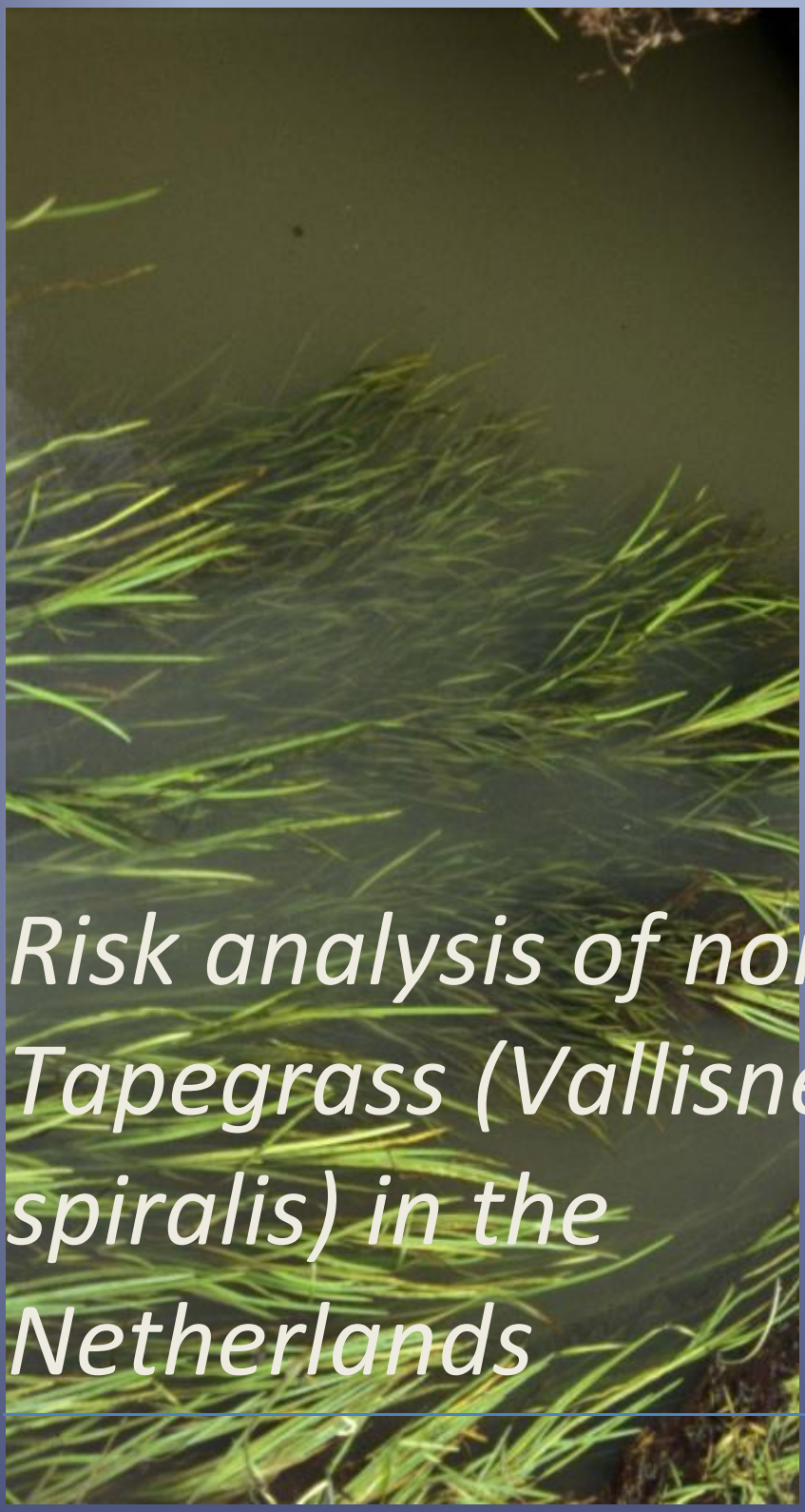

Risk analysis of non-native Tapegrass (Vallisneria spiralis) in the Netherlands

By J. Matthews, R. Beringen, F.P.L. Collas, K.R. Koopman, B. Odé, R. Pot, L.B. Sparrius, J.L.C.H. van Valkenburg, L.N.H. Verbrugge & R.S.E.W. Leuven

Risk analysis of non-native Tapegrass (*Vallisneria spiralis*) in the Netherlands

J. Matthews, R. Beringen, F.P.L. Collas, K.R. Koopman, B. Odé, R. Pot, L.B. Sparrius, J.L.C.H. van Valkenburg, L.N.H. Verbrugge & R.S.E.W. Leuven

draft report
22 August 2012

Radboud University Nijmegen,
Institute for Water and Wetland Research
Department of Environmental Sciences,
FLORON & Roelf Pot Research and Consultancy

Commissioned by
Invasive Alien Species Team
Netherlands Food and Consumer Product Safety Authority
Ministry of Economic Affairs, Agriculture and Innovation

Roelf Pot research and consultancy

Floron

Netherlands Food and Consumer Product Safety Authority
Ministry of Economic Affairs, Agriculture and Innovation

Radboud University Nijmegen

Series of Reports on Environmental Science

The series of reports on Environmental Science are edited and published by the Department of Environmental Science, Institute for Water and Wetland Research, Radboud University Nijmegen, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands (tel. secretariat: + 31 (0)24 365 32 81).

