Risk assessment of alien species found in and around the oyster basins of Yerseke

E.M. Foekema, J. Cuperus en B. van der Weide

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Client: Office of Research and Risk Assessments (BuRO) of the Netherlands Food and Consumer Product Safey Authority (NVWA)
Postbus 43006, 3540 AA Utrecht

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P.O. Box 68	P.O. Box 77	P.O. Box 57	P.O. Box 167
1970 AB IJmuiden	4400 AB Yerseke	1780 AB Den Helder	1790 AD Den Burg Texel
Phone: +31 (0)317 48 09 00	Phone: +31 (0)317 48 09 00	Phone: +31 (0)317 48 09 00	Phone: +31 (0)317 48 09 00
Fax: +31 (0)317 48 73 26	Fax: +31 (0)317 48 73 59	Fax: +31 (0)223 63 06 87	Fax: +31 (0)317 48 73 62
E-Mail: imares@wur.nl	E-Mail: imares@wur.nl	E-Mail: imares@wur.nl	E-Mail: imares@wur.nl
www.imares.wur.nl	www.imares.wur.nl	www.imares.wur.nl	www.imares.wur.nl

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Summary

On behalf of the Office of Research and Risk Assessments (BuRO) of the Netherlands Food and Consumer Product Safey Authority (NVWA), IMARES conducted a species inventory in the Oyster basins in Yerseke and the surrounding area in the Eastern Scheldt, known to be subject to shellfish related activities. This inventory that was performed in September/October 2013 revealed 21 macro invertebrate species that are regarded as alien species. Five of these are assumed not to be present in the Wadden Sea and one species was discovered there once very recently. For all six alien species an assessment was performed to define the potential risk that they will reach the Wadden Sea and affect the local native ecosystem, which is described in this report.

Most of the species already are established in the Eastern Scheldt and for none of them information is available that indicates that establishment in the Wadden Sea will not be possible. The sponge *Hymeniacidon perlevis* has already recently been observed in the Wadden Sea. For the two mollusc species it is considered likely that they will be able to become established in the Wadden Sea after introduction. For the bryozoan *Tricellaria inopinata* especially the lower salinity and the higher turbidity in the Wadden Sea compared to the eastern Scheldt could limit colonisation, although clear information to support this is lacking, this is also the case for the other bryozoan *Pacificincola perforata.* The potential of the annelid *Bispira polyomma* to develop sustainable populations in the Wadden Sea remains unclear.

For the sponge *Hymeniacidon perlevis,* the two bryozoan species *Tricellaria inopinata* and *Pacificincola perforata,* and the annelid *B. polyomma* it is considered unlikely that colonisation of a new area could result in substantial impact on the local ecosystem and conservation targets. Some impact of the Manila clam *Venerupis philippinarum* may be expected but probably only on a local scale. The highest risk for such substantial impact may be expected from the Japanese oyster drill *Ocenebra inornata* that has the potential to cause high mortality amongst habitat forming shellfish and can thus be regarded as a potential ‘problem or nuisance species’.

Results of this assessment are also summarised using ISEIA scores. According to this score *Venerupis philippinarum* (Manila clam) and *Ocenebra inornata* (Japanese oyster drill) are regarded as ‘species with a moderate environmental risk on the basis of current knowledge’, allocated to the medium risk category level (Category B). The bryozoans *Tricellaria inopinata* and *Pacificincola perforata* and the sponge *Hymeniacidon perlevis* are categorised as ‘species that are not considered as a threat for native biodiversity and ecosystems’ (Category C). For the polychaete *Bispira polyomma* no ISEIA score could be calculated due to lack of data about this species. *Bispira polyomma* has only recently been discovered and is until now only known from the Eastern Scheldt.

In the interpretation of the ISEIA scores one should be aware that lack of information could result in an underestimation of the actual risk.

