Risk Assessment of *Crepidula fornicata*

Name of Organism:	*Crepidula fornicata* Linnaeus, 1758 – Slipper Limpet
Objective:	Assess the risks associated with this species in Ireland
Version:	Final 23/09/2014
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Expert reviewer	Dan Minchin

Stage 1 - Organism Information

Stage 2 - Detailed Assessment
Section A - Entry
Section B - Establishment
Section C - Spread
Section D - Impact
Section E - Conclusion
Section F - Additional Questions

About the risk assessment

This risk assessment is based on the **N**on-native species **AP**plication based **R**isk **A**nalysis (NAPRA) tool (version 2.66). NAPRA is a computer based tool for undertaking risk assessment of any non-native species. It was developed by the European and Mediterranean Plant Protection Organisation (EPPO) and adapted for Ireland and Northern Ireland by Invasive Species Ireland. It is based on the Computer Aided Pest Risk Analysis (CAPRA) software package which is a similar tool used by EPPO for risk assessment.

Notes: Confidence is rated as low, medium, high or very high.
Likelihood is rated as very unlikely, unlikely, moderately likely, likely or very likely.
The percentage categories are 0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%.
N/A = not applicable.

This is a joint project by Inland Fisheries Ireland and the National Biodiversity Data Centre to inform risk assessments of non-native species for the European Communities (Birds and Natural Habitats) Regulations 2011. It is supported by the National Parks and Wildlife Service.

DOCUMENT CONTROL SHEET

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Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
1	What is the reason for performing the risk assessment?		A risk assessment is required as this species is listed as a "Non-native species subject to restrictions under Regulations 49 and 50" in the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011, SI 477/2011.
2	Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES	*Crepidula fornicata* Linnaeus, 1758 – Slipper limpet Taxonomy: Phylum: Mollusca Class: Gastropoda Order: Mesogastropoda Family: Calyptraeidae Genus: Crepidula Species: fornicata Synonyms: *Patella fornicata* Linnaeus, 1758; *Crepidula densata* Conrad, 1871; *Crepidula virginica* Conrad, 1871; *Crepidula maculata* Rigacci, 1866; *Crepidula mexicana Rigacci*, 1866; *Crepidula violacea* Rigacci, 1866; *Crepidula roseae* Petuch, 1991; *Crypta nautarum* Mörch, 1877; and *Crepidula nautiloides* auct. NON Lesson, 1834 (CABI, 2014; GISD, 2005; Jensen, 2010; Minchin, 2009) Common names (English): Slipper limpet; American slipper limpet; Common slipper snail; American limpet; Common Atlantic slippersnail; Oyster-pest; Boat-shells; Bungalows; and Thumbnails (CABI, 2014; GISD, 2005; Jensen, 2010; Minchin, 2009) The genus *Crepidula* contains approximately thirty species distributed across the continents and classification problems occur when different *Crepidula* species are present in the same location (CABI, 2014; GISD, 2005).
3	If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	N/A	
4	Describe the organism.	-	*Crepidula fornicata* is a marine gastropod (snail). The cap shaped shell is oval (distinctively longer than wide), up to 5 cm in length, with a much reduced spire (Jensen, 2010). The large aperture (shell opening) has a characteristic and distinct calcareous septum (shelf), extending from beneath the spire to half its length; behind which the visceral mass is protected (Jensen, 2010; Minchin, 2009; Tyler-Walters, 2011). The shell is

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
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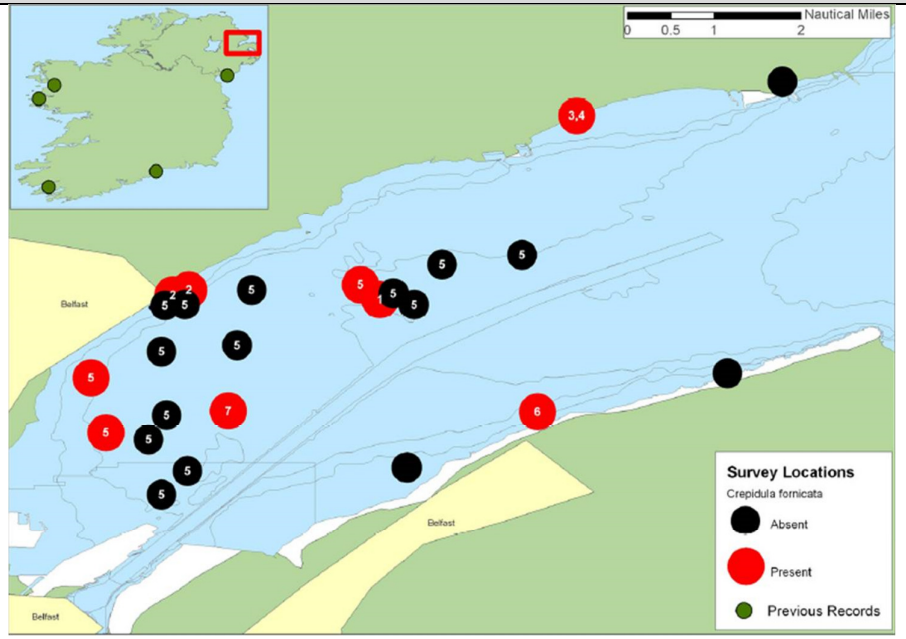
			smooth with irregular growth lines and white, cream, yellow or pinkish in colour with streaks or blotches of red or brown (GISD, 2005; Tyler-Walters, 2011). This variation in coloration is reflected in the number of synonyms referring to appearance (maculata, violacea, roseae) (Jensen, 2010). Using a muscular foot it attaches firmly to hard substrata (Minchin, 2009). Individuals can attach to each other, commonly forming curved chains (colonies) of up to 12 individuals, with the shells becoming progressively smaller towards the top (CABI, 2014; GISD, 2005; Tyler-Walters, 2011).
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment for Ireland)	YES	In Ireland, a preliminary risk assessment was previously carried out. This was a prioritisation risk assessment as part of the Risk Analysis and Prioritisation for Invasive and Non-native Species in Ireland and Northern Ireland (ISI, 2012). It designated *Crepidula fornicata* as a "high risk" invasive species.
6	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	PARTIAL	Only a preliminary risk assessment was previously conducted in Ireland (refer to Question 5).
7	Where is the organism native?		Is native of eastern North America, from the Gulf of St Lawrence to Texas (Abbott, 1954; Blanchard, 1997; Jensen, 2010).
8	What is the current global distribution of the organism (excluding Ireland)?	-	Including its native range (refer to question 6) the species has a current global distribution spanning Europe (Belgium (Adam and Leloup, 1934), Denmark (Hessalnd, 1951), France (Cole, 1952), Germany (Hessland, 1951), Italy (Di Natale, 1982), Malta (Cachia, 1981), The Netherlands (Korringa, 1949), Norway (Blanchard, 1997),-Spain (Rolán et al 1985; but not introduced from Ireland as suggested), Sweden (Hessland, 1951), and United Kingdom (Cole, 1952), Japan (along the coasts of Honshu and Shikoku Islands (Habe and Maze, 1970)), the North American Pacific coast (along the Washington state coast line (Hoagland, 1977)) and South America (Uruguay – although this has been suggested by Simone et al., 2000 to be C. argentina or C atrasolea)
9	What is the current distribution of the organism in Ireland?	-	While there have been historic records of *C. fornicata* in Ireland, the only known viable population was confirmed in 2009 within Belfast Lough on the east coast (Figure 1; McNeill *et al*., 2010). Although only a small number of individuals were recorded in Belfast Lough, their wide distribution from the lower shore to depths of 6 m and the presence of a brood and occurrence of 'chains' of individuals indicate the species is established (McNeill *et al*., 2010).

