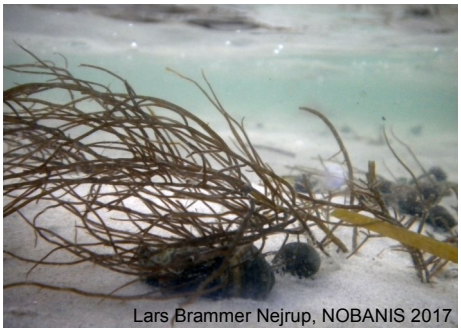
# *Gracilaria vermiculophylla*

- Red marine seaweed from the northwest Pacific.
- Large populations recently discovered in Dorset.
- Forms mats which may displace native species and can foul nets and propellers.


Lars Brammer Nejrup, NOBANIS 2017

## History in GB

Recently found in Dorset where large populations exist in Christchurch Harbour and on Brownsea Island, Poole Harbour. One individual has also been collected in Kingsbridge, Devon.
*G. vermiculophylla* occurs in shallow estuaries and bays, of which there are many in the risk assessment area.

## Native distribution

Native to the northwest Pacific (Japan, Korea, China and Vietnam).

**[map not available]**

## Distribution in GB


Adapted from: NBN 2017

## Impacts

Environmental

- Forms algal mats. Large populations may displace native species and cause mortality in larval stages by reducing light and oxygen availability.

Economic

- Damage to nets and propellers from fouling.

Social

- None known.

## Introduction pathways

Contaminant – *G. vermiculophylla* is thought to have been introduced originally through oyster cultivation. Further introductions may take place by this route or through transport of fragments via shipping or leisure craft.

## Spread pathways

Natural - within five years of the first record in northern Europe it was considered to be one of the most abundant macroalgae in the region, with a probable range increase of 150km in 2 years.
Human-aided - may spread from the areas where it is already found by transport of fragments via shipping, leisure craft or oyster cultivation.

## Summary

| | Risk | Confidence |
|---|---|---|
| Entry | VERY LIKELY | VERY HIGH |
| Establishment | VERY LIKELY | HIGH |
| Spread | RAPID | HIGH |
| Impacts | MODERATE | MEDIUM |
| Conclusion | MEDIUM | MEDIUM |

**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@apha.gsi.gov.uk

**Rapid Risk Assessment of: *Gracilaria vermiculophylla* (Ohmi) Papenfuss**
**Author: Christine Maggs**
**Date: December 2013**
**Signed off by NNRAP: November 2016**
**Approved by Programme Board: February 2017**
**Placed on NNSS website: February 2017**
**Suggestion citation: Maggs, Christine A. & Magill, Caroline L. (2014). GB Non-native Organism Rapid Risk Assessment for *Gracilaria vermiculophylla*. www.nonnativespecies.org**

## GB Non-native species Rapid Risk Assessment (NRRA)

### Introduction:

The rapid risk assessment is used to assess invasive non-native species more rapidly than the larger GB Non-native Risk Assessment. The principles remain the same, relying on scientific knowledge of the species, expert judgement and peer review. For some species the rapid assessment alone will be sufficient, others may go on to be assessed under the larger scheme if requested by the Non-native Species Programme Board.

### Guidance notes:

- We recommend that you read all of the questions in this document before starting to complete the assessment.
- Short answers, including one word answers, are acceptable for the first 10 questions. More detail should be provided under the subsequent questions on entry, establishment, spread, impacts and climate change.
- References to scientific literature, grey literature and personal observations are required where possible throughout.

**1** - What is the principal reason for performing the Risk Assessment? (Include any other reasons as comments)

**Response:** ***PROVIDED (To rapidly assess the risk associated with this species in GB)***

**2** - What is the Risk Assessment Area?

**Response:** ***PROVIDED (GB)***

**3** - What is the name of the organism (scientific and accepted common; include common synonyms and notes on taxonomic complexity if relevant)?

**Response:** ***Gracilaria vermiculophylla***

**4** - Is the organism known to be invasive anywhere in the world?

**Response: Yes.**

*Gracilaria vermiculophylla* is native to the NW Pacific (Japan, Korea, China and Vietnam) and was described from Hokkaido by Ohmi (1956). *G. vermiculophylla* was first reported outside this range in the Eastern Pacific, Mexico and California (Bellorin, 2004) and later in British Columbia (Saunders, 2009). Populations have been

