## 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**

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| **Name of Organism:** | ***Rapana venosa*** **- Rapa Whelk** |
| **Objectives:** | Assess the risks associated with this species in GB |
| **Version:** | Original draft 22/02/11 |
| **Author:** | N. Sweet (MBA) and J. Sewell (MBA) |
| **Suggested citation:** | Sweet and Sewell (2011). GB Non-native Orgaism Risk Assessment for *Rapa venosa* . www.nonnativespecies.org |

| N | QUESTION | RESPONSE | COMMENT |
|---|---|---|---|
| 1 | What is the reason for performing the Risk Assessment? | | Request by the GB Programme Board for Non-native Species |
| 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? | YES (Give the full name & Go to 7) | Phyla: Mollusca; Class: Gastropoda; Order: Neogastropoda; Family: Muricidae; Genus/species: *Rapana venosa*. *R. venosa* is a large predatory neogastropod native to temperate Asian waters: the Sea of Japan, the Yellow Sea, the Bohai Gulf, and the East China Sea (Saglam & Duzgunes, 2007). Rapana venosa Valenciennes 1846 has also been described with the junior synonyms Rapana thomasiana Crosse 1861, and Rapana thomasiana thomasiana (Thomas' Rapa Whelk). The taxonomic status of the genus Rapana has been recently reviewed by Kool (1993). |
| 6 | If not a single taxonomic entity, can it be redefined? | | |
| 7 | Is the organism in its present range known to be invasive, i.e. to threaten species, habitats or ecosystems? | YES (Go to 9) | Actively pursues prey by burrowing in sediments and on the surface and can rapidly consume large quantities of prey. Considered one of the most unwelcome invasive species worldwide (Mann, 2006; cited in Sewell *et al.* , 2008). Responsible for the decimation of native oyster, scallop, and mussel populations in receiving environments; this impact arises due to a general lack of competition from other predatory gastropods. In addition, the combination of fast growth rate, shape, large terminal size and longevity means that individuals rapidly reach refuge size from most predators. Once this refuge is reached longevity is assured providing prey are adequate and parasite and disease loads are low. A decline in epibenthic, structure forming bivalves (such as mussel *Mytilus edulis* ) caused by increased predation, may locally reduce the availability of this habitat. Such a loss may result in reduced refuge for juvenile crustaceans and other organisms (ICES, 2004). Could become a severe competitor for the native whelk *Buccinum undatum* (ISSG, 2006). According to Kerckhof *et al.* (2006), *R. venosa* 's success as an invasive species is also helped by its fast growth rate, high fecundity and high tolerance to lower salinities, pollution and oxygen deficiency. |
| 8 | Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems? | | |
| 9 | Does the organism occur outside effective containment in the Risk Assessment area? | YES (Go to 10) | Occurs in soft sediment areas in open water systems, including estuaries. Hard substratum areas may also be used for breeding, egg laying or by epibenthic individuals (Sewell *et al* , 2008) |
| 10 | Is the organism widely distributed in the Risk Assessment area? | NO (Go to 11) | Not widely recorded in the risk assessment area but recent findings have been reported from the North Sea. One live specimen was collected by a trawler in the wider Thames Estuary (Kerckhof *et al.,* 2006) and *R. venosa* records from Dutch waters have also been reported (ICES, 2006). Although records are limited, this may be due to low survey effort and the ability of individuals to remain undetected in early life and by burial during later life. It is considered likely that as waters become warmer, *R.venosa* is likely to extend its range further northwards. |
| 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) | Soft sediment areas would provide suitable habitat. Hard substratum areas may also be utilised for breeding, or by epibenthic individuals. Both of these habitat types are numerous in the risk assessment area. Mann & Harding (2003) note that *R. venosa* can exploit a variety of native bivalves as prey. |
| 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) | No one species is critical to any life stage of *R. venosa. R.venosa* exploits a wide variety of prey species and exhibits broad dietary capabilities (Mann & Harding, 2003). |

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| 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) | Current distribution of *R. venosa*: Native to the Sea of Japan and temperate Asian waters including the East China Sea. Non-native populations occur in the Black Sea, the Aegean and Adriatic seas, Uruguay, and the Chesapeake Bay area (eastern USA). In NW Europe, several specimens were discovered by the end of the 1990s in the Bay of Quiberon (Brittany, France) (ICES, 2004). The non-native populations occur in ecoclimatic zones which are comparable to those of the risk assessment area, although seawater temperatures in British waters are lower. |
| 15 | Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment area? | | N/A |