1. Introduction

Shellfish aquaculture and related transport are regarded as an important vector for alien species to reach a new region. The presence of different alien species in the Eastern Scheldt and especially near the city of Yerseke where the shellfish activities are concentrated seems to support this assumption.
In order to get more insight in presence of alien species associated with shellfish activities in Yerseke, IMARES conducted a species inventory in the Oyster basins in Yerseke and the surrounding area in the Eastern Scheldt on behalf of the Dutch Ministry of Economic Affairs.
This inventory that was conducted in September/October 2013, revealed 21 macro invertebrate species that are regarded as alien species (Foekema et al., 2014). All these species are already known to be present in the Eastern Scheldt. Five of them have never been reported to be present in the Wadden Sea, and one has only been observed in the Wadden Sea very recently.

As a follow up to this inventory the ministry asked IMARES to assess the potential risk of these six species for the ecosystems with high conservation value in the Eastern Scheldt and the Wadden Sea. This report describes the results of these assessments.

Based on information available from internet and literature for each of the six species the potency was assessed for:

- being introduced into the Eastern Scheldt;
- reaching the Wadden Sea from the Eastern Scheldt via natural or anthropogenic vectors;
- developing a sustainable population i.e. establishment in the Eastern Scheldt and the Wadden Sea;
- expanding in the Eastern Scheldt and the Wadden Sea;
- having a substantial impact on the ecosystem structure/diversity and functioning and therewith on the conservation targets of the Eastern Scheldt and the Wadden Sea.

Apart from a qualitative/descriptive assessment, an attempt was made to quantify the potential risk by following the guideline for Invasive Species Environmental Impact Assessment (ISEIA) as designed by the Belgian Biodiversity Platform (Belgian Biodiversity Platform, 2009).

2. Definitions

The definitions used in this report are based on Definitions of CBD VI/23.

'Native species' refers to a species, subspecies or genetically distinct populations, occurring within its natural range (past and present).

'Alien species' refers to a species, subspecies or genetically distinct populations, introduced outside its natural past or present distribution; includes any part, gametes, seeds , eggs, or porpagules of such species that might survive and subsequently reproduce.

'Invasive alien species' means an alien species whose introduction and/or spread threaten biological diversity (For the purposes of the present guiding principles, the term invasive alien species" shall be deemed the same as "alien invasive species" in decision V/8 of the Conference of the Parties to the Convention on Biological Diversity.).

'Problem or nuisance species' indicates a species for which it can be assumed that based on the best available scientific data it will have a (significant) negative impact on the conservation goals of a Natura 2000 area.

3. Practical approach

3.1 Descriptive risk assessment

For each of the six species information about biology and environmental impact was collected from internet and scientific literature. The search aimed for information about the biology of the species with special emphasis on features that are related to its dispersion potential like the reproduction strategy. When available, also information was collected about the requirements and tolerance of the species with respect to environmental conditions, such as water temperatures, salinity, food availability, substrates, etc. In case of poor data availability for a specific species, information from related species was used where assumed appropriate.

Together this data was used to assess the potency of the species to reach the Wadden Sea from the Eastern Scheldt via natural (e.g. water currents) or anthropogenic vectors; the latter including transportation of shellfish from the Eastern Scheldt to the Wadden Sea.

In order to reduce the risk that species are accidentally transferred with shellfish to new locations a protocol to treat the shellfish before transport has been proposed by Gittenberger, 2012. According to this protocol before being introduced at the new location, the batch of shellfish should be exposed for 5 hours to fresh water, then set dry for another 5 hours followed by a second exposure to fresh water for another 5 hours. The commercial shellfish like mussels and oysters will be able to withstand this treatment by closing of the shells. For our assessment we also made an assumption about the potency of the alien species to survive this treatment.

Based on the environmental requirements of the species, an assumption was made about the potential of the species to settle and further colonise the Wadden Sea. If available, reported observations from other regions about the impact of colonisation by this species on the local ecosystem were used to assess the risk that introduction of the species results in substantial changes of the local ecosystem. In cases where such data from other regions was not available, the potential impact was assessed by expert judgement based on the life strategy and the species specific environmental requirements.