Reports Environmental Science nr. 420

Title: Risk analysis of non-native Tapegrass (*Vallisneria spiralis*) in the Netherlands

Authors: J. Matthews, R. Beringen, F.P.L. Collas, K.R. Koopman, B. Odé, R. Pot, L.B. Sparrius, J.L.C.H. van Valkenburg, L.N.H. Verbrugge & R.S.E.W. Leuven

Cover photo: Tapegrass (*Vallisneria spiralis*) in a side-branch of the river Erft at Kasterer Mühlen, Northrhine-Westphalia, Germany (© Photo A. Hussner)

Project manager: Dr. R.S.E.W. Leuven, Department of Environmental Science, Institute for Water and Wetland Research, Radboud University Nijmegen, Heyendaalseweg 135, 6525 AJ Nijmegen, the Netherlands, e-mail: r.leuven@science.ru.nl

Project number: 62001590

Client: Netherlands Food and Consumer Product Safety Authority, P.O. Box 43006, 3540 AA Utrecht

Reference client: TRC/NVWA/2012/2009, order nr. 60400891, formdesk nr. 19460, specification code 6300004

Orders: Secretariat of the Department of Environmental Science, Faculty of Science, Radboud University Nijmegen, Heyendaalseweg 135, 6525 AJ Nijmegen, the Netherlands, e-mail: secres@science.ru.nl, mentioning Reports Environmental Science nr. 420

Key words: Dispersion; ecological effects; invasive species; management options, public health, socio-economic impacts

Printed on environmentally friendly paper

Contents

Summary

Tapegrass (*Vallisneria spiralis*) is an aquatic plant, non-native to the Netherlands. It was first recorded in the Netherlands in 1960 in the canal Maastricht-Luik and was recently observed in the Biesbosch area in the Rhine-Meuse estuary. Previously, there was a lack of knowledge regarding the pathways for introduction, vectors for spread, key factors for establishment and invasiveness, (potential) effects of *V. spiralis* and management options in the Netherlands. This report is the synthesis of results obtained from a literature study, field observations and expert consultation that address this knowledge gap in the form of a knowledge document. The knowledge document was used to assess the ecological risk using the Belgian ISEIA protocol. Socioeconomic and public health risks were assessed separately as these do not form part of the ISEIA protocol. Recommendations were then made regarding management options relevant to the situation found in the Netherlands.

Four factors are considered as part of the ISEIA protocol: dispersion potential and invasiveness, colonisation of high conservation habitats, adverse impacts on native species and alteration of ecosystem functions.

- Dispersion potential and invasiveness: Since it was first recorded in the Netherlands in the 1950s dispersal of *V. spiralis* has been slow and records remain limited to three distant locations. Plants are imported and sold as part of the plant trade and maybe released to the freshwater network by hobbyists. The species is able to reproduce vegetatively and can disperse via water, humans and bird vectors, displaying a strong reproductive potential. In future, the potential habitat area of *V. spiralis* may increase due to climate change and the discharge of cooling water.

- Colonisation of high conservation habitats: The only recent known habitat of *V. spiralis* in the Netherlands is the freshwater tidal area of the Biesbosch-Merwede, a Natura 2000 area. No other habitat of high conservation value in the Netherlands has been colonised by *V. spiralis*.

- Adverse impacts to native species: There is no evidence to suggest that *V. spiralis* has a negative impact on native species in the Netherlands. Field observations suggest that there are no signs that native aquatic plant species are displaced by *V. spiralis* in the Biesbosch.

- Alteration to ecosystem functions: No adverse effects of *V. spiralis* on ecosystem functioning in the Netherlands were identified.

Socio-economic impacts resulting from *V. spiralis* are limited in the Netherlands. Information from other countries indicates that *V. spiralis* is known to affect the drainage of different water bodies as well as impede recreational use.

There was no information found concerning the public health effects of *V. spiralis* during the literature study or in communications with project partners.

Banning of sale of *V. spiralis* via the plant trade is the most effective method of controlling its spread. Once established the management of plants is challenging. Managers may first wish to consider observing the dispersal potential of individual populations of *V. spiralis* prior to instigating active management. If populations become problematic (e.g. in cases of water-flow obstruction), isolation may be considered. This will facilitate the elimination of the species as was observed for isolated populations in Eijsden and Maastricht and other locations within the Netherlands. Costs and the risk of facilitating reproduction through fragmentation together with the limited dispersal potential of *V. spiralis* observed in the Netherlands since the 1950s, count against the early implementation of weed cutting measures.

V. spiralis is classified in the low risk category of the ISEIA protocol and C1 in the BFIS list, according to its recorded distribution. Category C1 includes species with distributions characterised by isolated populations with a low environmental hazard.

Although *V. spiralis* has been recorded in the Netherlands since the 1950s its recorded distribution is still limited. Moreover, no impacts on native species or on the functioning of ecosystems have been identified here. It is not expected that the distribution of *V. spiralis* will increase significantly in the future, that ecological and socio-economic impact will remain low and that *V. spiralis* will remain classified as a C1 species. Therefore, it is recommended that *V. spiralis* is not included in appendices of the Dutch Water Plant Code of Conduct.

It should be noted that *V. spiralis* is a very inconspicuous species. Most locations where the plants exist are almost invisible from on shore or from a boat making them difficult to locate. Therefore, there may well be discrepancies between the actual distribution and the recorded distribution of *V. spiralis* within the Netherlands. If the actual distribution of *V. spiralis* is higher than the recorded distribution then a re-classification of the species to a higher BFIS category would be required, for example C2. This category defines species characterised by a restricted range and a low environmental hazard.

1. Introduction

1.1 Background and problem statement

The Tapegrass (*Vallisneria spiralis*) is native in Northern Africa, Southern Europe and Asia. This plant species was first recorded in the Netherlands in 1960 in the canal Maastricht-Luik and was recently observed in the Biesbosch area in the Rhine-Meuse estuary (Boesveld, personal communication). At the start of this project, there was a lack of knowledge regarding the pathways for introduction, vectors for spread, key factors for dispersion and invasiveness, and (potential) effects of *V. spiralis* in the Netherlands.