| 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) | The following geographic regions currently contain reproducing populations of *R. venosa* that are distinct from the native (Asian) population: Black Sea and Mediterranean region, Chesapeake Bay, USA., the Brittany coast of France, and the Rio de la Plata, Uruguay and Argentina (ICES, 2004). |
| 17 | Can the organism spread rapidly by natural means or by human assistance? | YES (Go to 18) | The eggs hatch into pelagic larvae that have a long planktonic phase (up to 80 days), allowing accidental transfer throughout the oceans in ships' ballast water. Introductions of egg cases through hull fouling or with aquaculture products is also plausible (Kerckhof et al., 2006). Live adults could be found within batches of bivalves upon which *R. venosa* predates. |
| 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) | Potential adverse impacts on the local environment and local bivalve populations where introduced. The regional industries for edible bivalves such as mussels *Mytilus edulis*, Pacific oysters *Crassostrea gigas* and cockles *Cerastoderma edule* may be at risk. |
| 19 | This organism could present a risk to the Risk Assessment area and a detailed risk assessment is appropriate. | Detailed Risk Assessment Appropriate GO TO SECTION B | |
| 20 | This organism is not likely to be a harmful non-native organism in the Risk Assessment area and the assessment can stop. | | |

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| 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? | very many - 4 | MEDIUM -1 | (1) Pelagic larvae have a long planktonic phase (up to 80 days), allowing potential transfer in ballast water. This is thought to be the principal vector in recent years (Harding, 2006). (2) Transfer of *R. venosa* together with oysters,clams or mussel seed transported for aquaculture purposes. Mann & Harding (2003) suggest that the introduction of *R. venosa* to the Black Sea in the 1940s was probably associated with oysters transported from the Orient. (3) Egg-case transfer in hull fouling is also suggested as a possible vector although modern hull anti-fouling treatments would largely reduce this. (4) Once established, range extension could occur through planktonic larval dispersion alone (ICES, 2004; Kerckhof *et al.* , 2006). According to Mann & Harding (2000), ballast water transport of larval stages from the eastern Mediterranean or Black Sea is the suspected vector of introduction into the Chesapeake Bay. Genetic investigation by Chandler *et al* (2008) appears to support this theory. (5) Once a population is established, range expansion could also occur through adult or juvenile migration (Harding & Mann, 2005). |
| 1.2 | Choose one pathway from the list of pathways selected in 1.1 to begin the pathway assessments. | Transport in ballast water | | Ballast water transport of the planktonic larval stage is the most likely vector of introduction (Harding & Mann, 2005). |
| 1.3 | How likely is the organism to be associated with the pathway at origin? | very likely - 4 | LOW - 0 | Able to exploit estuarine regions and coastal seas (Mann & Harding, 2003). Likely to occur in areas of intense shipping traffic. The adult has great tolerance of poor environments, and appears able to reproduce even in the presence of overt imposex, possibly caused by TBT exposure. |
| 1.4 | Is the concentration of the organism on the pathway at origin likely to be high? | moderately likely - 2 | MEDIUM -1 | No comprehensive studies of the current populations in the native range were found, but *R. venosa* exhibits high fecundity in invasive populations. Saglam & Duzgunes (2007) found mean larval production per rapa whelk was about 392,931. Harding et al*.* (2008) also identified high levels of fecundity in rapa whelk populations in Chesapeake Bay. |
| 1.5 | How likely is the organism to survive existing cultivation or commercial practices? | very likely - 4 | LOW - 0 | Able to tolerate low salinity, water pollution and oxygen deficiency, and general physiological tolerances similar to those of commercially cultivated species(ICES, 2004). As a predator of bivalves, it may be present in areas of mussel/clam cultivation. |
| 1.6 | How likely is the organism to survive or remain undetected by existing measures? | likely - 3 | LOW - 0 | Planktonic larvae are unlikely to be detected. Early post metamorphic stages are easily misidentifed as native predatory gastropods. Their differing morphology only becomes obvious to the casual observer in larger animals. Even moderate size life history stages can remain buried in clam populations or beneath sediment and remain undetected. |
| 1.7 | How likely is the organism to survive during transport /storage? | very likely - 4 | LOW - 0 | High tolerance to low salinity, water pollution and oxygen deficiency. All larval stages exhibit 48 hour tolerance to salinities as low as 15 ppt (Mann & Harding, 2003). Evidence of established communities in multiple regions worldwide indicates a strong likelihood of surviving transport (Harding, 2006; Mann & Harding, 2003; ICES, 2004). |