3.2 Assessment according to the ISEIA protocol

Apart from the more descriptive risk assessment as described in the paragraph above, the risk of each species was also assessed according to the guideline for Invasive Species Environmental Impact Assessment (ISEIA) as designed by the Belgian Biodiversity Platform (Belgian Biodiversity Platform, 2009).

The ISEIA-guideline allows allocating species in one of the three following risk categories:

Category A (Black list):	species with high environmental risk.
Category B (Watch list):	species with a moderate environmental risk on the basis of current knowledge.
Category C :	all other alien species that are not considered as a threat for native biodiversity and ecosystems.

Based on current knowledge, preferably from actual observations from other regions, a species is scored on the following four features. For each of these features, three potential situations are described for species posing low, medium or high risk (Belgian Biodiversity Platform, 2009):

1: Dispersion potential or invasiveness

Low risk: The species does not spread in the environment because of poor dispersal capacities and a low reproduction potential.

Medium risk: Except when assisted by man, the species does not colonise remote places. Natural dispersal rarely exceeds more than 1 km per year. The species can however become locally invasive because of a strong reproduction potential.

High risk: The species is highly fecund, can easily disperse through active or passive means over distances > 1 km/year and initiate new populations.

2: Colonisation of high conservation value habitats

Low risk: Populations of the alien species are restricted to man-made habitats (low conservation value).

Medium risk: Populations of the alien species are usually confined to habitats with a low or a medium conservation value and may occasionally colonise high conservation value habitats.

High risk: The alien 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

Low risk: Data from invasion histories suggest that the negative impact on native populations is negligible.

Medium risk: The alien species is known to cause local changes (<80%) in population abundance, growth or distribution of one or several native species, especially among common and ruderal species. This effect is usually considered as reversible.

High risk: The development of the alien species often cause local severe (>80%) population declines and the reduction of local species richness. At a regional scale, it and can be considered as a factor precipitating (rare) species decline. Those alien species form long-standing populations and their impacts on native biodiversity are considered as hardly reversible.

4: Alteration of ecosystem functions

Low risk: The impact on ecosystem processes and structures is considered as negligible.

Medium risk: The impact on ecosystem processes and structures is moderate and considered as easily reversible.

High risk: The impact on ecosystems processes and structures is strong and difficult to reverse.

For each section a score of 1: Low risk, 2: Medium risk, or 3: High risk, is given. In situations where due to lack of information the score can only be based on expert judgement and field observations, the scoring system is adapted to score 1:Unlikely, and 2: Likely. If information about a species is that limited that even such an estimate cannot be justified, the section is scored ‘DD’ (deficient data), not allowing the calculation of the overall ISEIA-score.

For each section equal weight is assigned, and hence the overall score of a species is obtained by summing the four scores. The overall ISEIA-score will thus always range between 4 and 12. Species with ISEIA-scores 4-8 are not considered a threat (ISEIA Category C), species with ISEIA-scores 9-10 are considered moderate risk and placed on a watch list (ISEIA Category B), whereas species with a score 11-12 are assumed to pose a high environmental risk (ISEIA Category A/black list).

4. Assessment per species

4.1 Venerupis philippinarum, *Manila clam*

4.1.1 Introduction

The Manila clam (*Venerupis philippinarum)* is a bivalve mollusc and a native species of the subtropical to low boreal zone of the western Pacific (Boscolo Brusa et al., 2013). The species has a high commercial value, and for this reason it is deliberately transported to other regions. In addition, accidental transportation with Oysters from Japan, or as larvae in ballast water are also reported (Fisheries and Oceans Canada, 2013). The Manila clam has formed established populations in Europe and around the West coast of the USA and Canada. The Venice lagoon is the main production site for the Manila clam in Europe.