To support decision making with regard to the design of measures to prevent ecological, socio-economical and public health effects, the Invasive Alien Species Team of the Netherlands Food and Consumer Product Safety Authority (Ministry of Economic Affairs, Agriculture and Innovation) has asked to carry out a risk analysis of *V. spiralis.* The present report assesses relevant available knowledge and data which is subsequently used to perform a risk analysis of this species.

1.2 Research goals

The major goals of this study are:

- To perform a risk analysis based on dispersion, invasiveness, (potential) impacts and management options of *V. spiralis* in the Netherlands.

- To assess the dispersion, invasiveness and (potential) ecological, socio-economic and public health effects of *V. spiralis* in the Netherlands

- To describe effective management options for control of spread, establishment and negative effects of *V. spiralis*.

1.3 Outline and coherence of research

The present chapter describes the problem statement, goals and research questions in order to undertake a risk analysis of *V. spiralis* in the Netherlands. Chapter 2 gives the methodological framework of the project, describes the Belgian Invasive Species Environmental Impact Assessment (ISEIA) protocol and approaches used to assess socio-economic risks, public health risks and management approaches applicable in the Netherlands. Chapter 3 describes the results of the risk assessment, summarises the results of the literature study of socio-economic and public health risks and analyses risk management options. Chapter 4 discusses gaps in knowledge and uncertainties, other available risk analyses and explains differences between risk classifications. Chapter 5 draws conclusions and gives recommendations for further research. An appendix with background information in the form of a knowledge document completes this report. The coherence between various research activities and outcomes of the study are visualised in a flow chart (Figure 1.1).

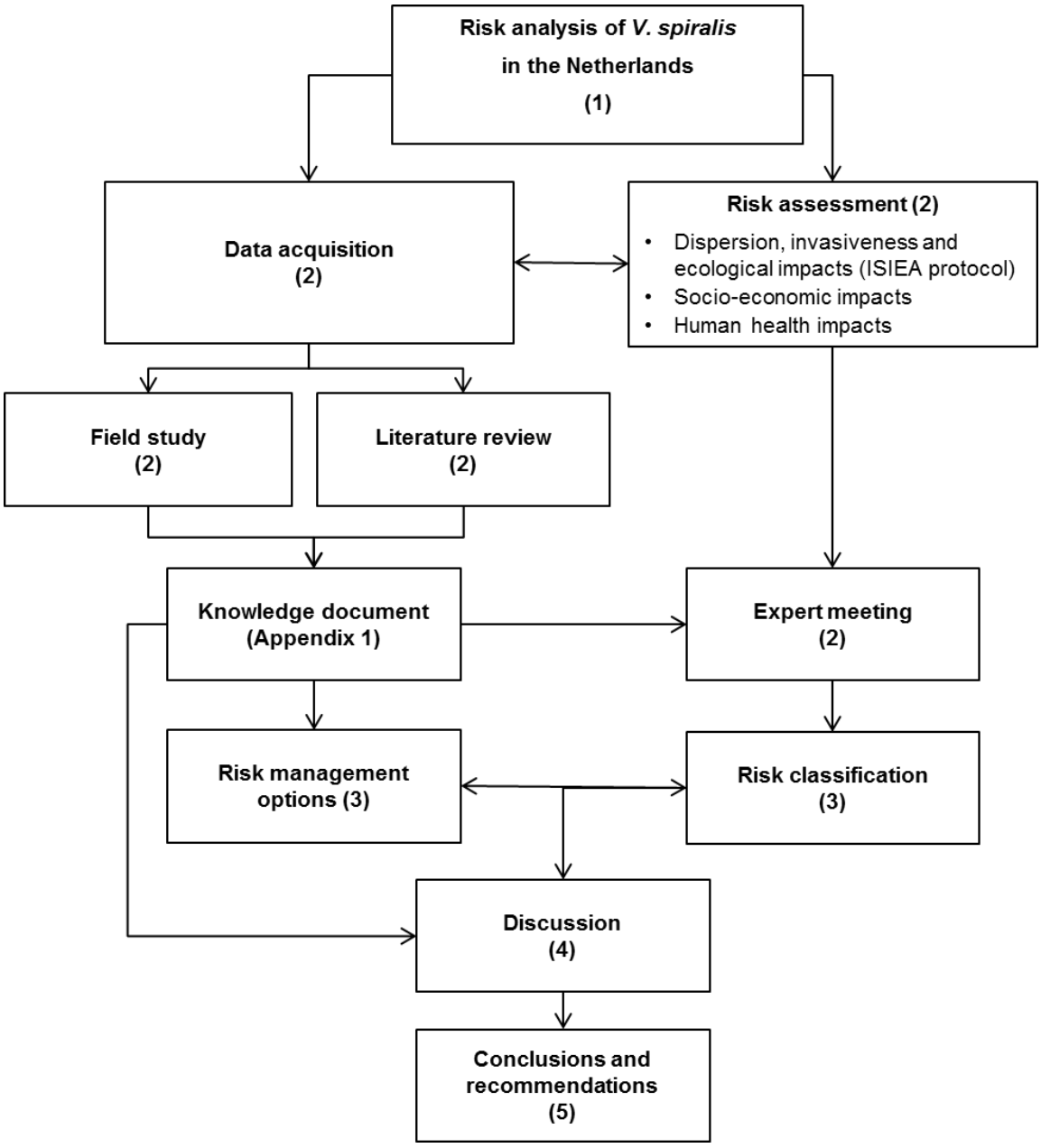

Figure 1.1: Flowchart visualising the coherence of various components of the risk analysis of Tapegrass (*Vallisneria spiralis*) in the Netherlands. Chapter numbers are indicated in brackets.