| 1.8 | How likely is the organism to multiply/increase in prevalence during transport /storage? | unlikely - 1 | LOW - 0 | Planktonic larvae in ballast water would not multiply/increase in prevalence during transport. |
| 1.9 | What is the volume of movement along the pathway? | major - 3 | LOW - 0 | The lowest estimates of the volumes of ballast water taken-up, transferred and discharged into world oceans each year are around 3 billion tonnes (GloBallast, 2004). About 17 million tonnes of ballast water is discharged at just under half the 129 ports in England and Wales (MAFF, 1999), and the total for Scotland is almost 26 million tonnes annually (Macdonald, 1994). Transportation of early post metamorphic stages with shellfish for mariculture may also be a vector. Volume will depend on the volume of host material moved. |
| 1.10 | How frequent is movement along the pathway? | very often - 4 | LOW - 0 | Shipping operations occur regularly throughout UK ports. |
| 1.11 | How widely could the organism be distributed throughout the Risk Assessment area? | moderately widely - 2 | LOW - 0 | Suitable soft sediment habitats exist throughout the UK. Refer to UK SeaMap (Connor *et al.* , 2006). However distribution is likely to be restricted by seawater temperature; Harding *et al.* (2008) found egg capsule deposition to begin at 18 ℃. |
| 1.12 | How likely is the organism to arrive during the months of the year most appropriate for establishment ? | likely - 3 | LOW - 0 | Mating occurs over an extended period during winter and spring. Egg cases are laid in April - late July corresponding to a temperature range of 13 - 26 ℃. Chung *et al.* (1993) cited in ICES (2004) report a 17 day incubation period between egg laying and first hatching, followed by a planktonic phase of up to 80 days. This extended planktonic phase could allow transport in ballast water over long distances. |
| 1.13 | How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) or other material with which the organism is associated to aid transfer to a suitable habitat? | very likely - 4 | LOW - 0 | As above, the extended planktonic phase of up to 80 days would facilitate transport over long distances in ballast water. |
| 1.14 | How likely is the organism to be able to transfer from the pathway to a suitable habitat? | likely - 3 | MEDIUM -1 | If ballast water exchange occurs in open seas rather than in coastal areas, transfer of planktonic larvae to suitable substrate will be hampered. If however ballast water is released in ports, estuaries or other coastal areas then establishment will be dependant on availablity of suitable habitat. If transported with shellfish, host material is likely to be laid in or close to suitable habitat into which individuals may be transferred. |

| | Probability of Establishment | RESPONSE | UNCERTAINTY | COMMENT |
|---|---|---|---|---|
| 1.15 | How similar are the climatic conditions that would affect establishment in the Risk Assessment area and in the area of current distribution? | similar - 3 | LOW - 0 | Native temperature range for adult: 4 - 27 ℃. Harding *et al.* (2008) found that egg capsule production by *R. venosa* in Chesapeake Bay was influenced by seasonal and absolute water temperatures as well as seasonal daylength cycles. Egg capsule deposition began at water temperatures of ~18 ℃ in Chesapeake Bay, and similar thresholds have been reported in the native habitat of *R. venosa*. The authors predict a latitudinal range of 30 - 41 °(N and S) as the reproductive range for *R. vensoa* populations. This could be a factor preventing the establishment of reproductive populations in the risk assessment area. Seawater temperatures in the risk assessment area are within the native temperature range for adults but generally do not attain temperatures of 18 ℃ for extended periods (although localised shallow, sheltered water bodies may attain higher temperatures for longer periods). It would be prudent to investigate further the potential of *R. venosa* to adapt to lower water temperatures and/or exploit areas with locally warmer water temperatures - for example estuaries. Future increases in water temperature would enhance this species' ability to successfully establish in the risk assessment area. |
| 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 | The risk assessment area contains numerous similar habitat types (Connor *et al.*, 2006). *R.venosa* exhibits high tolerence to low salinity and oxygen levels (Mann & Harding, 2003). This would suggest little in the way of abiotic barriers to establishment |
| 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. | many - 3 | LOW - 0 | Suitable habitat occurs within the risk assessment area (Connor et al, 2006). These would include sandflats and mudflats (733100 ha), estuaries (308355 ha), shallow bays and inlets (764560 ha)(JNCC, 2009). *R venosa* is known to prey on a wide range of bivalve species including *M. edulis*. |
| 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 | Prey species (bivalves including *M. edulis*) and habitats (sediment and hard substrate) are widespread in the risk assessment area (Connor *et al.*, 2006). |