In the Eastern Scheldt the species was first observed around the year 2008, most likely after importation for aquaculture, and since then numbers rapidly increase (Bruyne, 2013).
During the 2013 inventory the Manila clam was found in two of the four oyster pits, and at one of the five field locations (Figure 1). All clams were found in the sediment.

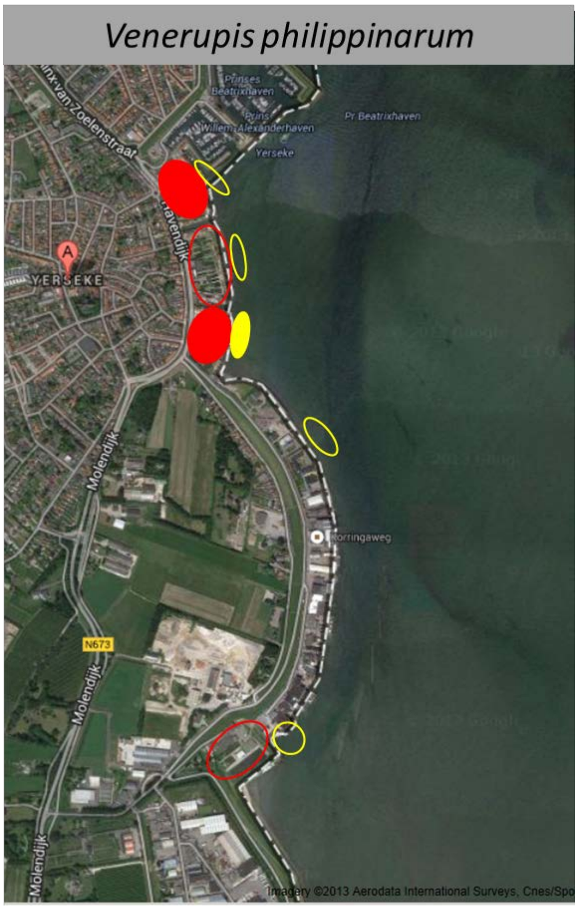

Figure 1 Presence of the Manila clam (Venerupis philippinarum) around the Oyster basins in Yerseke, the Netherlands in September/October 2013. The circles roughly indicate the explored areas; Red circles represent oyster pits, yellow circles the (related) field locations. Filled circles indicate where the species was found.

4.1.2 Biology

The Manila clam lives in the top layer of sandy or silky sediments in shallow/tidal areas. Like many bivalve molluscs it is a filter feeder, that collects phytoplankton and other edible organic particles from the water column (Bruyne, 2013).

At a length of 1 to 2 cm the clams become mature and are able to spawn when water temperatures are above 14°C. Fecundity increases with size but can exceed 2 million eggs per female (Fisheries and Oceans Canada, 2013). The gametes are spawned freely in the water column and depending on the water temperature the larvae spend about 3 to 4 weeks suspended as plankton. Then they settle to the bottom and attach with threads to sand, rocks or shells. With further development these threads are released allowing the clams to wonder around in the top layer of the sediment (Cohen, 2011). The maximum size of the clams is around 75 mm, the maximum life span is around 10 years.

4.1.3 Environmental requirements

One of the reasons for the successful distribution of the Manila clam to other regions is its great adaptability and resistance to a wide range of environmental conditions like salinity, temperature and dissolved oxygen (Boscolo Brusa et al., 2013).
The optimum salinity ranges between 24 and 35, but brackish water with salinity as low as 10-15 can be withstand (Bruyne, 2013; Cohen, 2011). Manila clams prefer sandy/silky sediments, but have a high capability to adapt to different substratum typologies (Boscolo Brusa et al., 2013). Although the optimal water temperature ranges between 15 and 28°C, the clams can survive temperatures between 0-35°C. Spawning usually takes place above 14°C, but is possible above 12°C (Bruyne, 2013). In sub-tropical regions even multiple spawning per year is possible (Boscolo Brusa et al., 2013; Humphreys et al., 2007).