identified in the Western North Atlantic in Virginia (possibly dating from 1999; Thomsen *et al*., 2005), and North Carolina (Freshwater *et al*., 2006). Molecular identification of herbarium specimens from 2000 has also confirmed the presence of *G. vermiculophylla* in New England from at least that date (Nettleton *et al*., 2013). The first report in the North East Atlantic was from France (Rueness, 2005); since then the alga has been recorded in: Sweden in 2003 (Wallentinus & Jenneborg, 2003, see Nyberg, 2007); Germany, Kiel Bight, in 2005 (Schories & Selig, 2006); Denmark (Nielsen, 2005, see Nyberg, 2007), Belgium (Kerckhof *et al*., 2012, in: ICES WGITMO, 2012) and Norway (ICES WGITMO, 2013). The alga is also present on the Atlantic coast of Morocco (Guillemin *et al.*, 2008) and was found in the Italian Mediterranean in 2008 (Sfriso *et al*., 2010). *G. vermiculophylla* was ranked as one of the top four macroalgal species most likely to become invasive in Europe (Nyberg, 2007). *G. vermiculophylla* has been recorded in N. Ireland (Strangford Lough, Co. Down) and the Republic of Ireland (Carlingford Lough, Dundrum Bay) and has become established in Carlingford Lough and Dundrum Bay as there have been records of it in the same areas over 5 years. These populations reproduce sexually as well as vegetatively and all reproductive phases have been observed (personal observations).

## **5** - What is the current distribution status of the organism with respect to the Risk Assessment Area?

**Response:**

We have recently found that this species occurs within the Risk Assessment Area, in Dorset. There are large established populations in Christchurch Harbour and on Brownsea Island, Poole Harbour. One individual has also been collected in Kingsbridge, Devon.

## **6** - Are there conditions present in the Risk Assessment Area that would enable the organism to survive and reproduce? Comment on any special conditions required by the species?

**Response: Yes.**

*G. vermiculophylla* occurs in shallow, low energy, soft-bottomed estuaries and bays (Freshwater *et al*., 2006; Thomsen *et al*., 2007; Sfriso *et al*., 2010). Established populations are often found in association with habitat-building benthic invertebrates, for example, being incorporated into the tubes of *Diopatra cuprea* (Thomsen & McGlathery, 2005; Thomsen, 2010; Byers *et al*., 2012; Berke, 2012) or using the byssal threads of mussels for attachment (Thomsen *et al*., 2007). There are many shallow, muddy bays and estuaries in the Risk Assessment Area, with and without *Mytilus edulis* reefs.

## **7** - 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?

**Response: Yes.**

The alga has broad environmental tolerances. Growth has been observed at salinities from 5–45 ppt (Jensen *et al*., 2007) and survival down to 2 ppt (Nyberg, 2007). Non-native populations of *G. vermiculophylla* have been recorded from both cold and warm temperate waters.

## **8** - Has the organism established viable (reproducing) populations anywhere outside of its native range (do not answer this question if you have answered 'yes' to question 4)?

**Response: See Q4**

## **9** - Can the organism spread rapidly by natural means or by human assistance?

**Response: Yes**

*G. vermiculophylla* can survive emersion for long periods of time (Nyberg, 2007; Thomsen *et al*., 2007) which would allow it to be transported on nets and other marine equipment. Although like all red algae *G. vermiculophylla* does not have motile spores and therefore can only spread naturally by passive distribution, it can grow and reproduce as unattached fragments, facilitating the human assisted spread of the organism. It is often found near oyster or other shellfish fisheries (Rueness, 2005, C. Maggs *pers obs*) and it is thought that importation of oysters or shipping may have been the means of its original spread from its native range (Kim *et al*., 2010 and references therein). The introduction to Europe is suspected to have been on oysters imported from Virginia, USA (Rueness, 2005). Concerning the invasion of the Po Delta lagoons, Italy, mariculture (Manila clam) is again thought to be the vector as there is no shipping to the lagoons (Sfriso *et al*., 2010). One of the locations in Ireland where *G. vermiculophylla* has been reported has an oyster culture facility in close proximity. Once *G. vermiculophylla* becomes established, it can attain very high biomass and the long stringy thalli can easily become tangled in nets, boat propellers and other machinery allowing fragments to be transported to new areas (Thomsen *et al*., 2007).

## **10** - Could the organism itself, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment Area?

**Response: Yes.**

*G. vermiculophylla* has been reported fouling nets, trawls and power plant cooling intakes in N. Carolina, USA (Freshwater *et al*., 2006). In Hog Island Bay, Virginia, USA, one of the earliest sites to record the species, it accounts for ~80% of the total algal biomass (Thomsen & McGlathery, 2007).

*G. vermiculophylla* can form dense matted beds on substrate that was previously more open and accessible. This can affect deposit feeders, similar to what has been seen with *Caulerpa taxifolia* where red mullet changed their foraging behaviour in response to invasion by the alga (Levi & Francour, 2004).

