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:	***Didemnum sp. (Ascidiacea, Tunicata)***
	Objectives:	Assess the risks associated with this species in GB
	Version:	FINAL 22/03/11

N	QUESTION	RESPONSE	COMMENT
1	What is the reason for performing the Risk Assessment?	The organism has invaded a new area, other than the Risk Assessment area	Request made by GB Programme Board
2	What is the Risk Assessment area?	Great Britain	
3	Does a relevant earlier Risk Assessment exist?	NO OR UNKNOWN (Go to 5)	
4	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?		
A	**Stage 2: Organism Risk Assessment SECTION A: Organism Screening**		
5	Identify the Organism. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	NO (Go to 6)	At present, there is some controversy regarding the taxonomic relationships of the *Didemnum* species reported in the literature. Two species have been formally named: *Didemnum vexillum* described from New Zealand (Kott, 2002) and *Didemnum vestum* , described from the US east coast (Kott, 2004), based on morphological characteristics. Species of the genus *Didemnum* that are possibly different but related to *D. vexillum* and *D. vestum* have been recorded from France and the Netherlands (*D. lahillei* or *D. helgolandicum*), the U.S. west coast (*D. carnulentum*), New England (US) (*D. lutarium*), British Columbia, and recently from Ireland and Japan (*D. pardum*). These organisms have not yet been formally compared to either *D. vexillum* or *D. vestum* in the published literature, so they are provisionally called *Didemnum* sp. However, Stefaniak *et al.* (2009) and Lambert (2009) have demonstrated that some, if not all, of these are *D. vexillum* , and this is now the generally accepted name for the globally invasive cool-temperate species. Nevertheless, identification to species is extremely difficult.
6	If not a single taxonomic entity, can it be redefined?	YES (Go to 7)	The genus *Didemnum* is relatively easily distinguished from other colonial ascidians. However, there are relatively few diagnostic characteristics at the morphological level that can be used to identify the species, and there is great variability in these characteristics. Some mitochondrial DNA analyses have been carried out to identify conspecifics, but the results are not yet published.
7	Is the organism in its present range known to be invasive, i.e. to threaten species, habitats or ecosystems?	YES (Go to 9)	*Didemnum* sp. has successfully invaded habitats in Europe, New Zealand, the USA and Japan; see, for example, Coutts (2002), Minchin and Sides (2006), Bullard *et al.* (2007), Coutts and Forrest (2007), Osman and Whitlatch (2007).
8	Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems?		Additional comment: *Didemnum* sp. has a short larval dispersal phase, duration typically several hours, but can spread by fragments of the parent colony breaking off to form new colonies (Coutts, 2002). These fragments may be carried further than the larvae by man-aided transport giving the
9	Does the organism occur outside effective containment in the Risk Assessment area?	NO (Go to 11)	
10	Is the organism widely distributed in the Risk Assessment area?		
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)	Approximately 120 major marinas and 40 commercial harbours containing water of suitable salinity and temperature exist throughout the Risk Assessment area (Reeds, 2007). A further 40 marinas and 15 commercial harbours in Scotland may be suitable to support *Didemnum* sp. colonies but the water may not be sufficiently warm for the ascidian to breed (minimum temperature 15ºC).
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)	*Didemnum* sp. has been recorded in harbours and marinas in New Zealand (Coutts, 2002), northern France and the Netherlands (Gittenberger, 2007) and the Republic of Ireland (Minchin and Sides, 2006) that have similar climate, salinity and water temperature to many potential receptor sites in Great Britain.

15	Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment area?		Additional comment - It can become established in marinas and harbours e.g. Coutts (2002), Gittenberger (2007) and Minchin and Sides (2006) and in aquaculture facilities - for example, it has been reported overgrowing oyster bags on intertidal trestles in Clew Bay, County Mayo (http://woodshole.er.usgs.gov/project-pages/stellwagen/didemnum/htm/ire_clewbay.htm) and South Galway Bay, County Galway (http://woodshole.er.usgs.gov/project-pages/stellwagen/didemnum/htm/ire_galway.htm), Ireland.