In the Venice lagoon and at the south coast of England the distribution of the Manila calm coincides with intertidal flats that are covered with benthic diatoms as a result of eutrophication and that experience little wave action (Humphreys et al., 2007). The clams thus seem to prefer eutrophic, sheltered intertidal flats.

4.1.4 Chances for colonisation of Eastern Scheldt / Wadden Sea

Since 2008 the Manila clam can be regarded as an established species in the Eastern Scheldt (Bruyne, 2013). As far as we are aware of, the species has not yet been observed in the Wadden Sea. Adult specimens from the Eastern Scheldt population could in theory reach the Wadden Sea as ‘stowaway’ during shellfish transfers. The freshwater treatment that might be applied to remove undesired organisms from a group of mussels prior to transport, will probably not be effective against Manila clams, as these will protect themselves in the same way mussels do; by closing their shells. On the other hand it is not likely that Manila Clams will live in association with oysters and mussels and therefore undeliberate transport with these species is not a likely vector. Due to their high commercial value Manila Clams are deliberately transported for aquaculture purposes to other regions. However no such transports are taken place to the Wadden Sea. It is however possible that the planktonic larvae can reach the Wadden Sea via natural water movements along the Dutch coast or facilitated by transport of ballast water.
Given the environmental requirements of the Manila clam, it may be expected that populations can develop at specific locations in the Wadden Sea. Such locations would be intertidal silky flats covered with benthic diatoms in a sheltered area that experiences little wave action (Humphreys et al., 2007). Most of the Wadden Sea is exposed to stronger water currents and suitable habitats are probably limited to specific areas.

4.1.5 Potential ecosystem impact

Manila clams are present as alien species in different parts of the world. When consequences of this presence are described it always concerns the economic value of this species for aquaculture and fisheries. No records about environmental impact have been found.

The biology of the species is highly comparable with the cockle (*Cerastoderma edule*), a very common native species in the Wadden Sea, as they share the habitat (sandy, silky sediments at shallow/tidal areas) and food sources (both are filter feeders). Competition between these species cannot be ruled out. However, as cockles prefer locations with substantial currents velocity (Kater et al., 2006), and the Manila clam seems more at home in less dynamic environments (Humphreys et al., 2007) it is likely that competition for space and food will only occur occasionally. When present in aquaculture related extremely high densities (2000-2500 ind/m^2), Manila clams can affect the plankton community (Humphreys et al., 2007). This is however not a specific feature of this species, but similar for all filter feeding organisms.

Manila clams will not alter the local habitat and therefore it is not likely that their presence will have a major impact on the ecosystem.

4.1.6 ISEIA score

The ISEIA score for *V. philippinarum* was assessed before also as 10 by *Team Invasieve Soorten* (Bijlage 3 bij ‘Advies exoten April 2013’). In that score however the risk for ‘Adverse impact on native species’ and for ‘Alteration of the ecosystem functions’ were both scored as ‘Medium’. We assume that this ‘Medium’ score was based on observations made in situations with extremely high densities of clams (2000-2500 ind/m^2) that can be reached under aquaculture/cultivation conditions. As we are not sure that such densities are realistic in natural conditions we scored these sections as ‘Likely’. This does not change the overall score, but underlines the lack of confidence.

Table 1 ISEIA-score (Belgian Biodiversity Platform, 2009) for Venerupis philippinarum, the Manila clam

Venerupis philippinarum, Manila clam	Score	Comment
Dispersion potential or invasiveness	3 (High)	High fecundity and pelagic larvae
Colonisation of high conservation value habitats	3 (High)	Potential to colonise habitats with specific features that therefore could be important for over all biodiversity
Adverse impacts on native species	2 (Likely)	Extremely high densities could alter plankton communities, but is unclear if such densities will be reached in a natural situation
Alteration of ecosystem functions	2 (Likely)	Extremely high densities could alter plankton communities, but is unclear if such densities will be reached in a natural situation
ISEIA score	10	Category B (Watch list)

4.2 Ocenebra inornata, *Japanese oyster drill*

Figure 2 Japanese oyster drill collected from the Eastern Scheldt near Yerseke during the species inventory in October 2013.