2. Methods

2.1 Components of risk analysis

The risk analysis of Tapegrass (*Vallisneria spiralis*) in the Netherlands was comprised of an ecological risk assessment using the Belgian Invasive Species Environmental Impact Assessment (ISEIA), developed by the Belgian Biodiversity Platform (Branquart, 2007; ISEIA, 2009). Separate assessments of socio-economic, public health impacts and management options were made. Background information and data used for the risk analysis was summarised in the form of a separate knowledge document (Section 2.2).

2.2 Knowledge document

A literature search and data analysis describing the current body of knowledge with regard to taxonomy, habitat preference, dispersal mechanisms, current distribution, ecological and socio-economic impacts and management options for *V. spiralis* was undertaken. The results of the literature search were presented in the form of a knowledge document (Collas *et al*., 2012; Appendix 1) and distributed to an expert team in preparation for the risk assessment.

2.3 Risk assessment

2.3.1 Dispersal potential, invasiveness and ecological impacts

The ISEIA protocol assesses risks associated with dispersion potential, invasiveness and ecological impacts only (Branquart, 2007). The *V. spiralis* risk assessment was carried out by an expert team. This team consists of five individuals. One from the Netherlands Food and Consumer Product Safety Authority; one from the Dutch plant research and conservation organisation FLORON; one from the Roelf Pot Research and Consultancy firm and two from the Radboud University, Nijmegen. Each expert completed an assessment form independently, based on the contents of the knowledge documents. Following this preliminary individual assessment, the entire project team met, elucidated differences in risk scores, discussed diversity of risk scores and interpretations of key information. The results of these discussions were presented in an earlier draft of this report. Following the submission of this draft version to the expert team, further discussion led to agreement on consensus scores and the level of risks relating to the four sections contained within the ISEIA protocol (Table 2.1).

Table 2.1: Definitions of criteria for risk classifications per section used in the ecological risk assessment protocol (Branquart, 2007; ISEIA, 2009).

1. Dispersion potential or invasiveness risk	
Low	The species does not spread in the environment because of poor dispersal capacities and a low reproduction potential.
Medium	Except when assisted by man, the species doesn't colonize remote places. Natural dispersal rarely exceeds more than 1 km per year. However, the species can become locally invasive because of a strong reproduction potential.
High	The species is highly fecund, can easily disperse through active or passive means over distances > 1km / year and initiate new populations. Are to be considered here plant species that take advantage of anemochory, hydrochory and zoochory, insects like *Harmonia axyridis* or *Cemeraria ohridella* and all bird species.
2. Colonisation of high conservation habitats risk	
Low	Population of the non-native species are restricted to man-made habitats (low conservation value).
Medium	Populations of the non-native species are usually confined to habitats with a low or a medium conservation value and may occasionally colonise high conservation habitats.
High	The non-native species often colonises high conservation value habitats (i.e. most of the sites of a given habitat are likely to be readily colonised by the species when source populations are present in the vicinity) and makes therefore a potential threat for red-listed species.
3. Adverse impacts on native species risk	
Low	Data from invasion histories suggest that the negative impact on native populations is negligible.
Medium	The non-native is known to cause local changes (<80%) in population abundance, growth or distribution of one or several native species, especially amongst common and ruderal species. The effect is usually considered as reversible.
High	The development of the non-native species often causes local severe (>80%) population declines and the reduction of local species richness. At a regional scale, it can be considered as a factor for precipitating (rare) species decline. Those non-native species form long standing populations and their impacts on native biodiversity are considered as hardly reversible. Examples: strong interspecific competition in plant communities mediated by allelopathic chemicals, intra-guild predation leading to local extinction of native species, transmission of new lethal diseases to native species.
4. Alteration of ecosystem functions risk	
Low	The impact on ecosystem processes and structures is considered negligible.
Medium	The impact on ecosystem processes and structures is moderate and considered as easily reversible.
High	The impact on ecosystem processes and structures is strong and difficult to reverse. Examples: alterations of physico-chemical properties of water, facilitation of river bank erosion, prevention of natural regeneration of trees, destruction of river banks, reed beds and / or fish nursery areas and food web disruption.

The ISEIA protocol contains twelve criteria that match the last steps of the invasion process (i.e., the potential for spread establishment, adverse impacts on native species and ecosystems). These criteria are divided over the following four risk sections: (1) dispersion potential or invasiveness, (2) colonisation of high conservation habitats, (3) adverse impacts on native species, and (4) alteration of ecosystem functions. Section 3 contains sub-sections referring to (i) predation / herbivory, (ii) interference and exploitation competition, (iii) transmission of diseases to native species (parasites, pest organisms or pathogens) and (iv) genetic effects such as hybridisation and introgression with native species. Section 4 contains sub-sections referring to (i) modifications in nutrient cycling or resource pools, (ii) physical modifications to habitats (changes to hydrological regimes, increase in water turbidity, light interception, alteration of river banks, destruction of fish nursery areas, etc.), (iii) modifications to natural successions and (iv) disruption to food-webs, i.e. a modification to lower trophic levels through herbivory or predation (top-down regulation) leading to ecosystem imbalance.

Each criterion of the ISEIA protocol was scored. Scores range from 1 (low risk) to 2 (medium risk) and 3 (high risk). Definitions for low, medium and high risk, according to the four sections of the ISEIA protocol are given in table 2.1. If knowledge obtained from the literature review was insufficient, then the assessment was based on expert judgement and field observation leading to a score of 1 (unlikely) or 2 (likely). If no answer could be given to a particular question (no information) then no score was given (DD - deficient data). Finally, the highest score within each section was used to calculate the total score for the species.