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)	See for example, Coutts (2002), Minchin and Sides (2006), Gittenberger (2007), Coutts and Forrest (2007), Valentine *et al.* (in press (a)).
17	Can the organism spread rapidly by natural means or by human assistance?	YES (Go to 18)	The larval phase of *Didemnum* sp. is typically only several hours, so natural dispersal is of local importance only. However, it can spread by fragments of the parent colony breaking off to form new colonies, and these fragments
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)	It can blanket the sea bed (Valentine *et al.,* 2007), and affect fisheries and shellfisheries, see for example, Bullard *et al.* (2007), Morris *et al.* (in press), Mercer and Whitlatch (in press).
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	Examples of the potential harm that this organism can cause are given in Coutts (2002), Coutts and Forrest (2007), Valentine *et al.* (2007), Carman *et al.* (in press), Mercer and Whitlatch (in press).
20	This organism is not likely to be a harmful non-native organism in the Risk Assessment area and the assessment can stop.		

B	SECTION B: Detailed assessment of an organism's probability of entry, establishment and spread and the magnitude of the economic, environmental and social consequences			
	Probability of Entry	**RESPONSE**	**UNCERTAINTY**	**COMMENT**
1.1	List the pathways that the organism could be carried on. How many relevant pathways can the organism be carried on?	many - 3	LOW - 0	Seven pathways: 1) By commercial shipping, e.g. as hull and sea-chest fouling on ships, as fouling of towed hulks, rafts and pontoons. 2) As colony fragments on trawls, nets, shellfish dredges and other fishing gear of inshore fishing boats. 3) By pleasure craft, e.g. as hull, anchor and rope fouling on recreational small boats. 4) By transfer of contaminated shellfish to new growing areas. 5) As colony fragments in the waste from shellfish processing plants. 6) As larvae or fragments of colonies carried over short distances by tidal currents or in ballast water. 7) As colonies attached to flotsam carried by tidal currents.
1.2	Choose one pathway from the list of pathways selected in 1.1 to begin the pathway assessments.	Hull and sea-chest fouling of commercial ships.		
1.3	How likely is the organism to be associated with the pathway at origin?	very likely - 4	MEDIUM -1	Colonies thrive in the protected environment of harbours and marinas (which are often adjacent to harbours); commercial ships visit these harbours and remain long enough for larvae to settle (seasonal) or fragments of a colony to be drawn into the sea-chests. *Didemnum* spp. brood larvae within the colonial tunic (Kott, 2002; 2004) and these are released when close to settlement; the free-living stage generally lasts less than a few hours, so transport of settled, metamorphosing larvae is possible, but ballast water is an unlikely vector for the free-swimming larvae.
1.4	Is the concentration of the organism on the pathway at origin likely to be high?	likely - 3	MEDIUM -1	Distribution is disjunct. Where present, the colonies are usually dense and widespread.
1.5	How likely is the organism to survive existing cultivation or commercial practices?	very likely - 4	LOW - 0	It is extremely difficult to eradicate, see Coutts and Forrest (2007).
1.6	How likely is the organism to survive or remain undetected by existing measures?	very likely - 4	LOW - 0	It is not well known at present and can easily be missed in rapid surveys. In addition, once detected, it is extremely difficult to eradicate, see Coutts and Forrest (2007).
1.7	How likely is the organism to survive during transport /storage?	very likely - 4	LOW - 0	It is very robust and difficult to kill (Coutts and Forrest, 2007).
1.8	How likely is the organism to multiply/increase in prevalence during transport /storage?	likely - 3	LOW - 0	The larval stage generally lasts less than a few hours, so it is an unlikely to spread far and may settle in or on the vector near to the parent colony (Valentine, in press (b)). Fragments of the colony can rapidly form new colonies in or on the vector (Coutts, 2002). The didemnid *Diplosoma listerianum* (the only didemnid studied in this respect) can store exogenous sperm and thereby produce outcrossed progeny for some weeks in reproductive isolation following sperm uptake (Bishop, 1998; Bishop & Ryland, 1991), for instance as a single colony on a vector. If *D. vexillum* stores sperm in this way, it is possible that after a suitable brooding period (typically a few weeks), a single colony could release progeny whilst in transit or at the destination, and thereby found a new population.