4.2.1 Introduction

Ocenebra inornata, the Japanese oyster drill (Figure 2) is a predatory marine gastropod mollusk in the family Muricidae. It is native in Asia (Japan and Korea), but has become an introduced pest species in oyster beds in the western USA and Europe. The species was first observed in the Eastern Scheldt around 2007 and is found in increasing numbers since then (Faasse, 2009). So far the Eastern Scheldt is the only location in the Netherlands where this species has been observed.

During the 2013 inventory the Japanese oyster drill and its eggs were found in two of the four oyster pits, and at four of the five field locations (Figure 3). Japanese oyster drills are likely to survive the freshwater treatment of shellfish before transportation (van den Brink, 2010).

As the risk of this species to predate on commercial important shellfish like mussels and oysters is recognized, the Dutch Ministry of Economic Affairs also initiated a species specific risk assessment for this species that is performed by Bureau Waardenburg bv. In this report the risk assessment for the Japanese oyster drill is therefore limited to the ISEIA score that was determined mainly based on data presented in (Lützen, 2011). It is advised to update this score once the extended risk assessment for this species is available.

Figure 3 Presence of the Japanese oyster drill (Ocenebra inornata) around the Oyster basins in Yerseke, the Netherlands in September/October 2013. The circles roughly indicate the explored areas; Red circles represent oyster pits, yellow circles the (related) field locations. Filled circles indicate where the species was found.

4.2.2 ISEIA score

This score is solely based on information from (Lützen, 2011), and should be reconsidered when the risk assessment that is now being performed by Bureau Waardenburg bv is available.

Table 2 ISEIA-score (Belgian Biodiversity Platform, 2009) for Ocenebra inornata, the Japanese oyster drill

Ocenebra inornata, Japanese oyster drill	Score	Comment
Dispersion potential or invasiveness	2 (Medium)	Sessile eggs and no pelagic larvae
Colonisation of high conservation value habitats	3 (High)	According to the colonisation success in the Eastern Scheldt
Adverse impacts on native species	2 (Medium)	In the USA the species is considered as the most dominant predator on oysters
Alteration of ecosystem functions	2 (Likely)	Can cause high mortality in oyster reefs
ISEIA score	9	Category B (Watch list)

4.3 Bispira polyomma

Figure 4 Bispira polyomma as observed in the Eastern Scheldt during the species inventory in October 2013.

4.3.1 Introduction

Bispira polyomma is an annelid that has first been described in 2012 (Faasse and Giangrande, 2012). Until now the Eastern Scheldt is the only location where this species has been found. The real distribution, and thus the origin of this species, and the way it reached the Eastern Scheldt is yet unknown.

During the 2013 inventory *Bispira polyomma* was found in three of the four oyster pits, and at three of the five field locations visited (*Figure 4* and Figure 5). They were found on different types of hard substrates like brick walls, wooden poles, rocks and oyster shells.

Figure 5 *Presence of Bispira polyomma around the Oyster basins in Yerseke, the Netherlands in September/October 2013. The circles roughly indicate the explored areas; Red circles represent oyster pits, yellow circles the (related) field locations. Filled circles indicate where the species was found.*