Stage 1 - Organism Information

The aim of this section is to gather basic information about the organism.

N	QUESTION	RESPONSE	COMMENT
			 **Figure 1.** Sites visited during McNeill, Nunn and Minchin's 2009 study of Belfast Lough, showing the records of *Crepidula fornicata*. Sites: (1) Folly Roads, (2) Jordanstown shore, (3) Fisherman's Quay shore, (4) Fisherman's Quay shore, (5) mussel beds (2-7 m), (6) Craigavad shore and (7) Navital. Inset map highlighting the locations of previous (historic) records of the species (Modified from McNeill *et al*, 2009).
10	Is the organism known to be invasive anywhere in the world?	YES	*Crepidula fornicata* was accidentally introduced to Europe at the end of the 19th century, where it found favourable conditions to establish and spread; and is today considered one of Europe's most harmful invasive species (Minchin, 2009). Characteristics of *C. fornicata* biology (high reproduction and feeding) and ecology (ubiquitous habitat, environmental tolerances and lack of known specialist predators) predispose it to acting as an invasive.

Stage 2 - Detailed assessment: Section A - Entry

This section evaluates the probability of entry of an organism into Ireland. For organisms which are already present, only complete the entry section for currently active pathways of entry and potential future pathways. The entry section need not be completed for pathways which have allowed an organism to enter in the past but are no longer active.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.01	How many active/future pathways are relevant to the potential entry of this organism (n/a, very few, few, moderate number, many or very many)?	MANY (polyvectic)	HIGH (Level of certainty ranges from direct evidence to possible, depending on site of introduction)	There are many active/future pathways relevant to the entry of *C. fornicata*. Pathways include: • Contaminate aquaculture/mariculture - introduced in association with imported commercial bivalues. *Crepidula fornicata* original introduction to Europe was with American oysters, *Crassostrea virginica*, for culture in the United Kingdom (Jensen, 2010). Since then small males have been found in consignments of half-grown Pacific oysters imported to Ireland and cultured in bags on trestles(McNeill *et al*., 2010). • Vessel hull fouling - transported attached to ships hulls, temporay harbour installations rafts and fishing gears (pots and buoys) (JNCC, 2014). • Discharges at sea - Dredgers and fishing craft may return spoil/discards to extend the range of a population. • Vessel ballast water - pelagic larvae may be transported in ballast waters released into harbours or bays (Blanchard, 1997; Tyler-Walters, 2011). • Natural dispersal - pelagic larvae can move by themselves but are primarily carried in water currents, and can travel several kilometres a day. Direction of currents could be responsible for dispersal along northern European shores (Tyler-Walters, 2011). • Contaminate floating material – adults can attach to and travel with floating objects, litter and debris (Sewell *et al*., 2008), e.g. Mulberry Harbours - large floating pontoons used during the Normandy landing during World War II. •
1.02	List <u>significant</u> pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	1. contaminate aquaculture/mariculture - transfers with oysters and mussels 2. Vessel hull fouling -transmitted on the hulls of vessels 3. Discharges at sea		Likely pathways of *C. fornicata* entry to Ireland are transfers with oysters and mussels (contaminate aquaculture/mariculture), transported on the hulls of vessels (vessel hull fouling), with drifting materials (contaminate floating material), or discharges at sea (McNeill *et al*. 2010; Minchin, 2009)