1.9	What is the volume of movement along the pathway?	moderate - 2	MEDIUM -1	The volume of movement is variable. Commercial shipping may be free of *Didemnum* sp. or well fouled with it; see, for example, the barge Steel Mariner described in Coutts (2002) and Coutts and Forrest (2007).
1.10	How frequent is movement along the pathway?	often - 3	MEDIUM -1	This depends upon the shipping routes and docking frequency of the commercial ships.
1.11	How widely could the organism be distributed throughout the Risk Assessment area?	very widely - 4	LOW - 0	All harbours and adjacent marinas are potential receptor habitats. The conditions necessary for *Didemnum* sp. to become established are similar to those required by *Styela clava* (Davis *et al.* , 2007). There are approximately 120 major marinas and 40 commercial harbours containing water of suitable temperature (>15ºC; Valentine *et al.,* in press (a); in press (b)) for *Didemnum* sp. to become established throughout the Risk Assessment area (Reeds, 2007; Davis *et al.* , 2007). A survey of harbours and marinas for *Styela clava* (Davis *et al.* , 2007) found that most of these 160 sites contained water of suitable salinity (>20 psu; Bullard and Whitlatch, in press). A further 40 marinas and 15 commercial harbours in Scotland have suitable salinity to support *Didemnum* sp. colonies but the water temperature, although sufficient for *Didemnum* sp. to grow (14-18ºC; Gittenberger, 2007) may not be sufficient for it to breed (minimum temperature 15ºC; Valentine *at al., 2009*). In fact, no populations of *Styela clava* were found north of Latitude 55º 38' N on the west coast and 53º 34' N on the east coast of Great Britain (Davis *et al.* , 2007) and this will probably be the limit of distribution for *Didemnum* sp.; nevertheless, it is possible that insolation could increase the summer water temperatures of some shallow bays sufficiently for *Didemnum* sp. to breed north of these limits.

1.12	How likely is the organism to arrive during the months of the year most appropriate for establishment ?	very likely - 4	LOW - 0	The organism is most likely to arrive on or in the ship as established colonies or fragments of colonies; both are capable of establishing new colonies throughout the year. In addition, if the ship travels through cold deep water into the shallow warm water of a harbour, the temperature shock may trigger synchronised spawning which would provide the high-density inoculum of larvae necessary to give a high probability of successful establishment of colonies in the new habitat.
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?	N/A		
1.14	How likely is the organism to be able to transfer from the pathway to a suitable habitat?	very likely - 4	LOW - 0	Transported colonies may readily fragment and disperse into the new habitat. Synchronised spawning could increase the probability of successful establishment of the organism in the new habitat.

	Probability of Establishment	RESPONSE	UNCERTAINTY	COMMENT
1.15	How similar are the climatic conditions that would affect establishment in the Risk Assessment area and in the area of current distribution?	very similar - 4	LOW - 0	*Didemnum* sp. has been recorded in New Zealand (Coutts, 2002), Carlingford Lough, Clew Bay (County Mayo), Malahide Estuary and South Galway Bay in the Republic of Ireland (Minchin and Sides, 2006), in Brest and Le Havre in northern France, and Grevelingen and Oosterschelde in The Netherlands (Gittenberger, 2007). These sites experience similar climatic conditions to much of England and Wales.
1.16	How similar are other abiotic factors that would affect establishment in the Risk Assessment area and in the area of present distribution?	similar - 3	LOW - 0	Larval recruitment on the New England coast occurs at temperatures of 14-20ºC (Valentine *et al.* , 2009), water temperatures found around the coast of England and Wales in summer. The majority of harbours and marinas in northern France, the Netherlands and Eire exhibit similar abiotic factors such as salinity, temperature, dissolved oxygen, substrate type and availability, and exposure, to those in England and Wales. Water temperatures in Scottish harbours may be considerably lower.