Consensus on the risk score of each section was reached using a hierarchical method where evidence from within the Netherlands was given priority over evidence derived from impacts occurring outside the Netherlands. It was also considered that the suitability of habitats in the Netherlands may change due to e.g. water temperature rise due to climate change. Moreover, consideration was given to the future application or non-application of management measures that will affect the invasiveness and impacts of this invasive plant in the Netherlands.

Subsequently, the Belgian Forum Invasive Species (BFIS) list system for preventive and management actions was used to categorise the species of concern (Branquart, 2007; ISEIA, 2009). This list system was designed as a two dimensional ordination (Environmental impact * Invasion stage; Figure 2.1). This list system is based on guidelines proposed by the Convention on Biological Diversity (CBD decision VI/7) and the European Union strategy on invasive non-native species. Environmental impact of the species was classified based on the total risk score (global environmental risk) which is converted to a letter / list: score 4-8 (C), 9-10 (B - watch list) and 11-12 (A - black list). This letter is then combined with a number representing invasion stage: (0) absent, (1) isolated populations, (2) restricted range, and (3) widespread.

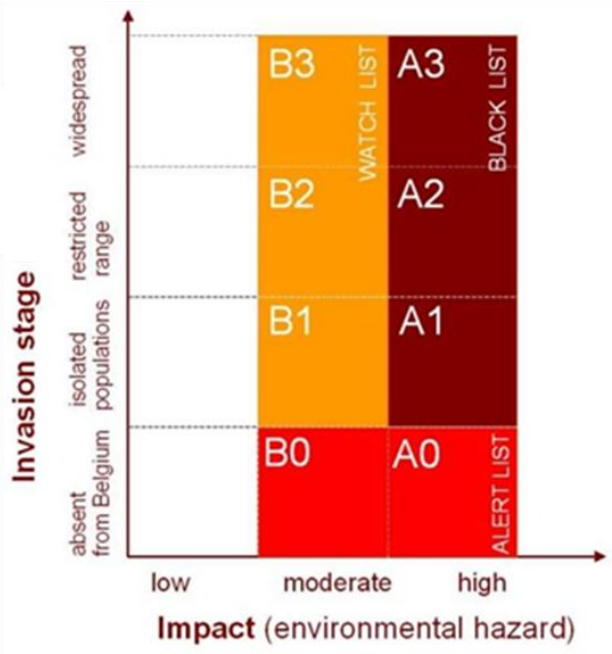

Figure 2.1: List system to identify species of most concern for preventive and mitigation action (Branquart, 2007; ISEIA, 2009).

2.3.2 Socio-economic and public health impacts

Potential socio-economic and public health impacts did not form a part in the risk analysis according to the ISEIA protocol. However, these potential risks should be considered in an integrated risk analysis. Socio-economic risks were examined as part of the literature study (Collas *et al.*, 2012) and in discussions with project partners. Socio-economic risks occurring at present or in the future dependent on alterations in habitat suitability and management interventions were considered.

2.4 Risk management options

Management options were examined as part of the literature study and extensively described in the knowledge document (Appendix 1) and in discussions with project partners. A description of effective management options is given. These are specifically relevant to, and therefore recommended for, the Netherlands. Recommendations are given in the context of the Dutch Water Plant Code of Conduct which provides voluntary guidelines that recommends limitations on the sale on non-native plants in the Netherlands depending on their potential impacts (Netherlands Food and Consumer Product Safety Authority, 2010).

3. Risk analysis

3.1 Risk classification using the ISEIA protocol

3.1.1 Expert consensus scores

The total risk score attributed to Tapegrass (*Vallisneria spiralis*) was 7 out of a maximum risk score of 12. This results in an overall classification of low risk for this species.

Table 3.1: Consensus scores and risk classifications for Tapegrass (*Vallisneria spiralis*)

ISEIA Sections	Risk classification	Consensus score
Dispersion potential or invasiveness	high risk	3
Colonization of high value conservation habitats	medium risk	2
Adverse impacts on native species	low risk	1
Alteration of ecosystem functions	low risk	1
Global environmental risk	**C - list category**	**7**

3.1.2 Dispersion potential or invasiveness

Classification: **High risk**. *V. spiralis* is able to reproduce vegetatively and can disperse via water (hydrochory), humans and bird vectors, displaying a strong reproductive potential. Since it was first recorded in the Netherlands in the 1950s, dispersal of *V. spiralis* has been slow and the distribution of records within the Netherlands remains isolated to three distinct locations. However, there continues to be a market for *V. spiralis* in the Netherlands demonstrated by the availability of plants for sale online. This together with the possibility of voluntary disposal of plants by the public suggests that there is a continued risk of release of *V. spiralis* to the freshwater network. Moreover, records of *V. spiralis* may underestimate its actual distribution as plants are almost invisible if viewed from the water surface.

In future, the potential habitat area of *V. spiralis* will increase due to climate change and the discharge of cooling water. This may result in an increase in dispersal potential and a revision of the risk classification.

3.1.3 Colonisation of high conservation habitats

Classification: **Medium risk**. The only recent known habitat of *V. spiralis* in the Netherlands is the freshwater tidal area of the Biesbosch-Merwede. This area has a high conservation value since it is largely designated under the Habitat Directive as a Natura 2000 area. The area is also a bird directive area. The habitats in which the species grows within this area are more or less comparable to Habitat type H3260 Water courses of plain to mountain levels (*Ranunculion fluitantis* and *Callitricho-Batrachion*). However, no other habitat of high conservation value in the Netherlands has been colonised by *V. spiralis*.