| 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 | Several authors have reported a lack of general competition from other predatory gastropods (Zolotarev, 1996; ICES, 2004; Harding, 2003). Competition with the native whelk *Buccinum undatum* is unlikely to prevent the establishment of *R. venosa; B. undatum* is currently suffering from heavy fishing pressure and organotin water pollution (Kerckhof *et al.*, 2006). |
| 1.21 | How likely is it that establishment will not be prevented by natural enemies already present in the Risk Assessment area? | very likely - 4 | LOW - 0 | There are no reports of natural predators in the risk assessment area. In the Chesapeake Bay region, USA, the blue crab *Callinectes sapidus* preys on *R. venosa,* and so predation by large native crabs (such as *Cancer pagarus*) with similarities in crushing and feeding behaviour could be expected in the risk assessment area (Harding, 2003). |
| 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) | unlikely - 1 | MEDIUM -1 | More stringent controls on ballast water exchange may hinder establishment (for example the requirement for offshore exchange). Movement of products associated with aquaculture such as mussel seed may aid establishment. |
| 1.23 | How likely is it that existing control or husbandry measures will fail to prevent establishment of the organism? | likely - 3 | LOW - 0 | The spread of established populations in several geographical areas would suggest that existing controls are unlikely to prevent establishment. Populations in the USA, the Black Sea, the Aegean and Adriatic seas, Uruguay and France have all successfully established and spread (ICES, 2004). |
| 1.24 | How often has the organism been recorded in protected conditions, e.g. glasshouses, elsewhere? | very rare - 0 | MEDIUM -1 | No records were found of *R. venosa* occurrences in protected conditions. |
| 1.25 | How likely is the reproductive strategy of the organism and duration of its life cycle to aid establishment? | likely - 3 | LOW - 0 | The life history strategy of *R. venosa* incorporates generation times of less than a year, initially high fecundities (>1 x $10^6$ larvae produced per female annually) that increase with age, and potential life spans in excess of 10 years (Harding, 2003). *R. venosa also* attains a 'predator refuge' size rapidly when compared with native gastropods. Duration of pelagic larval phase (up to 80 days) enhances the potential to expand range (ICES, 2004). Egg cases are laid on hard surfaces, which may then be moved and thus transfer eggs. Giberto *et al.* (2006) found egg cases attached to debris, plastic litter and large whelks, all of which could aid transfer. |
| 1.26 | How likely is it that the organism's capacity to spread will aid establishment? | likely - 3 | LOW - 0 | The duration of the pelagic larval phase (up to 80 days) increases the capacity of *R. venosa* to extend its range. Natural spread may occur through the transfer of pelagic larvae by tidal or wind driven currents, or by migration of adults or juveniles. (ICES, 2004; Harding & Mann, 2005) Egg cases attached to hard surfaces may also enhance the species' capacity to spread through natural drift (for example of plastic debris in the water), or through man's activities. |

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| 1.27 | How adaptable is the organism? | adaptable - 3 | LOW - 0 | *R.venosa* can tolerate a range of salinities, temperature, water pollution and oxygen depletion, and will thus be adaptable to conditions in numerous locations (ICES, 2004). Whilst it occurs principally in soft sediment, it also colonises hard substrate (Kerckhof *et al.*, 2006). *R. venosa e* xhibits broad dietary capabilities (Mann & Harding, 2003). |
| 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 | Chandler *et al.* (2008) examined variation in two mitochondrial gene regions in order to investigate the invasion pathways of *R. venosa,* identify likely sources of introduced populations, and evaluate current hypotheses of potential transportation vectors. Collections from within the native range displayed very high levels of genetic variation while collections from all introduced populations showed a complete lack of genetic diversity; a single haplotype was common to all introduced individuals. This finding is consistent with the hypothesis that *R. venosa* was initially introduced into the Black Sea, and this Black Sea population then served as a source for the other secondary invasions by various introduction vectors including ballast water transport. The lack of genetic variability raises questions regarding the evolutionary persistence of these populations in the very long term. However, non-native *R. venosa* populations appear to be thriving in their new environments, and there is currently no indication that populations are being limited by low genetic diversity even after 60 years on the Black Sea. |