Pathway 1 – Contaminate aquaculture/mariculture				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	ACCIDENTAL	VERY HIGH	Contaminate aquaculture/mariculture is an accidental entry pathway. *Crepidula fornicata* is known to grow attached to a number of commercially important bivalve species transported for culture including oysters, mussels and scallops (Sewell *et al*., 2008). It is the primary spread of *C. fornicata* in Europe (Blanchard, 1997).
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	LIKELY	MEDIUM	Given that *C. fornicata* is a gregarious species, with individuals forming chained colonies large numbers are likely to travel along this pathway from the point of origin. However consignments of oysters have also been found with low numbers of small individuals (males).
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	HIGH	*Crepidula fornicata* larvae are 0.4 mm long when released from brood and only 1 mm when they metamorphose (Pechenik *et al*., 2002). The inconspicuous larval stage in brood pouches, if present, could be easily be overlooked in transfers of oysters and mussels.
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	HIGH	Known to survive during past transport with mussel and half-grown and adult oysters and their spat in consignments (Blanchard, 1997; Jenson, 2010).
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	HIGH	Normally in the spring to early summer with oyster movements and when consignments of mussels are moved.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	VERY LIKELY	VERY HIGH	The species can occupy a range of habitats and attach to a range of host material (refer to Question 2.03). Developing oyster spat and mussel seed is of itself suitable hosts for *C. fornicata* and which are laid on suitable habitat in shellfish areas (CABI, 2014).
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	LIKELY	HIGH	It is already in Ireland and is very likely to spread in the future. *C. fornicata* when small are easy to overlook in imported bivalves for commercial culture, due to their size and cryptic colouration (Sewell et al 2011). This will make future detection unlikely and entry likely.
1.10	Do other pathways need to be considered?	YES	HIGH	See Q 1.01 and 1.02

Pathway 2 – Vessel hull fouling				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	ACCIDENTAL	VERY HIGH	Vessel hull fouling is an accidental entry pathway. *Crepidula fornicata* is known to transported attached to ships hulls, temporary harbour installations rafts and fishing gears (pots and buoys) (JNCC, 2014)
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	MODERATELY LIKELY	LOW	The numbers of *C. fornicata* potentially travelling along this pathway from the point of origin would be expected to be less than the entry via contaminated aquaculture/mariculture stocks. However, where *C. fornicata* settle, in this instance on the hull of vessels, they may occur in high concentrations due to gregarious nature. It is likely for the threat of entry via this pathway to be dependent on the demand for shipped imports from infested locations or movements associated with slow vessels or structures.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	HIGH	The adult stage is conspicuous (Clark, 2008) and as such less like to remain undetected compared to its larval stage. There is no inspection service dealing with hull fouling and it is very likely that the organism could arrive undetected.
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	MEDIUM	Known to have survived during transport as the hull foul of vessels (Blanchard, 1997; Jenson, 2010).
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	MODERATELY LIKELY	LOW	Transport of vessels and aquaculture products take place all year around. Should the species be introduced outside of the breeding season it may survive to breed at a future time.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	MODERATELY LIKELY	LOW	Individuals or chains of *C. fornicata* may disperse from vessels during periods of high wave energy (CABI, 2014). Hull foul constitutes settled individuals or chained colonies of *C. fornicata* and it is perhaps most likely for their offspring to be successful in transferring to a suitable habitat and host. In dry-dock hull cleaning all waste should be disposed of appropriately and not 'brushed' back into the water.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	MODERATELY LIKELY	HIGH	The threat of entry via hull foul of vessels is likely to be dependent on the demand for shipped imports from infested locations. Especially from slow moving vessels such as dumb barges.
1.10	Do other pathways need to be considered?	YES	MEDIUM	

Pathway 3 –Discharges at sea				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	MODERATELY LIKELY	LOW	Dredgers and fishing craft may return spoil/discards to extend the range of a population.
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	LIKELY	LOW	Depends on the contracts that involve vessels for exploitation of sands and gravels or for clearing channels to ports. Long-distance fishing vessels may discharge by-catch and waste some distance from fishing grounds.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	LOW	The high level of trade in different products makes this a high risk area. Dredgers are from time to time contracted to undertake port dredging and spillage from a previous infested region is a risk. Fishing vessels may discharge mussel consignments for restocking or waste close to a port region having come from an infested site. Consignments refused at entry may be dumped locally.
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	MEDIUM	Much depends on sea and meteorological conditions during transport. In dry hot conditions many may expire whereas under damp conditions from sea-spray survival is likely.
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	HIGH	An arrival may take place during any month.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	VERY LIKELY	MEDIUM	This may have been the situation for the inoculation of *Crepidula* in Belfast Lough. A consignment of mussel seed from the south of Wales is known to have been refused in Belfast Port by a fishery officer in the early 2000s on account of the presence of slipper limpets he recognised. Where this consignment ended-up is unknown.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	MODERATELY LIKELY	MEDIUM	The species is already established in Ireland. A further arrival may well take place as the range of *Crepidula* continues to expand within northern Europe (see 1.08). Incremental spread with discharge of returned dredge and trawl debris may also take place. Dredged aggregates might also be involved in a transmission. Dredgers are known to have arrived from regions contaminated with *Crepidula*.

Pathway 3 –Discharges at sea				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.10	Do other pathways need to be considered?	LIKELY	MEDIUM	Other transmissions are possible. Here in are details of the three most significant pathways. All potential pathways are listed in Question 1.01.

Overall likelihood				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.11	Estimate the overall likelihood of entry into Ireland based on all pathways (comment on the key issues that lead to this conclusion).	VERY LIKELY	HIGH	There are many pathways via which *C. fornicata* has the potential to enter. Of these pathways, contaminated molluscan shellfish and vessel hull fouling are likely to be the most threatening, with the former known to be the primary cause of entry in Europe (Blanchard, 1997). The species wide tolerance of environmental conditions is likely to aid its survival during transport (refer to Question 2.03). The threat of entry via hull fouling of vessels is likely to be dependent on slow moving vessels from infested locations.