3.1.4 Adverse impacts on native species

Classification: **Low risk**. There is no evidence to suggest that the presence of *V. spiralis* has a negative impact relating to predation / herbivory, interference and exploitation competition, transmission of diseases to native species and genetic effects such as hybridisation and introgression with native species. Field observations suggest that there are no signs that native aquatic plant species are displaced by *V. spiralis* in the Biesbosch.

3.1.5 Alteration of ecosystem functions

Classification: **Low risk**. There is no evidence to suggest that the presence of *V. spiralis* has a negative impact relating to modifications in nutrient cycling or resource pools, physical modifications to habitats, modifications to natural successions and disruption to food-webs.

3.1.6 Species classification

The species classification corresponds to global environmental risk score of the ISEIA (Table 3.1) combined with the current distribution of the non-native species within the country in question. The species classification for *V. spiralis* is C1 (Figure 3.1). This indicates a non-native species with isolated populations and low environmental hazard (ecological risk).

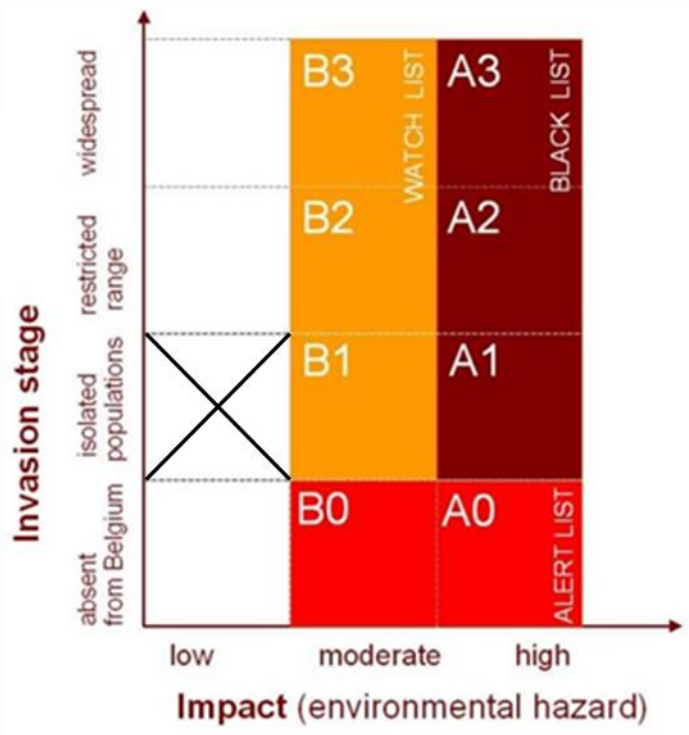

Figure 3.1: Tapegrass (*Vallisneria spiralis*) species classification according to the BFIS list system.

However, habitat alteration resulting from climate change may result in a future re-grading of risk. Future increases in water temperature may increase habitat availability

for the colonisation of *V. spiralis*. However, this increase in habitat availability is likely to be limited due to its relatively low minimum temperature tolerance for survival, the presence of warmer refuges in deeper water that do not appear to have influenced the distribution of *V. spiralis* in the past and the fact that *V. spiralis* has been recorded in the Netherlands since the 1950s without an extensive increase in distribution. It is expected, therefore, that impacts on native species and alterations to ecosystem functions will not alter from the present situation. This would lead to the same low global environmental risk classification as is seen today (Table 3.2). In this theoretical scenario *V. spiralis* would remain in the C1 classification within the BFIS list system.

Table 3.2: Tapegrass (*Vallisneria spiralis*) species theoretical classification according to potential future habitat scenario.

ISEIA Sections	Risk classification	Consensus score
Dispersion potential or invasiveness	high risk	3
Colonization of high value conservation habitats	medium risk	2
Adverse impacts on native species	low risk	1
Alteration of ecosystem functions	low risk	1
Global environmental risk	**C - list category**	**7**

3.2 Socio-economic impacts

There is little evidence of socio-economic impacts related to *V. spiralis* in the Netherlands. *V. spiralis* is known to affect the drainage of different water bodies as well as impede recreational use (CABI, 2012).

3.3 Public health effects

There was no information found concerning the public health effects of *V. spiralis* during the literature study or in communications with project partners.

3.4 Risk management

3.4.1 Prevention

The main distribution channel or vector for the spread of *V. spiralis* is the trade in plants for aquaria and garden ponds. The species may be replaced by *Sparganium emersum*, a more benign species, in the plant trade. Plants are also sold under the names *Vallisneria americana* and *Vallisneria gigantea* but the taxonomic status of this alternatives are unclear. These plants may be a more potable strain of *V. spiralis*, which makes them an even more risky alternative. Currently, in the Netherlands, a campaign is underway that aims to prevent further introductions and spread by making consumers and employees from garden centres and plant nurseries more aware of the problems with non-native species. The name of this campaign is 'Geen exoot in de sloot'. Its effectiveness is currently being examined (Verbrugge *et al.*, 2010). *V. spiralis* can be kept in isolation to prevent release from aquaria, with the cooperation of the owners. However, there is no feasible option for preventing spread of species after establishment in the freshwater network. *V. spiralis* cannot be stopped from autonomously dispersing through fragmentation or through the deployment of runners.

Public awareness is an important component in a strategy aimed at controlling or removing an invasive species from a catchment area. This is especially true of species such as *V. spiralis* where people are a major vector of dispersal. Awareness leaflets, press releases, calendars, lakeside notifications and an information website, warning of the environmental, economic and social hazards posed by this plant will contribute to public awareness (Caffrey & O'Callaghan, 2007).

Education of anglers and boaters may be especially useful as they can assist in reporting sightings of the plant.

