary, community composition within the oyster beds is found to be high, with species density also being high within those species observed.
2.12	How important is environmental harm likely to be in the Risk Assessment area?	moderate - 2	MEDIUM -1	C.gigas is a trophic competitor for other bivalves, in the context of end-member supply limitation (Decottignes et al., 2007). And would likely impact populations of native bivalve species, including mussels and the native oyster. Other non-native species, including oyster pests, pathogens and algae have been introduced worldwide, including North West Europe as a result of C.gigas introductions and movement (Miossec et al 2009, Verlaque et al 2007). A number of potentially damaging species are already present in the Britain and Ireland (for example the sting winkle *Urosalpinx cinerea* and the algae *Undaria pinnatifida*) and transport of oyster stock from infected to uninfected sites could potentially facilitate the spread of these species. Introductions of the non-native copepods *Mytilicola orientalis* and *Myicola ostrea* took place in Ireland in 1993 when half grown oysters were imported from France (Holmes and Minchin 1995 cited in Miossec et al 2009) . Illustrating the need to maintain the currently strict regulations in the UK. In Sylt, Wadden Sea previously known mussel beds and mud flats have now been transformed to oyster reefs within the intertidal. It is likely that similar habitats will be affected should C.gigas spread. A loss of mudflat, mussel beds and other habitat, exacerbated by the expansion of C.gigas reefs may impact wider ecosystems by reducing feeding sites for fish, birds and other organisms. A study in British Columbia found that while oysters and eelgrass coexist at a regional scale, eelgrass is typically absent directly seaward of oyster beds. Concluding that, the below-oyster zone is unsuitable for eelgrass growth; if a causal link exists between oyster presence in the high intertidal zone and eelgrass absence directly seaward, then expansion of feral and farmed oyster beds may result in further eelgrass loss on Cortes Island (Kelly & Volpe, 2007). It is reasonable to expect that if C.gigas spreads to areas where eelgrass beds exist in the UK, eelgrass loss may occur. Recent studies in the USA (Wall et al 2008) suggest that the presence of filter feeding bivalves may increase eelgrass productivity. However, the study was undertaken using native species to the area in specific environmental conditions and whether similar benefits would occur in UK waters with the introduction of C. gigas is not clear. Cognie et al (2007) suggest that wild C.gigas may be trophic competitors and compete for space with the reef-forming polychaete Sabellaria alveolata (protected under the habitats directive)
2.13	How important is social and other harm caused by the organism within its existing geographic range?	minor - 1	MEDIUM -1	This has been very much dependant on the impacts on coastal communities. In some areas of the Wadden Sea the coastline has become less desirable to walk on because of the sharp shells (NIMPIS, 2002), As noted above the oysters have potentially affected eelgrass beds which will have potential impacts ecologically that may further impact economically important fish stocks.
2.14	How important is the social harm likely to be in the Risk Assessment area?	minimal - 0	HIGH -2	This is very much dependant on the impacts on communities that rely on commercial species such as mussels, and any resultant drop in the value of commercial stocks as a due to *C.gigas*. Loss of seaside amenity due to hazardous/ nuisance feral oysters is another potential impact (Miossec et al 2009 and Syvret et al 2008). There have been few studies which the authors are aware of to quantify this issue.

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	HIGH -2	There has been no evidence, to date, of *Crassostrea gigas* modifying their genetic nature. This is an area that minimal literature exists.
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	Natural enemies such as the common shore crab, and barnacles will effect settlement and the spread of C.gigas. These predators and other natural predators such as avian species have had little effect on the rate of spread in other areas.
2.17	How easily can the organism be controlled?	very difficult - 4	MEDIUM -1	Eradication is unlikely to be an option in many areas. From the social and economic perspective, Pacific oysters are the most important commercial oyster species in the UK and Europe. There is no compensation measure in place to reimburse the financial investment made by commercial producers into Pacific oyster cultivation (at the national and European level). Unilateral action by the UK is unlikely to be an option, due to the potential for spat settlement from Europe (Child et al 1995). Secondly, Pacific oysters occur in many other European countries (see reports of the ICES Introduction and Transfer of Marine Organisms Working Group) from where natural spread is likely to occur in the future, whether by natural spread linked to climate change or accidental introduction through human activities, e.g. leisure boats, marinas (Anon referee pers. com.). Miossec & Goulletquer (2007) report that In an enclosed lagoon In France removal of feral C. gigas, associated pests (oyster drills and the slipper limpet C. fornicata) and suitable settlement structures (in particular abandoned shellfish gear) was undertaken using adapted caterpillar tractors and a barge. In 2004 a total of 600 Hectares was cleared at a cost of 610,000 Euros. An asessment of potential environmental impacts resulting would be required before any such clearance opperations could be reccomended in other areas.
2.18	How likely are control measures to disrupt existing biological or integrated systems for control of other organisms?	very likely - 4	LOW - 0	
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	MEDIUM -1	Globally and elsewhere in Europe, other invasive species have settled as a result of introducing the organism, such as:Mytilicola orientalis, Undaria pinnatifida, Crepidula fornicata. P.35 Nehl and Buttger (2007) gives a comprehensive list of associated introductions. In the UK we have no evidence that C.gigas has introduced pathogens or parasites to native aquatic animal species. However, C.gigas are a suseptable species for two of the three exotic molluscan pathogens listed in 2006/88 (Perkinsus marinus and Microcytos mackini, both currently found in the USA). It is not recognised as a susceptible species of the two endemic molluscan diseases, Bonamia ostreae and Marteilla refringens. there have been large scale movements of C.gigas and no field evidence thath they have spread these diseases within the EU (e.g. by actiing as mechanical vectors). The movement of Pacific oysters to France (from the US) appears to have resulted in the introduction of Haplosporidium nelsoni (not listed by OIE or EU) but seemingly with no identified consequences to date. We do not have evidence that H. nelsoni is present in the UK, but its introduction might be possible if oysters are transfered from France to the British Isles for aquaculture.
2.20	Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur			Areas in the vicinity of c.gigas growing sites or feral populations or down-stream of these sites are likely to experience spatfall if conditions are favourable. This is most likely at sites in the South and South East of England, moderately lilkely and less regularly in Northern Ireland, Wales and the south west of England and less likely in Scotland and North West England due to water temperatures (Syvret et al 2008). Within these areas, sites used for recreation/ tourism and sites containing species of commercial interest, likely to be adversely impacted by the presence of C.gigas are likely to be most impacted. Genetic evidence shows that spatfall in the River Teign originated from French stock (Child et al 1995), although it is unclear whether this was from adult specimens discarded at English sites or from larvae that crossed from the French side of the channel. Should the latter be the case, it would appear that, under favourable conditions for larval development, Crassostrea gigas has the capacity to spread substantial distances.