| 1.29 | How often has the organism entered and established in new areas outside its original range as a result of man's activities? | many - 3 | LOW - 0 | The introduction of *R. venosa* into the Black Sea is suspected to have occurred during the 1940s. Since this time, populations have become established in other regions worldwide: Chesapeake Bay, USA., Rio de la Plata, Uruguay and Argentina and the Brittany coast of France. Since 2005, specimens have been recorded from the North Sea. Vectors are thought to include tranport associated with oyster seed from the Orient, larval transport within ballast water, and transport as part of a hull-fouling community (ICES, 2004; Kerckhof, 2006; Mann & Harding, 2003). |
| 1.30 | How likely is it that the organism could survive eradication campaigns in the Risk Assessment area? | very likely - 4 | MEDIUM -1 | Prevention of introduction into the risk assessment area would require sampling and treatment of ballast water to identify planktonic larvae. In response to this issue, The International Convention for the Control and Management of Ships' Ballast Water and Sediments was adopted in 2004 (IMO, 2009). In practice it is probable that *R. venosa* would remain undetected until established. According to ICES (2004) an eradication programme using nets and dredges, and a public education programme were proposed for the Brittany coast. Removal or eradication methods could be logistically difficult, time consuming and expensive and could involve harm to non-target species. Harding (2003) reported the predation by blue crab *Callinectes sapidus* on *R. venosa* in Chesapeake Bay, USA, suggesting a possible natural biological control mechanism. |
| 1.31 | Even if permanent establishment of the organism is unlikely, how likely is it that transient populations will be maintained in the Risk Assessment area through natural migration or entry through man's activities (including intentional release into the outdoor environment)? | likely - 3 | LOW - 0 | Due to the nature of shipping operations the continued possibility of accidental introductions exists. |

| | Spread | RESPONSE | UNCERTAINTY | COMMENT |
|---|---|---|---|---|
| 2.1 | How rapidly is the organism liable to spread in the Risk Assessment area by natural means? | rapid - 3 | MEDIUM -1 | Harding & Mann (2005) noted concern at the rate of range extension of *R. venosa* in the Chesapeake Bay region, USA. The first collections of adult specimens and egg masses in 1998 was followed by three distinct range extensions in the following seven years. At least part of this extension is attributed to natural population expansion, representative of seasonal migration or foraging activity, with larval transport facilitated by tidal currents. Adult *R. venosa* were shown to tolerate exposure to salinities as low as 10 ppt for several days, allowing migration some distance upriver. *R. venosa* was introduced into the Black Sea in the 1940s and within a decade had spread along the Caucasian and Crimean coasts and to the Sea of Azov. Its range extended into the northwest Black Sea to the coastlines of Romania, Bulgaria and Turkey from 1959 to 1972 (a distance of >500 miles). Further populations have been reported in the northern Adriatic and Aegean seas (Mann & Harding, 2000). And population expansion westward across the Mediterranean continues. Once established in the Black Sea it is thought that the subsequent expansion could have been facilitated by planktonic larval dispersal alone, without the need for other vectors (ICES, 2004) Observed salinity tolerances and potential for dispersal of planktonic larvae by coastal currents would indicate a high probability of spreading by natural means. |
| 2.2 | How rapidly is the organism liable to spread in the Risk Assessment area by human assistance? | rapid - 3 | MEDIUM -1 | There is potential for spread in the risk assessment area through vectors mentioned previously; planktonic larvae in ballast water, as part of hull-fouling communities; or transported (eggs or individual animals) in association with other material (for example lobster pots, fishing nets, shellfish). Dredging activities targeting commercial species such as oysters and scallops may further facilitate spread. |
| 2.3 | How difficult would it be to contain the organism within the Risk Assessment area? | difficult - 3 | LOW - 0 | The nature of previous invasions in the Black Sea, Chesapeake Bay and other areas would indicate that containment within one geographical area would be difficult. |
| 2.4 | Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism. | | | Areas with suitable habitat (soft sediment/hard sand and also some hard substrata) are potentially endangered. This may include protected areas such as SACs including sandflats and mudflats (290000 hectares throughout UK), estuaries (308355 hectares throughout UK), shallow bays and inlets (764560 hectares througout UK) and areas of aquaculture/mariculture. According to Harding *et al.* , 2008, the reproductive range of *R. venosa* may be limited to a latitudinal range of 30 - 41° (N and S) due to the influence of water temperature and daylength cycles on egg capsule deposition. However, water temperatures in some areas of the risk assessment area, during summer months (e.g. estuaries and shallow inlets and bays), may support reproduction. Furthermore, *R. venosa* exhibits several adaptations to salinity levels, pollution, and depleted oxygen and so it would be prudent to recognise the potential for adaptation to temperature. It is possible that Northern England and Wales and Scotland may be less at risk of invasion than areas on the southern coasts of England and Wales due to colder waters, however the potential for the species to adapt to colder temperatures and thus pose a threat to these areas should not be ruled out. Shallow, sheltered coastal waters and estuaries on the south coast of England and Wales may be most endangered due to the potential for localised seasonal warming and proximity to source populations. |