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	*Didemnum* sp. thrives in the protected environment of harbours and marinas (Coutts, 2002; Minchin and Sides, 2006; Gittenberger, 2007) with high salinity (Bullard and Whitlatch, in press), and on the seabed (Valentine *et al.,* 2007). Approximately 120 major marinas and 40 commercial harbours (see 1.11) containing water of suitable salinity (>20 psu; Bullard and Whitlatch, in press) and temperature (>15C; Valentine *et al.* , in press (b)) are available as potential receptors in Great Britain; some of the 55 harbours and marinas in Scotland may also be suitable. There are also extensive areas of suitable seabed available throughout the 10,000 km of coast line in the Risk Assessment area.
1.18	How widespread are the species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism in the Risk Assessment area?	widespread - 4	LOW - 0	The organism thrives in the protected environment of harbours and marinas with high salinity (Bullard and Whitlatch, in press), and on the seabed (Valentine *et al.* , 2007). These habitats are widespread around the 10,000 km of coast of Great Britain (see 1.11).
1.19	If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the risk assessment area?	N/A		
1.20	How likely is it that establishment will not be prevented by competition from existing species in the Risk Assessment area?	very likely - 4	LOW - 0	*Didemnum* sp. overgrows sessile competitors and is capable of completely encapsulating them (Carman *et al.* , in press).
1.21	How likely is it that establishment will not be prevented by natural enemies already present in the Risk Assessment area?	very likely - 4	LOW - 0	*Didemnum* sp. has few predators. In experiments, Asian shore crab (*Hemigrapsus sanguineus*), common spider crab (*Maja squinado*) and purple sea urchin (*Paracentrotus lividus*) all consumed frozen *Didemnum* sp. (Guida *et al.,* in press*),* green sea urchins (*Strongylocentrotus droebachiensis*) were observed to graze on fresh *Didemnum* sp. (Epelbaum *et al.,* in press) but the caloric content (390-420 cal per gram wet weight of *Didemnum* sp.) is low compared to many other food organisms (Guida *et al* ., in press) and it is therefore less likely to be selected by predators. Although the common periwinkle (*Littorina littorea*) appeared to consume stressed *Didemnum* sp. in the field, it showed no preference for healthy *Didemnum* sp. in the laboratory (Carmen *et al.* in press).
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		There are no apparent differences in habitat management between the potential source areas and the Risk Assessment area.
1.23	How likely is it that existing control or husbandry measures will fail to prevent establishment of the organism?	very likely - 4	LOW - 0	There are no controls to prevent the ingress of marine fouling organisms and, even if there were, it is unlikely that they could prevent the opportunistic introduction of this organism as shown by Coutts (2002) and Minchin and Sides (2006).
1.24	How often has the organism been recorded in protected conditions, e.g. glasshouses, elsewhere?	frequent - 3	LOW - 0	All European and New Zealand records are for sheltered marinas and harbours, see Coutts (2002), Minchin and Sides (2006) and Gittenberger (2007). It has also been reported overgrowing oyster bags on intertidal trestles in Clew Bay, County Mayo (http://woodshole.er.usgs.gov/project-pages/stellwagen/didemnum/htm/ire_clewbay.htm) and South Galway Bay, County Galway (http://woodshole.er.usgs.gov/project-pages/stellwagen/didemnum/htm/ire_galway.htm), Ireland.
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	*Didemnum* sp. larvae are held in the colony tissue and released, as competent larvae, only a few hours before settlement (Kott, 2002; Valentine *et al.* , in press (a)). This reduces the loss of larvae by predation. Furthermore, restricted dispersal of short-duration competent larvae promotes local recruitment and consequent local population increase. In addition, fragments that break off a colony can start a new colony (Coutts, 2002; Valentine *et al.* , in press (a)).