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.01	Is the organism well established in Ireland (if there is any uncertainty answer 'unsure')	NO	MEDIUM	The species is established (McNeill *et al.*, 2010). Its range is localised, currently known as being limited to Belfast Lough. The species could not be described as well established i.e. widespread.
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local climatic conditions and the organism's current global distribution?	VERY LIKELY	HIGH	Conditions in Ireland are suitable for the establishment of the limpet on all coasts since Irish conditions lie within its tolerance range. The species prefers a temperate/mesothermal climate (i.e. average temperature of coldest month ranging from >0°C to < 18°C and a mean warmest month > 10°C) (CABI, 2014), but can survive light frosts and temperatures up to ~30°C (Minchin, 2009). As Ireland has a temperate oceanic climate (Keane and Collins, 2004), it is likely for the species to establish in areas other than Belfast Lough. Establishment of the species may be limited by high mortalities associated with cold winter temperatures (Minchin *et al.*, 1995; Thieltges *et al.*, 2003, 2004); particularly for shallow water areas where even native species may expire. It is thought that the population in Clew Bay died out due to the 1962/63 winter. Deeper water areas should not pose a problem under the current climate.
2.03	How likely is it that the organism will be able to establish in Ireland based on the similarity between other local abiotic conditions and the organism's current global distribution?	VERY LIKELY	HIGH	*Crepidula fornicata*, being ubiquist, eurythermal and euryhaline, can occupy a range of habitats, including harbours, marinas, inlets, bays, channels, estuaries and open coast (GISD, 2005; Tyler-Walters, 2011).The species' varied habitat reflects its ability to tolerant a range of abiotic conditions (tolerant of, water depths from low water mark to 60 m; 5-10mg/l dissolved oxygen; 20-40 psu salinity; 0-10g/l turbidity; -2°C to 30°C temperature; and moderately strong tidal strength (1-3kn)) (CABI, 2014; Hinz *et al* 2011) It appears most abundant in low energy shallow sheltered estuaries, bays and channels from low water mark to ~30m depth (Blanchard, 1997; Minchin, 2009). Equally varied are the species settlement surfaces and seabed types, which can include rocks, cobbles, stones, shells, coarse sand, gravel, mud, other species and man-made surfaces .It appears most abundant on muddy and sandy sediment, with hard surfaces such as shells, stones and rocks (Clark, 2008; Minchin, 2009; Tyler-Walters, 2011). There are many examples of these habitat types in Ireland

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?	VERY LIKELY	HIGH	The Irish coastline extends over 5631 km (OSI, 2014), along which *C. fornicata* is likely to encounter an abundance of suitable habitat (refer to Question 2.03) necessary for survival, development and multiplication, especially within bays, inlets and estuaries. *C. fornicata* is an active suspension feeder, able to feed on a variety of food types (Clark, 2008;) likely to be widespread Ireland. Aquaculture practices occur in areas where suitable habitats often occur.
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	VERY LIKELY	MEDIUM	Establishment is likely given that the species is spatially competitive; inhabiting areas already occupied by other species, by overgrowing settled species, such as mussels, oysters and scallops (Blanchard, 1997; Frésard & Boncoeur, 2006; Thieltges *et al*., 2003). Le Pape *et al*. (2004) showed spatial competition between the flat fish sole (*Solea solea*) and *C. fornicata*, where completion favoured the latter. Grall and Hall-Spencer (2003) state that *C. fornicata* is one of many reasons for the decline in local maerl bed habitats in Britain. In areas of high *C. fornicata* abundance trophic completion for food with other molluscs is proposed (Blanchard, 1997) but recent studies do not support the species as a trophic competitor (de Montaudouin *et al*., 1999; Thouzeau *et al*., 2000). Thieltges (2005b) did, however, find increased mortality of blue mussels in mussel-beds invaded by the species, and also reduced growth in surviving mussels. As there is no indisputable evidence that *C. fornicata* competes trophically with other species, more research is need in this area.
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?	VERY LIKELY	MEDIUM	It is likely that *C. fornicata* will establish despite predation, although there have been no directed studies on this topic. There are no reported species specific natural enemy of *C. fornicata* in Europe (Blanchard, 1997) and establishment success may possibly be due to a lack of predation (JNCC, 2014). Potential generalist predators may include crabs (i.e. the common shore crab (*Carcinus maenus*), starfish (*Asterias rubens*) which prefer mussels (Tyler-Walters, 2011) and fishes such as rays, birds and predatory snails (CABI, 2014; Minchin, 2009).
2.07	How likely is it that establishment will occur despite existing management practices?	LIKELY	HIGH	In the first instance control is by prevention of entry; regular monitoring of transfers of oysters and mussels, used for stocking from uninfested areas and ensuring that any such use of stocking transfers do not come from infested regions (Minchin, 2009). Such consignments should be