| | Impacts | RESPONSE | UNCERTAINTY | COMMENT |
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| 2.5 | How important is economic loss caused by the organism within its existing geographic range? | major - 3 | MEDIUM -1 | Following the introduction of *R. venosa* to the Black Sea, its excessive predation on native mussel stocks has resulted in their disappearance in some areas. However, *R. venosa* has since become an important commercial species in the region and are fished throughout coastal waters (Langmead *et al.*, 2008). The successful local recruitment of *R. venosa* in Chesapeake Bay, USA has raised concerns about the co-location of the invasion with a native hard clam (*M. mercenaria*) population that supports a local fishery worth in excess of $3 million per year (ICES, 2004).<br>However, despite initial concerns about the potential impact in certain regions (Mediterranean Sea and northern Adriatic Sea) no obvious impacts have yet been reported (Streftaris & Zenetos, 2006). |
| 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 | The figures are based on (A) overall area of sandflats and mudflats (733100 ha), estuaries (308355 ha), shallow bays and inlets (764560 ha) in UK waters (JNCC, 2009:http://www.jncc.gov.uk/page-4166 ). These habitats are potentially suitable sites for establishment of *R. venosa.* (B) Due to the successful establishment of *R. venosa* following invasions in other geographical regions, all suitable areas are considered 'at risk' for the purposes of this assessment although uncertainty is high. (C) *R. venosa* has not yet become established in UK waters. (D) Total value of UK mussel, oyster, clam, cockle and scallop production in 2006 was £35.77million (FAO, 2009). (E) Estimated final proportion of the resource value at risk is based on records of *R. venosa* having decimated native bivalve populations in the Black Sea following introduction in the 1940s. Again, there is high uncertainty with such an estimation. (F) *R. venosa* displays high fecundity, fast growth rate and spread is facilitated by a long planktonic larval stage. Thus, if establishment were successful it would be possible for *R. venosa* to extend its range around UK waters fairly quickly. (G) There are no proven methods of control or eradication for this species. The cryptic nature of *R. venosa* presents difficulty in observation until individuals reach a large size. Egg case mats may be spread over vast areas. Dredging for infaunal populations would involve unacceptable environmental harm. Large epifaunal individuals may be recognised and collected but this method would be extremely time consuming and present logistical difficulties. In Chesapeake Bay, USA, a bounty system operates but this is intended as a monitoring method. Temporary, focused fisheries for this species are an option suggested by ICES, 2004 with possible subsidised effort. |
| 2.7 | How great a loss in producer profits is the organism likely to cause due to changes in production costs, yields, etc., in the Risk Assessment area? | moderate - 2 | HIGH -2 | Total value of UK mussel, oyster, clam, cockle and scallop production in 2006 was £35.77million (FAO, 2009). In the Black Sea, *R. venosa* decimated native bivalve populations in some areas. No quantitative data was found concerning the precise extent of population decline, or associated costs. |
| 2.8 | How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area? | moderate - 2 | HIGH -2 | If native shellfish stocks were severely affected by the establishment of *R. venosa*, market price would rise and consumer demand may be affected. |
| 2.9 | How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets? | moderately likely - 2 | HIGH -2 | If native shellfish stocks were severely affected by the establishment of *R. venosa*, export markets could be affected by rising costs and reduced demand. |
| 2.10 | How important would other economic costs resulting from introduction be? (specify) | moderate - 2 | HIGH -2 | Potential job losses if aquaculture were affected. Costs involved with attempts at control or eradication could be considerable due to logistical difficulties. |