1.26	How likely is it that the organism's capacity to spread will aid establishment?	very likely - 4	LOW - 0	See, for example, Coutts (2002), Minchin and Sides (2006), Coutts and Forrest (2007), Valentine *et al.* (in press (a)).
1.27	How adaptable is the organism?	moderately adaptable - 2	MEDIUM -1	It is capable of living at a range of temperatures, salinities and depths (Bullard and Whitlatch, in press: Valentine *et al.* , in press (a)), but will not breed at temperatures <15ºC and exhibits reduced survival at salinity <20 psu.

1.28	How likely is it that low genetic diversity in the founder population of the organism will not prevent establishment?	likely - 3	MEDIUM -1	No information is available on this aspect of establishment, but small colonies appear to survive (e.g. Gittenberger, 2007), and can be established by fragments of parent colonies, suggesting that low genetic diversity will not prevent establishment. In the laboratory, the didemnid *Diplosoma listerianum* (the only didemnid studied in this respect) can survive for at least fifteen years through asexual reproduction (J. D. D. Bishop, pers. comm.).
1.29	How often has the organism entered and established in new areas outside its original range as a result of man's activities?	moderate number - 2	LOW - 0	Populations in New Zealand (Coutts, 2002), Ireland (Minchin and Sides, 2006), France and The Netherlands (Gittenberger, 2007), Holyhead (Holt *et al.* , 2009) and Plymouth (J. D. D. Bishop, pers. comm.) all appear to have arrived by man-aided transport. Transport on the hulls of leisure craft is implicated in the recent occurrences at Holyhead and Plymouth; considerable numbers of leisure craft travel from Ireland (where *D. vexillum* is established) to Holyhead, and from France to Plymouth.
1.30	How likely is it that the organism could survive eradication campaigns in the Risk Assessment area?	very likely - 4	LOW - 0	A variety of eradication techniques was applied to recently arrived colonies in New Zealand but all failed (Coutts and Forrest, 2007). Local eradication in the in the early stages of establishment seems possible, but this requires early detection of arrival. Holyhead Marina might provide a trial of this; suitable techniques are assessed by Kleeman (2009).
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)?	N/A		

	Spread	RESPONSE	UNCERTAINTY	COMMENT
2.1	How rapidly is the organism liable to spread in the Risk Assessment area by natural means?	very slow - 0	LOW - 0	The larval stage generally lasts less than a few hours so larvae are unlikely to spread far from the parent colony by natural means (Valentine *et al.* , in press (b)). Fragments of the colony can form new colonies, but usually settle near the parent colony (Coutts, 2002; Valentine *et al.* , 2009). Fragments suspended in the water column develop spherical morphology and can survive for many days, 60% for 18 days and 15% for 30 days (Carman, 2008). Fragments can attach to a suitable substrate within 6 hours of coming into contact with it (Bullard *et al.* , 2007). Thus natural transport of fragments may spread the organism considerable distances if suitable currents are present.
2.2	How rapidly is the organism liable to spread in the Risk Assessment area by human assistance?	very rapid - 4	LOW - 0	Fragments of the colony can form new colonies, but usually settle near the parent colony (Coutts, 2002) unless transported by main-aided vectors such as shipping. So, once established in a harbour or marina, fouled commercial and recreational boats (e.g. Minchin and Sides, 2006) can rapidly transport the organism long distances, rapidly increasing its distribution. Fragments suspended in the water column can survive for many days, 60% for 18 days and 15% for 30 days (Carman, 2008). Fragments can attach to a suitable substrate within 6 hours of coming into contact with it (Bullard *et al.* , 2007). Thus transport of fragments by shipping may rapidly spread the organism considerable distances.
2.3	How difficult would it be to contain the organism within the Risk Assessment area?	very difficult - 4	LOW - 0	As the organism inhabits habitats directly connected to the open sea, containment will be extremely difficult. Furthermore, as it lives at depths of between 1 m (Bullard and Whitlatch, in press) and 65 m (Valentine *et al.* , in press (a)) containment and eradication usually involve divers, which makes the project both difficult and expensive (Coutts and Forrest, 2007).