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				inspected before their release. Mechanical control via the cultivation practices of oysters in bags laid on trestles may reduce establishment, with smaller *C. fornicata* becoming crushed. In spite of this, establishment is likely as no real control can be set on a species with (1) an inconspicuous larval stage which can be spread with water currents, once established in Ireland (2) a gregarious adult stage, with individuals forming 'chains' (refer to Question 2.10).
2.08	How likely is it that management practices in Ireland will facilitate the establishment of the organism?	LIKELY	LOW	Man-made sea defences provide a potential habitat for limpets especially where there are coastal defences (i.e. groynes, harbour breakwaters) which provide additional substrata for settlement.
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?	VERY LIKELY	LOW	There are no eradication campaigns in Ireland. The pelagic, planktonic during which individuals can travel and estimated 30 kilometers is beyond the ability to control the species. Survival is likely as no real control can be set on a species which is capable of larval transport (although it is thought to have been eradicated from the Menai Straight region soon after it was found).
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	VERY LIKELY	MEDIUM	*Crepidula fornicata* is a long lived, protandrous hermaphrodite; (Jensen, 2010).Individuals form chains, where the largest and bottom individual is female. Those attached individuals are initially males but become females with age (CABI, 2014). The protandric status of the species and the fact that individuals are fixed in the same colony, ensures efficient reproduction (Dupont *et al*., 2006). Females brood their eggs and reproduce from 1 year. Females may spawn twice a year after neap tides, producing ~11000 eggs at a time (Minchin, 2009; Tyler-Walters, 201). Larval survival rate is high (Blanchard, 1997) Such characteristics probably explain the species establishment success (Blanchard, 1997).
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	LIKELY	MEDIUM	Once introduced the free-swimming larval stage can become dispersed locally (Minchin, 2009). Juveniles are capable of pedal movement. The adult life stage of *C. fornicata* is settled and hence much less mobile but can be dispersed during periods of high wave energy or attached to mobile species and floating debris (CABI, 2014; Minchin, 2009, Tyler-Walters, 2011). *Crepidula* have been found attached to the holdfasts of detached kelps which can be dispersed by currents.

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	LIKELY	MEDIUM	*Crepidula fornicata* can occupy a wide range of habitats under varied environmental conditions and settle on an equally wide range of substrata (refer to Question 2.03).
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	LIKELY	HIGH	The current population of *C. fornicata* in Belfast Lough is likely to be an introduction from Britain's genetically diverse population (Viard *et al.,* 2006). Dupont *et al.* (2003) concluded from molecular genetic data that the French populations of *C. fornicata* established after 1940, and derive from several genetically diverse source populations, either from Europe or North America.
2.14	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Ireland? If possible, specify the instances of invasion elsewhere in the justification box	VERY LIKELY	MEDIUM	*Crepidula fornicata* has been repeatedly introduced worldwide primarily in association with bivalve culture and shipping (Blanchard, 1997; Sewell *et al.*, 2008). It invaded the eastern coast of England in the 1880's; Belgium, Germany and the Netherlands in the 1910's; Northwestern USA in the 1930's; South England and France in the 1940's; Denmark, Sweden and Norway in the 1950's; Japan in the 1970's and Spain and Mediterranean spots in the 1970's (Blanchard, 1997). The first known occurrence of *C. fornicata* in Europe was in 1872 in Liverpool Bay (MacMillan, 1938), but this population became extinct (JNCC, 2014; Minchin *et al.*, 1995) and it is thought to have become established in the United Kingdom between 1887 and 1890. It remained within localities on the south eastern coast of Britain until about 1940 (Minchin *et al.*, 1995). Presently, it is well established on the southern coasts of both England and Wales spreading northwards on the east coast of England up to Spurn Head and on the west coast up to Cardigan Bay in Wales (Blanchard, 1997; Tyler-Walters, 2011). *C. fornicata* was transferred to Ireland with live American oysters in 1902 to the west coast of Ireland but these were removed before being laid (McNeill *et al.*, 2010). Since this time the species has been repeatedly introduced with oysters (Minchin *et al.*, 1995), but not until 2009 was the species shown to have found a favourable environment in Belfast Lough (McNeill *et al.*, 2010). Establishment of new populations along the Irish coast are expected (McNeill *et al.*, 2010).

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	MODERATELY LIKELY	MEDIUM	Historic recordings of *C. fornicata* in Ireland are based on McNeil *et al*. (2010) and Minchin *et al*. (1995). Individual specimens that were removed from consignments were associated with oysters held in bags on trestles and over the first few months became crushed. Shells of *Crepidula* that were autoclaved were introduced to increase settlement surfaces for oysters in Tralee Bay. There were accounts from Kenmare and Clew bays of specimens but none were subsequently found in searches (Minchin et al., 1995). So the populations in Kenmare and Clew bays might have been transient populations or may have been purged by the frosts in 1963.
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	VERY LIKELY	HIGH	Progressive establishment of new populations along the Irish coast are very likely (McNeill *et al*., 2010), management and regulatory actions may greatly reduce the rate at which this may take place. It is unclear whether single weather events, such as, a cold winter event may limit or otherwise cutail its expansion(Minchin *et al*., 1995; Thieltges *et al*., 2003, 2004). Being ubiquist, eurythermal and euryhaline, the species is likely to establish in a range of habitats (e.g. harbours, marinas, inlets, bays, channels, estuaries and open coast) and on a range of substrata (e.g. rocks, cobbles, stones, shells, coarse sand, gravel, mud, other species and man-made surfaces) (GISD, 2005; Tyler-Walters, 2011). *C. fornicata* is also known to overgrow existing species and as such, competition for settlement space is not likely to prevent its establishment. Any potential predation pressures are not likely to prevent establishment. Studies on the shells of retrieved limpets from Belfast Lough indicate that some were seven years of age. As a result it is possible that the founder population might have arrived in or after 2001, (Guy et al., 2013) or perhaps before this date should the seven year old specimen represent a filial generation of the founder population. The species establishment elsewhere would seem to have had a lag phase where population numbers were initially low for some years before its expansion. This pattern may also occur in Belfast Lough.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.01	What area (given in % or 10km squares) in Ireland could the organism establish (0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%)?	0% - 10%	HIGH	The species is likely to establish in a range of inshore, offshore and open coastline habitats, such as harbours, marinas, inlets, bays, channels, estuaries and open coast. With reference to the CORINE (2006) land cover classification (categories and their percentage cover) slipper limpet have the potential to establish in about 1.24% of the Irish landscape - sea ports 0.01%, intertidal flats 0.75%, coastal lagoons 0.01% and estuaries 0.47%. Most likely this is not a very representive figure for the area in Ireland where the species could establish but presently there is a paucity of detailed land cover data.
3.02	How important is the expected spread of this organism in Ireland by natural means (minimal, minor, moderate, major or massive)?	MAJOR	LOW [MEDIUM]	A female *C. fornicata*, anchored to substrate at the bottom of a chain of males, exhibits egg brooding and is able to reproduce from 1 year (Clark, 2008). The female may spawn twice a year after neap tides, laying ~11000 eggs at a time (Minchin, 2009; Tyler-Walters, 2011). Only viable larvae are released and survival rate is high (Blanchard, 1997).The larval duration is in the order of two to three weeks and dispersal capability of ~30km depending on coastal currents (In: Shanks, 2009). Once established, the incremental spread of the species via natural dispersal is inevitable within a bay system.
3.03	How important is the expected spread of this organism in Ireland by human assistance (minimal, minor, moderate, major or massive)?	MODERATE	LOW	Once introduced the spread of *C. fornicata* is likely to be aided by aquaculture and fishery practices. The practice of disposing by- catch non valuable species, including *C. fornicata*, is known to extend the range of a number of non-indigenous species (CABI, 2014). Trawling and dredging practices may also spread such species (CABI, 2014). It is almost certain that trade in oysters will lead to the spread of limpets as oysters get relaid in different bays and consignments are often 'freshened-up' by being laid on shores over short periods of time. When dredging scallops in the Bay of Saint-Brieuc (France) a single boat could disperse, in hundred meters, about one ton of *C. fornicata* (GISD, 2005).
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MAJOR	HIGH	It would not be possible to control the pelagic planktonic larval stage of *C. fornicata*. To date, attempts to eliminate populations once they have become established have been largely unsuccessful (Clark, 2008).