4.3.2 Biology

As *Bispira polyomma* has only recently been described for the first time, hardly any information about the biology of the species is available. The group of Sabellids that includes *Bispira polyomma* are suspension feeders that use their tentacles to collect edible particles from the water. Larger inedible particles can also be collected to be used in tube building.
Bispira polyomma seems to prefer vertical structures to settle but was also found on the sediment surface during the 2013 inventory, however not in the dense colonies that are found on vertical objects at shallow water depth (30-70 cm) (Faasse and Giangrande, 2012). The formation of colonies is most likely the result of asexual reproduction by fragmentation that is known from other Sabellid species. Sexual reproduction of Sabellids occurs via pelagic larval stages that are spread with water currents and are able to colonise new areas. For some species this larval stage can last

for months, for others this is much shorter (Hartmann-Schroder, 1996). The duration of this larval stage strongly affects the dispersion potential of a species. No information is available about the duration of the larval stage of *B. polyomma.*

4.3.3 Environmental requirements

The species survived a low water temperature of about 0°C during winter 2010/2011 and a high water temperature of 19°C in summer 2011 and was capable of successful reproduction. Faasse and Giangrande (2012) found *B. polyomma* in dense clusters of individuals on hard substrates especially at places that are “extremely sheltered with respect to prevailing (south)westerly winds”. Although other finding locations indicate that they are able to resist strong water currents, they might be thus sensitive to strong wave movements, which could be related that dense colonies are especially found around the waterline.

4.3.4 Chances for colonisation of Eastern Scheldt / Wadden Sea

Faasse et al, 2012 assume that *Bispira polyomma* has established a permanent population in the Eastern Scheldt, as indications for successful reproduction were observed and the populations survived severe summer and winter conditions.

If *Bispira polyomma* is able to settle on pleasure crafts, dispersal is highly probable, also to the Wadden Sea. In theory *B. polyomma* can also be transferred attached to shellfish that are transported, although for this species flushing with fresh water will probably form a good measure. Given the limited knowledge about their environmental requirements it is hard to predict whether B. *polyomma* is able to develop a sustainable population in the Wadden Sea. Taking into account the preference of the species for hard vertical substrates at wind sheltered places, the presence of suitable habitats for this species in the Wadden Sea is probably restricted to local positions in harbours and on dikes.

4.3.5 Potential ecosystem impact

Lack of information about this species also hampers the prediction of potential ecological effects of the introduction to an ecosystem. As it is unknown whether it is a strong competitor for space and food (Faasse and Giangrande, 2012).

4.3.6 ISEIA score

Due to lack of information it is not possible to define the ISEIA score for *Bispira polyomma.* As the species is only identified recently. The fact that, despite its remarkable blue colour, this species is only known from one location in the Netherlands might indicate relative low potential for dispersion and invasiveness. However, future monitoring of the distribution of the species is required to assess this potential with more reliability.

Table 3 ISEIA-score (Belgian Biodiversity Platform, 2009) for Bispira polyomma

Bispira polyomma	Score	Comment
Dispersion potential or invasiveness	2	It reached the Eastern Scheldt probably with an anthropogenic vector
Colonisation of high conservation value habitats	DD	Deficient Data, no score
Adverse impacts on native species	DD	Deficient Data, no score
Alteration of ecosystem functions	DD	Deficient Data, no score
ISEIA score	No score	

4.4 Hymeniacidon perlevis

Figure 6 The sponge Hymeniacidon perlevis as observed in the eastern Scheldt during the species inventory in October 2013.

4.4.1 Introduction

The sponge *Hymeniacidon perlevis* (Figure 6) is common in the more southern part of the NE Atlantic, but is also found in the pacific e.g. China Yellow Sea (Xue et al., 2009).
A specimen was collected near and most likely in the Eastern Scheldt already in 1951 (van Soest, 1977). In 2006 specimens were collected from land-locked locations (Veerse meer and Grevelingen) also in the Province of Zeeland (van Soest et al., 2007). This suggests that *H. perlevis* is established, if not native in the southern part of the Netherlands. However, the species has only very recently been observed in the Wadden Sea at a single location (Gittenberger et al., 2012).