3.4.2 Elimination

Once the plants have established eradication is very difficult. The best option to eliminate the species is through isolation of local populations. Natural disappearance should follow. Natural disappearance of isolated populations of *V. spiralis* has occurred near Eijsden and Maastricht and at other known sites in the Netherlands.

3.4.3 Control

There is no experience with species-specific control measures in the Netherlands. If control is required the best method is the removal of leaf biomass by weed cutting boats. Weed cutting boats are an example of active mechanical removal and are equipped with cutter bars coupled to a hydraulic control (Figure 3.2). This allows the depth and angle of the cutter bar to be adjusted in the water. Plants are cut more efficiently than with passive cutting boats. However, mechanical removal may result in the breakup of plant stems resulting in the dispersal of plants to new areas (Bowmer *et al.*, 1995). The dispersal of plant fragments and subsequent vegetative reproduction has been observed following the mechanical removal of the invasive Curly waterweed (*Lagarosiphon major*)

in the Netherlands (R. Pot, unpublished results). Therefore, it is recommended that *V. spiralis* is cut at a minimum height of 20 cm above the stem base to prevent spread of viable fragments with stolons or roots.

Figure 3.2: A weed cutting boat with adjustable mowing gear used for aquatic weed control in the Netherlands (©: Photo R. Pot).

4. Discussion

4.1 Risk assessment

A lack of information in the literature on the (potential) impact of Tapegrass (*Vallisneria spiralis*) in the Netherlands has resulted in a reliance on expert knowledge and field observations to judge the risk level of certain criteria. There is a lack of clarity regarding the taxanomic status of certain species. Moreover, it is not clear if only *V. spiralis* is circulated in the plant trade and present in the wild, or if other species, such as *Vallisneria americana,* are also present. The importance of water birds to the dispersal of *V. spiralis* in the Netherlands compared to other dispersal mechanisms is also unknown. This lack of information may be a reflection of the observed limited distribution of *V. spiralis* in the Netherlands at the present time.

V. spiralis is categorised as C1 (isolated populations and low environmental hazard) in the BFIS list system based on current records in the Netherlands. However, *V. spiralis* is a very inconspicuous species, most sites are almost invisible from on shore or from a boat. The real extent of *V. spiralis* presence in the Biesbosch only became clear in 2011 when, at low tide and in a period of low river discharge, leaves protruded above the water surface (Van der Neut & Muusse, 2011). Therefore, there may well be discrepancies between the actual distribution and the recorded distribution of *V. spiralis* within the Netherlands. If the actual distribution of *V. spiralis* is higher than the recorded distribution then a re-classification of the species to a higher BFIS category would be required, for example C2.

Future changes such as increases in water temperature associated with climate change may result in an increase in the distribution of *V. spiralis* in the Dutch freshwater network as well as in isolated water bodies. Therefore, the risk of impacts may have to be reassessed in future in view of greater potential impacts.

The ISEIA protocol is limited to an assessment of invasiveness and ecological impacts. Socio-economic impacts or impacts to human health were therefore considered separately.

Risk criteria in the ISEIA protocol were sometimes restrictive, as there was an absence of quantitative data that allowed the criteria to be assessed e.g. 1 km per year dispersal criterion for the ‘dispersion or invasiveness’ section.

4.2 Comparison of available risk classifications

No examples could be found where the ISIEA protocol was applied to assess the risk of *V. spiralis* in other countries.

Two risk assessments have been carried out for Tapegrass (*Vallisneria spiralis*). One risk assessment was performed in New Zealand and used the aquatic weed risk assessment model (AWRAM) with a minimum value of 4 and a maximum value of 100 (Champion & Clayton, 2000). *V. spiralis* scored a 51 and was thus listed as a

surveillance pest plant in New Zealand. However, the species assessed is now known as *Vallisneria australis* (Paul Champion, personal communication, July 23, 2012). The other assessment was carried out in Great Britain and was based on the Australian Weed Risk Assessment (WRA; Natural England, 2011). *V. spiralis* was classified as an urgent species with a score of 22 and a potential score of 28.

The high risk associated with *V. spiralis* to native species and ecosystem functions in other countries may be a function of a greater habitat suitability and resultant high level of invasiveness in those countries.

4.3 Risk management

Banning of sale of invasive plants via the plant trade continues to be the most potentially effective method of controlling the spread of invasive plant species. Once *V. spiralis* is released to the environment, control and elimination becomes more difficult.

Management by mechanical means has been recommended for the control and possible elimination of the species. However, managers may first wish to consider observing the dispersal potential of individual populations of *V. spiralis* prior to instigating active management. If populations become problematic (e.g. cause restriction in water flow), isolation may be considered as this will facilitate the elimination of the species. Isolated populations of *V. spiralis* have disappeared naturally in Eijsden and Maastricht and other locations within the Netherlands. Costs and the risk of a facilitation of reproduction through fragmentation together with the limited dispersal potential of *V. spiralis* observed in the Netherlands since the 1950s, count against the early implementation of weed cutting measures.

V. spiralis is classified in the low risk category of the ISEIA protocol. Although *V. spiralis* has been recorded in the Netherlands since the 1950s its distribution is still characterised by isolated populations. Moreover, no impacts on native species or on the functioning of ecosystems have been recorded in the Netherlands. It is not expected that the distribution of *V. spiralis* will increase significantly in the future. Therefore, it is recommended that *V. spiralis* is not included in appendices of the Dutch Water Plant Code of Conduct restricting its sale (Netherlands Food and Consumer Product Safety Authority, 2010).