| 2.11 | How important is environmental harm caused by the organism within its existing geographic range? | major - 3 | LOW - 0 | Responsible for the decimation of native oyster, scallop, and mussel populations in receiving environments; this impact arises due to a general lack of competition from other predatory gastropods, a lack of direct predation on *R. venosa* by resident predators, and an abundance of potential prey species (ICES, 2004). A decline in epibenthic, structure forming bivalves (such as the mussel *Mytilus edulis*) caused by increased predation may reduce the availability of this diverse habitat locally. Such a loss may result in reduced refuge for juvenile crustaceans and other organisms(Sewell *et al.*, 2008). *R. venosa* could become a severe competitor for the native whelk *B. undatum* (ISSG, 2006). Other impacts include the provision of larger shells to hermit crabs allowing increased growth and increased demand by hermit crabs on food resources (ISSG, 2006). |
| 2.12 | How important is environmental harm likely to be in the Risk Assessment area? | major - 3 | MEDIUM -1 | Should *R. venosa* become established in the risk assessment area, it would likely have significant adverse impacts on the biodiversity and local environment, in particular native soft sediment bivalve communities typical of many estuaries, mud flats and sandflats, shallow inlets and bays, and large areas of open coast throughout the UK. Areas of particular concern include areas where bivalves form biogenic reefs, for example mussel beds. Reduced food availability may impact other species which prey on bivalves, including species of crab, bird, fish, starfish and other predatory gastropods (Sewell *et al.*, 2008). However, this may be dependent on water temperatures remaining above 18 ℃ for extended periods - current literatu re suggests that egg case deposition, hatching and larval development require such conditions (ICES, 2004; Harding *et al*, 2008). |

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| 2.13 | How important is social and other harm caused by the organism within its existing geographic range? | minor - 1 | MEDIUM -1 | Loss of income where aquaculture is affected. Reduction in consumer choice and possibly loss of traditional fisheries where native shellfish stocks are severely affected. Important to note that in the Black Sea, fisheries have adapted to include *R. venosa* following decimation of native mussels (Langmead *et al.* , 2008). |
| 2.14 | How important is the social harm likely to be in the Risk Assessment area? | minor - 1 | HIGH -2 | Loss of income if aquaculture is impacted. Reduction in consumer choice and possible loss of traditional fisheries if native shellfish stocks are severely affected. |
| 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 | LOW - 0 | No native congeners are 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? | likely - 3 | MEDIUM -1 | No known natural predators occur in the risk assessment area. This species may provide a food source for large crabs but due to fast growth rate and large size, a predator refuge size is quickly achieved (Harding, 2003). |
| 2.17 | How easily can the organism be controlled? | very difficult - 4 | LOW - 0 | There are no proven methods of control or eradication for this species. The burrowing nature of *R. venosa* presents difficulty in observation until individuals reach a large size. The small size of juveniles would render them easy to overlook when associated with imported bivalves. Egg case mats may be spread over vast areas and hence would present logistical difficulties for attempts at removal. Dredging for infaunal populations would involve unacceptable environmental harm. Large epifaunal individuals may be recognised and collected by hand but this method would be extremely time consuming and present logistical difficulties (ICES, 2004). |
| 2.18 | How likely are control measures to disrupt existing biological or integrated systems for control of other organisms? | unlikely - 1 | HIGH -2 | No information was found about the likelihood of disruption to control measures for other organisms. |
| 2.19 | How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms? | very unlikely - 0 | MEDIUM -1 | No information was found to suggest the likelihood of *R. venosa* acting as food, host, symbiont or vector for other damaging organisms. |
| 2.20 | Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur | | LOW - 0 | Sandbanks, estuaries, large shallow inlets and bays (including protected areas). Commercial fishing areas and bivalve aquaculture sites. |

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| **Summarise Entry** | very likely - 4 | LOW - 0 | Entry into new geographical regions has continued since first reported in the Black Sea in the 1940s. Mann & Harding (2003) suggest that the initial introduction of *R. venosa* to the Black Sea in the 1940s was probably associated with oysters transported from the Orient, but planktonic larval transport in ballast water is the most likely vector for subsequent range extension (Harding & Mann, 2005). An extended planktonic larval phase of up to 80 days facilitates this method of entry. |