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	0-10%	MEDIUM	The only presently known established population of *C. fornicata* is at Belfast Lough on the north-east coast (Figure 1; McNeill *et al*., 2010). Less than 1% of the area in Ireland suitable for establishment has been colonised by the species.
3.06	What proportion of the area in Ireland suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	0-10%	LOW	In the United Kingdom *C. fornicata* is presently, well established on the southern coasts of England and Wales and spreading northward on the east coast (up to Spurn Head, England) and west coast (up to Cardigan Bay, Wales) It first became established on the south eastern coast between 1887 and 1890 where it remained locally for ~ 50 years until about 1940 (Minchin *et al*., 1995). With reference to the time-scale of spread of *C. fornicata* in the United Kingdom it may be possible to predict that the Irish population in Belfast Lough will have spread elsewhere along the east coast but is likely to remain local to this region five years from now. The main risk is to Carlingford Lough. An increase in the the population to the expansive phase is expected in Belfast Lough during the next 5 years and this should result in a gradual expansion within this Lough. Ultimately the species is expected to become a general pest during this century.
3.07	What other timeframe would be appropriate to estimate any significant further spread of the organism (10, 20, 40, 80 or 160 years)? Please comment on why this timeframe is chosen.	160	LOW	With further reference to the time-scale of spread of *C. fornicata* in the United Kingdom (refer to Question 3.06) it is likely that the species will become more widely spread in several localities by the end of the century and might have become established on all Irish coasts.
3.08	In this timeframe, what proportion of the area (including any currently occupied areas) is likely to have been invaded by this organism?	0-10%	LOW	0-10% is chosen as the current established population is limted to one area in Belfast Lough. The overall sea area under the jurisdiction of Ireland includes sea areas down to the bathyl zone. To this area must be added the sea area of the UK that can be apportioned to Northern Ireland. As a result the level is most likely to be 0-10%.
3.09	Based on the answers to questions on the potential for establishment and spread in Ireland, define the area endangered by the organism. Be as specific as possible. If available, provide a map showing the area most likely to be endangered.	-	MEDIUM	*Crepidula fornicata* potential establishment and spread is a threat to inshore water - inlets, bays, channels, estuaries, harbours, marinas and islands and open coastline (GISD, 2005; Tyler-Walters, 2011) and some offshore areas within the shallower areas of the continental shelf.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.10	Estimate the overall potential for future spread for this organism in (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues.	MODERATE	MEDIUM	*Crepidula fornicata* have a high reproductive viability and fecundity which strongly aids population establishment. Once established, natural dispersal of the pelagic planktonic larval stage is likely to cause moderately rapid spread. Fishery practices may also have a hand in spread of the species. Suitable habitat inshore, offshore and open coastline is in danger of invasion.