5. Conclusions and recommendations

The main conclusions and recommendations of the risk analysis of non-native Tapegrass (*Vallisneria spiralis*) in the Netherlands are as follows:

- Since it was first recorded in the Netherlands in the 1950s dispersal of *V. spiralis* has been slow and records remain limited to three distant locations. However, its actual distribution may be more extensive as it is a very inconspicuous species. Most locations are almost invisible from on shore or from a boat. It is recommended that the monitoring of *V. spiralis* is continued, and takes into account the difficulties associated with locating the plant.

- Plants are imported and sold as part of the plant trade and maybe released to the freshwater network by hobbyists. The species is able to reproduce vegetatively and can disperse via water, humans and bird vectors, displaying a strong reproductive potential.

- The only known habitat of *V. spiralis* in the Netherlands is the freshwater tidal area of the Biesbosch-Merwede, a Natura 2000 area in accordance with the EU Habitats and Birds directives.

- There is no evidence to suggest that *V. spiralis* has a negative impact on native species in the Netherlands. Field observations suggest that there are no signs that native aquatic plant species are displaced by *V. spiralis* in the Biesbosch.

- No adverse effects of *V. spiralis* on ecosystem functioning in the Netherlands were identified.

- *V. spiralis* is rated as a low risk species for ecological impacts according to the ISEIA protocol. According to recorded distributions and risk score, *V. spiralis* is classified as a C1 species in the BFIS list system.

- Information from other countries indicates that *V. spiralis* is known to affect the drainage of different water bodies as well as impede recreational use.

- Socio-economic impacts resulting from *V. spiralis* are limited in the Netherlands.

- No human health impacts resulting from *V. spiralis* have been identified for the Netherlands.

- Due to the low impact of *V. spiralis* on native species and ecosystem functions it is recommended that populations are observed. Active management through isolation is recommended only if populations become problematic (e.g. cause restriction in water flow).

- The early implementation of weed cutting is not recommended due to cost and the potential for further dispersal of *V. spiralis* by fragmentation.

- It is recommended that *V. spiralis* is not included in appendices of the Dutch Water Plant Code of Conduct.

6. Acknowledgements

We thank the Netherlands Food and Consumer Product Safety Authority (Invasive Alien Species Team) of the Dutch Ministry of Economic Affairs, Agriculture and Innovation for financial support of this study and all volunteers and organisations that contributed to the knowledge report on *V. spiralis*. Dr. Trix Rietveld-Piepers of the Netherlands Food and Consumer Product Safety Authority who delivered constructive comments. Finally, Andreas Hussner (Heinrich-Heine-Universität Düsseldorf, Germany) for allowing us to use his photos of *V. spiralis* from the river Erft.

7. References

Bowmer, K.H., Jacobs, S.W.L. & Sainty, G.R., 1995. Identification, biology and management of *Elodea canadensis*, Hydrocharitaceae. *Journal of Aquatic Plant Management* 33: 13-19.

Branquart, E., (Ed.), 2007. *Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium*. Belgian Biodiversity Platform, Belgium.

CABI, 2012. *Invasive Species Compendium: Vallisneria spiralis*. http://www.cabi.org/isc/?compid=5&dsid=56573&loadmodule=datasheet&page=481&site=144 last accessed: 25 June 2012.

Caffrey, J.M. & O'Callaghan, D., 2007. *A guide to the identification of aquatic invasive species in Ireland*. Central Fisheries Board, Swords, Dublin. *Cited in:* Caffrey, J. & Acavedo, S., 2007. Status and Management of *Lagarosiphon major* in Lough Corrib 2007. Central Fisheries Board, Ireland.

Champion, P.D., & Clayton, J.S., 2000. *Border control for potential aquatic weeds. Stage 1 - weed risk model.* Wellington, Australia: Department of Conservation.

Collas F.P.L., Beringen, R., Koopman, K.R., Matthews, J., Odé, B., Pot, R., Sparrius, L.B., Van Valkenburg, J.L.C.H., Verbrugge, L.N.H. & Leuven, R.S.E.W., 2012. *Knowledge document for risk analysis of non-native Tapegrass (Vallisneria spiralis) in the Netherlands.* Reports Environmental Science 416, Radboud University Nijmegen, The Netherlands.

ISEIA, 2009. Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium. Version 2.6. Http://ias.biodiversity.be/documents/ISEIA_protocol.pdf, last accessed: 14 June 2012.

Natural England, 2011. *Horizon-scanning for invasive non-native plants in Great Britain*. http://www.naturalengland.org.uk/ourwork/conservation/biodiversity/threats/default.as, last accessed: 18 July 2012.

Netherlands Food and Consumer Product Safety Authority, 2010. Convenant Waterplanten. Http://www.vwa.nl/onderwerpen/gevaren/dossier/invasieve-waterplanten/convenant-waterplanten, last accessed: 17 August 2012.

Pheloung, P.C., 1995. *Determining the weed potential of new plant introductions to Australia. Report of the Development of a Weed Risk Assessment System Commisioned by the Australian Weeds Committee*. South Perth, Australia: Agriculture Western Australia.

Van der Neut, J., Muusse, T. & Van der Sikke, W., 2011. *Aquariumplant Vallisneria vaste grond onder voeten in Biesbosch*. Http://www.natuurbericht.nl/?id=6755, last accessed 30 July 2012.

Van Valkenburg, J.L.C.H., (ed.), 2011. *Invasieve waterplanten in Nederland*. nVWA, Wageningen; Bureau Waardenburg, Culemborg; Communicatiebureau de Lynx, Wageningen.

Verbrugge, L.N.H., Van den Born, R.J.G. & Leuven, R.S.E.W., 2011. Evaluatie convenant waterplanten: startmeting. Reports Environmental Science 383. Department of Environmental Science, Faculty of Science, Radboud University Nijmegen, The Netherlands.

8. Appendices

Appendix 1. Knowledge document used for the risk analysis