The added three-dimensional structure that *G. vermiculophylla* mats create is thought to increase numbers and biodiversity of invertebrates by providing refuge (Nyberg *et al*., 2009; Thomsen 2010; Byers *et al*., 2012; Hammann *et al*., 2013; Thomsen *et al.*, 2013). However, the grazers that shelter amongst the algal mat may feed preferentially on nearby native algal species (Jensen *et al*., 2007; Weinberger *et al*., 2008; Nejrup *et al*., 2012; Hammam *et al*., 2013). There is also evidence that mats of *G. vermiculophylla* can retard settlement of native species by making the substratum inaccessible (Thomsen & McGlathery, 2006) and cause mortality in settled

larval or germling stages by reducing light and oxygen availability (Hammann *et al*., 2013).

Dense stands of algae can also encourage sediment accretion and shading, both of which can have effects on native erect and prostate algae (Piazzi *et al*., 2005) and seagrasses (Den Hartog, 1987, 1994; Davidson & Hughes, 1998). *Zostera spp.* were identified as an important component of the Annex I habitat "Large shallow inlets and bays, Estuaries and Mudflats" of the EC Habitats Directive 1992. *G. vermiculophylla* has been shown to have negative effects on *Zostera* spp. above-ground biomass (Martinez-Luscher & Holmer, 2010; Hoeffle *et al*., 2011; Thomsen *et al*., 2013). These effects are thought to be due to shading, depletion of oxygen and nutrients and reduced water currents (Holmer & Nielsen, 2007; Holmer *et al*., 2011). Dundrum Bay has small *Zostera* beds in the vicinity of the sites where *Gracilaria* has been reported and there is evidence of them co-occuring with a resultant reduction in seagrass biomass (C. Beer, pers. comm.). However *G. vermiculophylla* patches can be ephemeral (Abreu *et al*., 2011), as a large proportion of the biomass can occur as unattached thalli, thus it is not certain they are a long-term threat to seagrass species in the Risk Assessment Area.

## Entry Summary

Estimate the overall likelihood of entry into the Risk Assessment Area for this organism (comment on key issues that lead to this conclusion).

**Response: v*ery likely (already present)***

**Confidence: *very high***

**Comments (include list of entry pathways in your comments):**

It is known that *G. vermiculophylla* arrived in Poole Harbour prior to 2010, probably with oyster cultivation, and secondarily spread to Christchurch Harbour. It may spread from the nearby areas where it is already found, by transport of fragments via shipping, leisure craft or oyster cultivation; there may also be new introductions from the native range.

## Establishment Summary

Estimate the overall likelihood of establishment (comment on key issues that lead to this conclusion).

**Response: *very likely (already established)***

**Confidence: *high***

**Comments (state where in GB this species could establish in your comments, include map if possible):**

*G. vermiculophylla* has the potential to become established in any shallow soft-bottomed bay in the Risk Assessment Area as it has broad environmental tolerances. With increased rainfall and the resulting lowered salinities in estuaries and bays around the UK it is expected that the alga will become more widely established as it can out-compete most native algae under these conditions. *G. vermiculophylla* can also grow maximally at low irradiances, giving it an advantage in eutrophic estuaries (Jensen *et al*., 2007). Those bays with biogenic reefs are particularly at risk as an attached population of the algae could become established and persist where unattached populations may not.

## Spread Summary

Estimate overall potential for spread (comment on key issues that lead to this conclusion).

**Response: *rapid***

**Confidence: *high***

**Comments (include list of spread pathways in your comments):**

Within approximately five years of the first record in Northern Europe it was considered to be one of the most abundant macroalgae in the region (Germany, Sweden and Denmark), although biomass varied from year to year (Thomsen *et al*., 2007). The spread was rapid, e.g. Sweden: probable range increase of 150 km in two years (Nyberg *et al.,* 2009). *G. vermiculophylla* was first reported in Ireland in 2008 (Carlingford Lough), since then it has been found increasingly distant from this site with the latest new report coming from Strangford Lough, Co. Down, N. Ireland – a spread of around 70 km in approximately 6 years. However, the various populations could represent separate establishments.

## Impact Summary

### Estimate overall severity of impact (comment on key issues that lead to this conclusion)

**Response:** ***moderate***

**Confidence:** ***medium***

**Comments (include list of impacts in your comments):**

Populations fluctuating at present but with lowered salinity expected to result from differing rainfall patterns associated with global warming (Cook *et al*., 2014), large stable populations may become established. These are expected to have negative impacts on native biota and economic use of the area, including decreased *Zostera* biomass (Thomsen *et al*., 2013), decreased recruitment of benthic organisms (Thomsen & McGlathery, 2006; Hammann *et al*., 2013; although there may be a positive effect on mobile invertebrate fauna), increase of turf-forming and filamentous (Thomsen *et al*., 2006) algal species and decrease of upright terete species (Airoldi, 2003), and damage to nets and propellors from fouling algal thalli (Freshwater *et al*., 2006).