Summarise Entry	very likely - 4	LOW - 0	Entry and spread into new areas very likely due to connectivity of suitable habitat and suitable environmental conditions and wide dispersal potential of larvae. Most likely to spread from feral populations given high dispersal potential. Spat settlement from new and existing oyster farms is possible given the right environmental conditions. Spread from food or processing activities is unlikely.
Summarise Establishment	very likely - 4	LOW - 0	Establishment is likely due to abundance of suitable habitat, favourable environmental conditions. Known to out compete native species sharing similar habitat requirements. Establishment is unlikely to be prevented by predation.
Summarise Spread	intermediate - 2	MEDIUM -1	Once established, spread is likely given the appropriate environmental conditions (primarily temperature). Further anthropogenic spread is also possible. Further spread may endanger a variety of areas around the coast, including estuaries, mudflats, eelgrass beds and rocky shores within the vicinity of existing feral and farmed populations.
Summarise Impacts	moderate - 2	HIGH -2	Primary economic loss may be though loss of mussel bed fisheries and loss of habitat for other intertidal bivalve species. Economic and social impacts may also be associated with loss of visitors to sites as oysters create a hazardous substrate. Environmental impacts are largely associated with loss of intertidal habitats, including mudflats and bivalve beds. Such impacts may affect habitats of high conservation value, including mudflats, estuaries, eelgrass beds and biogenic reefs. Spread by humans may also facilitate the spread of further non-native and 'pest' species.
For pathway/policy risk assessment Assess the potential for establishment and economic/environmental/social impacts of another organism or stop			
Conclusion of the risk assessment	MEDIUM -1	MEDIUM -1	Entry and spread into endangered areas is very likely due to connectivity of suitable habitat, suitable environmental conditions and wide dispersal potential of larvae. C.gigas is most likely to spread from feral population. However spat settlement from new and existing oyster farms is possible given the right environmental conditions and suitable settlement substrate. Spread from food or processing activities is unlikely. Given the quantity of suitable habitat in the UK and increasing suitability of conditions for reproduction (as seas become warmer with climate change), establishment is very likely in the endangered area. Predation and competition are also unlikley to prevent the establishment of C.gigas in these areas. The extremely high dispersal distance and fecundity of C.gigas, coupled with tolerance of wide salinity and temperature ranges and wide range of suitable habitat type means that once established in endangered areas, spread is highly likely. This spread may however be limited by temperature. The most important economic loss is likely to be through loss of mussel bed fisheries and loss of habitat for economically important intertidal bivalve species such as cockles. Economic and social impacts may also be associated with loss of visitors to sites as oysters create a hazardous substrate. Environmental impacts are largely associated with loss of intertidal habitats, including mudflats and bivalve beds. Such impacts may affect habitats of high conservation value, including mudflats, estuaries, eelgrass beds and biogenic reefs. The loss of bird feeding grounds may also result in impacts on native bird populations. Spread by humans may also facilitate the spread of further non-native and 'pest' species.
Conclusions on Uncertainty		MEDIUM -1	Overall, the information available with, which to complete this risk assessment for C.gigas is considered to be fairly good. Some areas require further study, particularly the source of new oyster spat in the South of England and whether or not spat is released by UK farmed stock needs to be identified. A good amount of information about the life history of C.gigas is available, reflecting the comercial importance of the species. Trophic interactions, competition for space and rate of spread is quite well studied in Europe (e.g. French lagoonal and Wadden Sea studies), but less studied in the UK. Due to climatic differences and other variables, further study should be undertaken to establish whether potential impacts are similar in UK waters. Studies into the potential impacts of oysters on features of particular conservation importance (e.g. Eel grass beds and biogenic reefs such as *Sabellaria alveolata*) are also limited, particularly in the UK.

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