| **Summarise Establishment** | moderately likely - 2 | MEDIUM -1 | Suitable habitat and prey species are widespread throughout the risk assessment area Climatic and other abiotic conditions are similar to those in the current area of distribution. Establishment is unlikely to be prevented through predation. However, risk of establishment has been summarised as moderate because literature suggests that water temperatures of at least 18 ℃ for extended periods are required for egg case deposition, hatching and larval development (ICES, 2004; Harding *et al.* , 2008). The risk assessment area is unlikely to attain such temperatures for extended periods, with the possible exception of localised shallow, sheltered water bodies. This may change with rising seawater temperatures associated with climate change. |
| **Summarise Spread** | rapid - 3 | LOW - 0 | Observed salinity tolerances and potential for dispersal of planktonic larvae by coastal currents would indicate a high probability of spreading by natural means (Mann & Harding, 2003). Spread would also be facilitated by human assistance through vectors including ballast water and egg case movement. Dredging activities may further facilitate spread. *R. venosa* was introduced into the Black Sea in the 1940s and within a decade spread along the Caucasian and Crimean coasts and to the Sea of Azov (a distance of <500 miles). Its range extended into the northwest Black Sea to the coastlines of Romania, Bulgaria and Turkey from 1959 to 1972 (ICES, 2004). Further populations have been reported in the northern Adriatic and Aegean seas (Mann & Harding, 2000). Expansion westward across the Mediterranean continues. Harding & Mann (2005) noted concern at the rate of range extension of R. venosa in the Chesapeake Bay region, USA. The first collections of adult specimens and egg masses in 1998 was followed by three distinct range extensions in the following seven years. At least part of this extension is attributed to natural population expansion. |
| **Summarise Impacts** | major - 3 | MEDIUM -1 | Responsible for the decimation of native oyster, scallop, and mussel populations in receiving environments. Impacts are exacerbated by a general lack of competition from other predatory gastropods, a lack of direct predation on *R. venosa* by resident predators, and an abundance of potential prey species. A decline in epibenthic, structure forming bivalves caused by increased predation, may reduce the availability of this diverse habitat locally (Sewell *et al.* , 2008). Such a loss may result in reduced refuge for juvenile crustaceans and other organisms (ICES, 2004). Could become a severe competitor for the native whelk *B. undatum* (ISSG, 2006). The primary economic impacts would arise from loss of shellfish production, in particular mussels, oysters and scallops. It is likely that environmental impacts will occur in all environments where *R.venosa* is likely to become established. Economic impacts will be most severe if the species becomes established in sites used for mariculture or where comercial shellfisheries occur. |
| **Conclusion of the risk assessment** | HIGH -2 | MEDIUM -1 | Entry into and spread within the risk assessment area are very likely due to connectivity of suitable habitat, suitable environmental conditions and wide dispersal potential of larvae. Successful establishment of reproductive populations is less certain owing to the apparent requirement for water temperatures of 18 ℃ for extended periods in order for egg case laying, hatching and larval development to occur (ICES, 2004; Harding *et al.* , 2008). It is possible that Northern England and Wales and Scotland may be less at risk of invasion than areas on the southern coasts of England and Wales due to colder waters, however the potential for the species to adapt to colder temperatures and thus pose a threat to these areas should not be ruled out. Shallow, sheltered coastal waters and estuaries on the south coast of England and Wales may be most endangered due to the potential for localised seasonal warming and proximity to source populations. If establishment were to be successful, it would present a high risk to native bivalves. The lack of competition and predation on *R. venosa* and a non-specific diet have resulted in the decimation of native bivalve populations in the Black Sea (ICES, 2004). Could become a severe competitor for the native whelk *B. undatum* . Potential economic losses associated with successful establishment would primarily involve adverse impacts upon native bivalve production. |

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| **Conclusions on Uncertainty** | | MEDIUM -1 | Due to its predatory impact *R. venosa* is considered one of the most unwelcome invasive species worldwide (Kerckhof *et al.*, 2006). As a result, it has been the subject of numerous studies and hence the quality of information provided in this risk assessment is considered to be reliable. The principal uncertainty centres around the ability of *R. venosa* to reproduce in the risk assessment area due to temperatures. Harding *et al.* (2008) suggest a latitudinal range of 30 - 41 °(N & S) as the realised reproductive range on the basis of water temperatures and daylength cycles. Further research into the reproductive potential of *R. venosa* in UK waters would be welcome. |

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