2.4	Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism.	Harbours, marinas and sheltered bays and coastline in the Risk Assessment area are endangered.	LOW - 0	Initially, in excess of 160 sites around the coast are at risk of ingress and establishment of *Didemnum* sp. Once established, it may spread to numerous neighbouring sites.

	Impacts	RESPONSE	UNCERTAINTY	COMMENT
2.5	How important is economic loss caused by the organism within its existing geographic range?	major - 3	MEDIUM -1	Not measured at present, but New Zealand has a green-lipped mussel farming industry worth an estimated NZ$ 150 million per year (Davis and Davis, 2008) that is now considered to be at risk, suggesting that potential economic loss can be very important.
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?	major - 3	MEDIUM -1	Shellfish landings are most likely to be affected as *Didemnum* sp. is known to blanket shellfish and reduce their growth rate, if not kill them. Landings from the wild in Great Britain in 2004 mainly involve mussels (12,074 tonnes worth £2 million), Queen scallops (5,151 tonnes worth £1.9 million) and scallops (22,356 tonnes worth £34 million). Shellfish farms produced oysters (855 tonnes), mussels (22,300 tonnes), Queen scallops (45 tonnes) and scallops (10 tonnes) worth £19.7 million in total (data from www.shellfish.org.uk/shellfish_production.htm). Therefore, a total of approximately £57.6 million (at 2004 rates) is at risk. It is not possible to predict how much this total is realistically at risk, or the timescale involved, as dispersal and establishment are stochastic processes.
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?	major - 3	MEDIUM -1	*Didemnum* sp. will reduce the yield and quality of the shellfish produced for market which will reduce producer profits. Infestation of a region might also reduce the potential for or value of seed-mussel export. It will also reduce natural recruitment of wild shellfish populations by consuming the spat. The extent of the profit reduction cannot be estimated at present.
2.8	How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area?	moderate - 2	LOW - 0	Consumer demand will be reduced by the presence of the organism if existing quality and price cannot be maintained, which is likely to be the case.
2.9	How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets?	moderately likely - 2	MEDIUM -1	Export markets are unlikely to take shellfish produced in an area that has extensive colonies of *Didemnum* sp. in case fragments of the organism are transported with the shellfish. Infestation of a region might also reduce the potential for or value of, for example, seed-mussel export
2.10	How important would other economic costs resulting from introduction be? (specify)	moderate - 2	MEDIUM -1	There will be a cost to the public purse if the government were to support monitoring to ascertain the distribution of the organism, research to find control techniques for it, outreach publicity to warn fishermen and boat owners, and any campaign to convince the export market of the safety of the product. As an example, mussel farming in New Zealand is worth an estimated NZ$500 million; since August 2005, when *Styela clava* was detected in Auckland harbour (Davis and Davis, 2006), Biosecurity New Zealand has spent approximately NZ$2 million on research and surveillance to determine its geographical spread (Bissmire and Stratford, in press; Gust and Graeme, in press).
2.11	How important is environmental harm caused by the organism within its existing geographic range?	major - 3	LOW - 0	The organism has affected extensive areas of the Georges Bank fishing grounds (Gulf of Maine, USA) where marine communities have been blanketed by it and destroyed (Valentine *et al.* , in press (a); Mercer and Whitlatch, in press). Species richness and biodiversity are reduced in habitats where *Didemnum* sp. becomes established (Lengyel *et al.,* in press; Dijkstra and Harris, in press*)* . This will have significant effects on designated environmentally sensitive areas.
2.12	How important is environmental harm likely to be in the Risk Assessment area?	massive - 4	MEDIUM -1	Once established, the organism can have a disastrous effect on the habitat (Valentine *et al.* , in press (a); Mercer and Whitlatch, in press; Lengyel *et al.* , in press; Dijkstra and Harris, in press). If introduced into Special Areas of Conservation (SACs), *Didemnum vexillum* could have a disastrous effect on species diversity leading to habitat destruction.