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.01	How great is the economic loss caused by the organism within its global distribution (excluding Ireland), including the cost of any current management?	MODERATE - MAJOR	MEDIUM	Dense *C. fornicata* populations disturb some fisheries and sea-bed oyster culture activities to such an extent that in some bays (e.g. Sheldt estuaries in Zeeland, Thames estuary and Fal River in Great Britain, the Norman Gulf or the Atlantic Marennes pond in France, that the cleaning and removal of *Crepidula* is necessary (Fitzgerald, 2007; Kostecki *et al*, 2011). Should *C. fornicata* populations reach high densities, oyster grounds must be regularly cleaned before sowing new seed. When *C. fornicata* attach to the shells of commercial molluscs these must be removed before sale (Blanchard, 1997). The vacant shells of limpets can form extensive changes to sediment structure altering habitats. Nevertheless where limpets are abundant fishery and culture practices continue. Economic losses depend on the usage within those areas where limpets become abundant. In the Marennes-Oleron region of France extensive dredging will have taken place in order to reduce the competition with oysters (La Moine et al., 2009).
4.02	How great has the economic cost of the organism been in Ireland from the time of introduction to the present? Exclude any costs associated with managing the organism from your answer.	MINOR	LOW	To date surveys have been carried out to evaluate their distribution and abundance and to age the early found specimens collected. Overall costs to 2014 probably <€ 10, 000.
4.03	How great is the economic cost of the organism likely to be in the future in Ireland? Exclude any costs associated with managing the organism from your answer.	MODERATE-MAJOR	LOW	There is a high level of uncertainty but should their abundance result in a high level of sustained biomass the impact on fisheries and aquaculture recruitment and production costs might exceed 1 million Euros annually, according to the extent of the coastal region that has been colonised.
4.04	How great have the economic costs of managing this organism been in Ireland from the time of introduction to the present?	MINOR	LOW	Invasive species Ireland will have undertaken risk assessments of limpets and there will have been inspections of consignments in Northern Ireland and Ireland.
4.05	How great is the economic cost of managing this organism likely to be in the future in Ireland?	MAJOR	LOW	Costs would accrue from monitoring and management practices. The costs could be major if the species became well established and impacting upon mussel and oyster fisheries productivity.
4.06	How important is environmental harm caused by the organism within its global distribution?	MAJOR	HIGH	Dense populations, like those in the bays of Brittany which reach up to 10,000 individuals/m^{-2} (Blanchard, 2009) can have negative environmental impacts. Such dense populations entirely alter the habitat with dead shell remains and from living individuals by locally covering the natural sediments and further modifying the habitat by trapping the

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				suspended fines, faeces and and pseudofaecal wastes resulting in muddy interstitial spaces high in organic content , which readily becomes anoxic and so unsuitable for other species (CABI, 2014). *C. fornicata* can overgrow species and alter the nature of sediment substrata, smothering areas previously dominated by bivalves (Thieltges, 2005).
4.07	How important has the impact of the organism on biodiversity* been in Ireland from the time of introduction to the present? *e.g. decline in native species, changes in community structure, hybridisation	N/A	N/A	The level of impact is unknown but is unlikely to be measureable. The species is established (McNeill *et al*., 2010) but its known range is limited to Belfast Lough. There are no known studies undertaken examining impact to biodiversity in this Lough.
4.08	How important is the impact of the organism on biodiversity likely to be in the future in Ireland?	MAJOR	MEDIUM	Change in species composition has been recorded in some sites, including reduced species diversity and dominance by individual species (Vallet *et al*., 2001). Reduced bivalve abundance has been recorded on the French Coast as a result of *C. fornicata* infestation most severely on coarse sands and gravels (de Montaudouin and Sauriau, 1999). In Mont Saint-Michel Bay, France, a rapid proliferation of *C. fornicata* led to decreased available seabed habitat for flatfishes, restricting flatfish distribution in the bay (Kostecki *et al*, 2011). Adult *C. fornicata* are suspension feeders as are most bivalves such as the blue mussel *M. edulis* potentially resulting in trophic competition, with increased competition likely to impact mussel communities (Thieltges, 2005b). The consumption of larvae by *C. fornicata* may limit the settlement of other species including the native oyster *Ostrea edulis* (Walne, 1956). It is very likely that the additional energetic demand associated with carrying *C. fornicata* individuals and colonies will have adverse effects on hosts, including potential impacts on spawning, feeding and migratory behaviour (GISD, 2005).
4.09	How important has alteration of ecosystem function* caused by the organism been in Ireland from the time of introduction to the present? *e.g. habitat change, nutrient cycling, trophic interactions	N/A	N/A	There have been no studies on the alteration of ecosystem function in Belfast Lough and the population as it currently exists is unlikely to result in any measureable alteration.

Stage 2 - Detailed assessment: Section D - Impact
This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the future?	MAJOR	HIGH	Large accumulations of *C. fornicata* can disturb normal water flow, leading to the accumulation of fine sediments (Jensen, 2010). Areas of hard, or even substrata, may be changed to fine, nutrient rich sediment by *C. fornicata* (Clark, 2008). The accumulation of fine sediments and suspended particles may reduce levels of suspended organic matter in the water column (CABI, 2014). Increased sedimentation caused by *C. fornicata* may threaten maerl beds (Clark, 2008).
4.11	How important has decline in conservation status* caused by the organism been in Ireland from the time of introduction to the present? *e.g. sites of nature conservation value, WFD classification, etc.	N/A	N/A	No knowledge of a decline in conservation status has been caused by *C. fornicata* in Ireland to-date.
4.12	How important is decline in conservation status caused by the organism likely to be in the future in Ireland?	MAJOR	MEDIUM	Potential introduction, establishment and spread would have a major impact of the conservation status of protected areas, for example, Lough Hyne in Co. Cork.
4.13	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within its global distribution?	MODERATE	MEDIUM	There may be possible loss of amenity value caused by *C. fornicata* infestation e.g. bathing areas. Impacts are likely to be high in areas where fisheries are the primary employment driving the local economy.
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	N/A	N/A	No knowledge of social or human health harm caused by *C. fornicata* in Ireland
4.15	How important is it that genetic traits of the organism could be carried to other organisms / species, modifying their genetic nature and making their economic, environmental or social effects more serious?	MINIMAL	HIGH	*Crepidula fornicata* is the only one of its genus in northern Europe, the radiation of the genus is in the western Atlantic. The nearest relative from the same family is *Calyptraea chinensis,* which is also introduced and present as several populations in Ireland; but unlikely to reproduce with *C. fornicata*
4.16	How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	UNLIKELY	LOW	It is possible that the shells of limpets may provide an added advantage for other non-native species at some future time.