## Climate Change

### What is the likelihood that the risk posed by this species will increase as a result of climate change?

**Response:** ***high***

**Confidence:** ***high***

**Comments (include aspects of species biology likely to be effected by climate change (e.g. ability to establish, key impacts that might change and timescale over which significant change may occur):**

Increased rainfall may increase the competitive advantage of *G. vermiculophylla* over native algae less tolerant to low or fluctuating salinity. *G. vermiculophylla* can also grow maximally at low irradiances, giving it an

advantage in eutrophic estuaries (Jensen *et al*., 2007). As *G. vermiculophylla* is able to propagate from fragments, increased intensity and frequency of storms may help to increase dispersal and allow colonisation of new areas (Cook *et al*., 2014)

## Conclusion

Estimate the overall risk (comment on the key issues that lead to this conclusion).

**Response:** ***medium***

**Confidence:** ***medium***

**Comments:** Prior to its arrival, *G. vermiculophylla* was ranked as one of the top four macroalgal species most likely to become invasive in Europe (Nyberg, 2007) and non-native populations of *G. vermiculophylla* have been recorded from both cold and warm temperate waters. *G. vermiculophylla* occurs in shallow, low energy, soft-bottomed estuaries and bays (Freshwater *et al*., 2006; Thomsen *et al*., 2007; Sfriso *et al*., 2010). Established populations are often found in association with habitat-building benthic invertebrates (Thomsen & McGlathery, 2005; Thomsen *et al*., 2007; Thomsen, 2010; Byers *et al*., 2012; Berke, 2012). There are many shallow, muddy bays and estuaries in the Risk Assessment Area with and without *Mytilus edulis* reefs. The alga has broad environmental tolerances; growth has been observed at salinities from 5–45 ppt (Jensen *et al*., 2007) and survives down to 2 ppt (Nyberg, 2007). *G. vermiculophylla* can survive emersion for long periods of time (Nyberg, 2007; Thomsen *et al*., 2007) which would allow it to be transported on nets and other marine equipment.

Once *G. vermiculophylla* becomes established, it can attain very high biomass and the long stringy thalli can easily become tangled in nets, boat propellers and other machinery allowing fragments to be transported to new areas (Thomsen *et al*., 2007). Although the alga can have positive effects on biodiversity and abundance of mobile benthic invertebrates it can also retard recruitment of benthic organisms and cause mortality by forming dense mats on the substratum (Thomsen & McGlathery, 2006; Hammann *et al*., 2013). These dense mats of *G. vermiculophylla* can also have negative effects on *Zostera* spp. above-ground biomass (Martinez-Luscher & Holmer, 2010; Hoeffle *et al*., 2011; Thomsen *et al*., 2013) due to shading, depletion of oxygen and nutrients and reduced water currents (Holmer & Nielsen, 2007; Holmer *et al*., 2011). When large biomass occurs *G. vermiculophylla* has been reported to foul nets, trawls and power plant cooling intakes (Freshwater *et al*., 2006).

However, in Ireland and Dorset there is no real evidence of adverse ecological impacts as *G. vermiculophylla* tends to establish in muddy areas where there are few other macroalgae, and in insufficient biomass to impact on water movement and oxygen supply to infaunal invertebrates. Conversely, in Brownsea Island Lagoon it provides habitat for the lagoon specialist species *Corophium insidiosum*.

## Management options (brief summary):

### 1 - Has the species been managed elsewhere? If so, how effective has management been?

**Response: Not really (see boxes below)**

### 2 - List the available control / eradication options for this organism and indicate their efficacy.

**Response:**

Physical removal and collection of the alga for agar extraction (Villaneuva *et al.*, 2010) and other marine bioactives (Imbs *et al.*, 2012; Kim *et al.*, 2012). Careful monitoring of oyster spat for attached fragments and inspection of nets and boat propellers for entangled alga.

### 3 - List the available pathway management options (to reduce spread) for this organism and indicate their efficacy.

**Response:** It seems very unlikely that spread can be slowed down or affected because there are multiple possible origins of invasive populations that are now established in Europe.

### 4 - How quickly would management need to be implemented in order to work?

**Response:** Unlikely to be effective at all.

## References

Provide here a list of the references cited in the course of completing assessment

**List:**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