2.13	How important is social and other harm caused by the organism within its existing geographic range?	moderate - 2	HIGH -2	Not measured at present, but it is unlikely to be as significant as the environmental harm. Social harm is most likely to impact upon fishing communities, small boat owners and marina operators, and communities dependent on aquaculture.
2.14	How important is the social harm likely to be in the Risk Assessment area?	moderate - 2	HIGH -2	This cannot be estimated at present, but it is unlikely to be as significant as the environmental and economic harm.
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?	very unlikely - 0	MEDIUM -1	The organism is not known to hybridise with other species at present.
2.16	How probable is it that natural enemies, already present in the Risk Assessment area, will have no affect on populations of the organism if introduced?	very likely - 4	MEDIUM -1	No natural enemies are known at present. See section 1.21.
2.17	How easily can the organism be controlled?	very difficult - 4	LOW - 0	Control appears feasible given very early detection and rapid response. Once the organism has spread significantly, experience to date suggests that it cannot be controlled, see sections 1.30 and 2.3. Most attempts to control it involve removal by divers; these have had limited success as one small fragment missed by the divers can start a new colony.
2.18	How likely are control measures to disrupt existing biological or integrated systems for control of other organisms?	likely - 3	MEDIUM -1	Control measures attempted in New Zealand included smothering habitats with uncontaminated dredge spoil or geotextile fabric, wrapping affected piles with plastic, water blasting, air drying, and dosing with acetic acid or chlorine (Coutts and Forrest, 2007). All these techniques would adversely affect the habitat.

2.19	How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms?	unlikely - 1	MEDIUM -1	Its nutritional and caloric value is low (Guida *et al.* , in press) and few organisms presented with it will consume it (Epelbaum *et al.* , in press). Mercer and Whitlatch (in press) reported that an epibenthic polychaete, *Lepidonotus squamatus* , and an infaunal polychaete, *Eusyllis lamelligera* , were only found within the blanket of *Didemnum* sp., but the significance of this observation is unclear. Lengyel *et al.* (in press) reported that the abundance of the polychaetes *Nereis zonata* and *Harmothoe extenuata* increased significantly in areas covered by *Didemnum* sp., but this was thought to be because the polychaetes live beneath the tunicate blanket and thus avoid predation by fish.
2.20	Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur	Shellfisheries, harbours and sheltered bays in the Risk Assessment area.	HIGH -2	Economic, environmental and social impacts are most likely to occur in shellfisheries in the Risk Assessment area. Environmental and social impacts will occur in harbours, marinas and sheltered bays in the Risk Assessment area. Some/many categories of biogenic reefs of conservation importance might be vulnerable (e.g. Sabella, Modiolus).

Summarise Entry	very likely - 4	LOW - 0	
Summarise Establishment	very likely - 4	LOW - 0	
Summarise Spread	rapid - 3	MEDIUM -1	
Summarise Impacts	massive - 4	LOW - 0	
Conclusion of the risk assessment	HIGH -2	LOW - 0	This organism presents a high risk to the Risk Assessment area because: entry appears to inevitable, although the stochastic nature of marine introductions makes quantitative prediction of probability difficult; establishment is very likely in a large number of receptor habitats and cannot, at present, be controlled, and spread will then occur. The consequences of introduction will be negative and will mainly impact on local economy and environment; the impacts will probably be sufficient to require government action.
Conclusions on Uncertainty			The risk assessment is based on the reported effect of *Didemnum* sp. in other ecosystems. Nevertheless, wherever it is found it appears to be an efficient invader and aggressive competitor. The main uncertainty is associated with the entry phase. Given that Great Britain is a major player in the international shipping trade, it is inevitable that non-indigenous marine species will enter commercial harbours. Control can only be achieved by stopping establishment and/or spread, and the probability of this is low.

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