Stage 2 - Detailed assessment: Section D - Impact

This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.17	How important might other impacts not already covered by previous questions be resulting from introduction of the organism? Specify in the justification box.	N/A	MEDIUM	We are not aware of any other impacts the introduction of this species would have.
4.18	How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Ireland?	MAJOR	MEDIUM	There is no species specific natural enemy of *C. fornicata* in Europe (Blanchard, 1997)
4.19	Indicate any parts of where economic, environmental and social impacts are particularly likely to occur. Provide as much detail as possible, where possible include a map showing vulnerable areas.	-	MEDIUM	Sedimentation increases caused by slipper limpets may threaten maerl beds (Clark, 2008) Coastal fishing activities may be threatened because heavily-impacted areas become unfit for commercial exploitation and estuarine shellfish operations (mussels, oysters, scallops) may be significantly affected (Fitzgerald, 2007; Sewell et al., 2011). Changes in the substratum may affect fish habitat, displacing commercially important species, as has occurred in Mont Saint-Michel Bay, France (Kostecki *et al*, 2011).
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MAJOR	MEDIUM	The potential economic impact of *C.fornicata* establishment is likely to be major, with loss of revenue from fisheries and aquaculture, loss of fishing grounds and the potential costs of attempting to control populations. Environmental harm within its existing range is major and it is predicted that similar impacts are likely in Ireland.

Stage 2 - Detailed assessment: Section E - Conclusion

This section requires the assessor to provide a score for the overall risk posed by an organism, taking into account previous answers to entry, establishment, spread and impact questions.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
5.01	Estimate the overall risk of this organism in Ireland. Noting answers given in 1.11, 2.16, 3.10 & 4.20	MAJOR	MEDIUM	There are many pathways via which *C. fornicata* has the potential to enter. Of these pathways, contaminated molluscan shellfish and vessel hull fouling are likely to be the most threatening, with the former known to be the primary cause of entry in Europe (Blanchard, 1997). The threat of entry via hull fouling of vessels is likely to be dependent on slow moving vessels from infested locations. Contaminated aquaculture/mariculture consignments and the stocking of molluscs and vessel hull fouling are likely to be the most threatening (Blanchard, 1997). However, dredging and fishing activities might also spread settled stages and larvae might be carried in ships' ballast water. Limpets can tolerate a wide range of environmental conditions that may enable high survival during transport and conditions in Irish coastal areas normally lie within these tolerance ranges. The threat of an arrival via hull fouling of vessels is likely to be associated with slow moving vessels such as barges or with decommissioned vessels. Progressive establishment of new populations along the Irish coast are very likely (McNeill *et al.*, 2010). Being ubiquist, eurythermal and euryhaline, the species is likely to establish within a range of habitats (e.g. harbours, marinas, inlets, bays, channels, estuaries and open coast) and on a range of substrata (e.g. rocks, cobbles, stones, shells, coarse sand, gravel, mud, other species and man-made surfaces) (GISD, 2005; Tyler-Walters, 2011). *C. fornicata* is also known to overgrow existing species and as such, competition for settlement space is not likely to prevent its establishment. There are no specific predators or pests or diseases of limpets known in Northern European waters to curtail expansion. Once established, natural dispersal of the pelagic planktonic larval stage is likely to cause localised spread and disjunct populations are likely to arise from anthropogenic causes. Once established, natural dispersal of the pelagic planktonic larval stage is likely to result in a moderately fast spread. Fishery practices may also aid in spread. Suitable inshore, offshore and open coastline habitat is vulnerable to colonisation. The potential economic impact of *C.fornicata* establishment should populations develop as they have along the French coast is likely to be major, with a losses of revenue to some fisheries and bivalve

Stage 2 - Detailed assessment: Section E - Conclusion

This section requires the assessor to provide a score for the overall risk posed by an organism, taking into account previous answers to entry, establishment, spread and impact questions.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				aquaculture. Environmental harm within its existing range is major at a local level and it is predicted that similar impacts may take place in Ireland.

Stage 2 - Detailed assessment: Section F – Additional questions

This section is used to gather information about the potential effects of climate change on the risk posed by an organism. It is also an opportunity for the risk assessor to highlight high priority research that could help improve the risk assessment.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
6.01	What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	-	MEDIUM	Increases in temperature and high rainfall associated with climate change are most likely to affect the risk assessment.
6.02	What is the likely timeframe for such changes (5, 10, 15, 20, 50 or 100 years)?	100	LOW	Future scenarios on climate alteration suggest changes in mean temperature, higher winter rainfall and more intense storm events. Such changes are more likely to be taking place when selecting longer timeframes although changes are already recognise by the majority of the science community.
6.03	What aspects of the risk assessment are most likely to change as a result of climate change	-	MEDIUM	Long term elevations in temperature may facilitate strong limpet recruitment and may enable greater levels of sustainability in more northern areas. Temperature increases would likely increase survival due to less winter mortalities and increase reproductive viability and fecundity as a result of more broods per year (Clark, 2008; Thieltges *et al*., 2003) Intense rainfall events may purge populations within estuarine regions where salinities may decline to levels not tolerated.
6.04	If there is any research that would significantly strengthen confidence in the risk assessment, please note this here. If more than one research area is provided, please list in order of priority.	YES	LOW	There is no indisputable evidence that *C. fornicata* competes trophically with other species, more research is need in this area. Evaluating the levels of certainty in relation to pathways and their vectors would increase confidence in the processes involved in dispersal. This is a general feature that should be considered in all risk assessments (Minchin, 2007).

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