During the 2013 inventory *H. perlevis* was observed at one of the five field locations visited. It was a large specimen with a surface area of over 0.5 m^2 located at the bottom of a shallow ditch that is used to drain an oyster pit (Figure 7).

Figure 7 *Presence of the sponge Hymeniacidon perlevis around the Oyster basins in Yerseke, the Netherlands in September/October 2013. The circles roughly indicate the explored areas; Red circles represent oyster pits, yellow circles the (related) field locations. Filled circles indicate where the species was found.*

4.4.2 Biology

Information about reproduction of this group is still rather scarce especially with respect to the development of the early life stages (Maldonado, 2006). As *Hymeniacidon perlevis* is being investigated for its potential for aquaculture knowledge about the reproduction of this species is available (Xue and Zhang, 2009; Xue et al., 2009). At water temperatures above 14°C a sponge can release up to 200 pelagic larvae per gram body weight. The larvae remain in the water column for at least two days before they settle.

This provides a means to colonize new suitable habitats in either local or geographically distant areas. In addition to this sexual reproduction, sponges can also reproduce from fragments that are separated by external forces from a larger specimen.

Sponges are sessile organisms that collect (micro)plankton, and edible organic matter from the water column. In the Netherlands *Hymeniacidon perlevis* is often found living on and partly covered with sediment (Gittenberger et al., 2012). However, it can also develop on hard substrates (Xue et al., 2009).

4.4.3 Environmental requirements

*Hymeniacidon perlevis s*eems not too critical with respect to the type of substrate. They can be found on, or even partly in, sediment as well as on hard substrates. In the Chinese Yellow Sea they live at an average salinity of 32 ‰ (Xue et al., 2009), which is comparable with the Eastern Scheldt. The recent observation in the Wadden Sea at a salinity of 21 ‰ indicates that they tolerate lower salinity levels.

H. perlevis adults live in an intertidal environment and periodic water flow and light illumination were found to stimulate the growth of *H. perlevis* early juveniles (Xue and Zhang, 2009).

4.4.4 Chances for colonisation of Eastern Scheldt / Wadden Sea

It cannot be excluded that larvae produced by sponges in the Eastern Scheldt will be transported by water currents along the Dutch coast towards the Wadden Sea. However the fact that the species has only recently been observed in the Wadden Sea, while it is already present for at least 60 years in the South of the Netherlands seems to indicate that this is not a very successful vector for this species. On the other hand the fact that the species was not observed before in the Wwadden Sea can also be related to the fact that monitoring effort in the Wadden Sea related to invasive species is low compared to the Eastern Scheldt, especially for specific taxonomic groups as sponges.

Transportation of (fragments of) sponges is another possibility to reach the Wadden Sea. It is possible that this sponge can settle on ship hulls, or that viable fragments are transported with shellfish. Sponges are expected to be sensitive for the fresh water treatment.

4.4.5 Potential ecosystem impact

Hymeniacidon perlevis feeds on microplankton and may thus compete for food with other sponges, and filter feeders. It is unclear if the presence of this species can result in substantial changes of the ecosystem structure and functioning. Sponges are in general slow growing organisms and are often fond together with other filter feeding organisms. Given the fact that the species is already present in Zeeland for a long time without substantial impact on the local ecosystem has been observed, its potential impact seems limited.

4.4.6 ISEIA score

Table 4 ISEIA-score (Belgian Biodiversity Platform, 2009) for Hymeniacidon perlevis

Hymeniacidon perlevis	Score	Comment
Dispersion potential or invasiveness	2 (Medium)	No indications of rapid dispersion although already present in Zeeland at least since 1955.
Colonisation of high conservation value habitats	2 (Medium)	No specific preference for high conservation areas expected
Adverse impacts on native species	1 (Unlikely)	Slow grower, no impact known from Eastern Scheldt
Alteration of ecosystem functions	1 (Unlikely)	Slow grower, no impact known from Eastern Scheldt
ISEIA score	6	Category C

4.5 Tricellaria inopinata

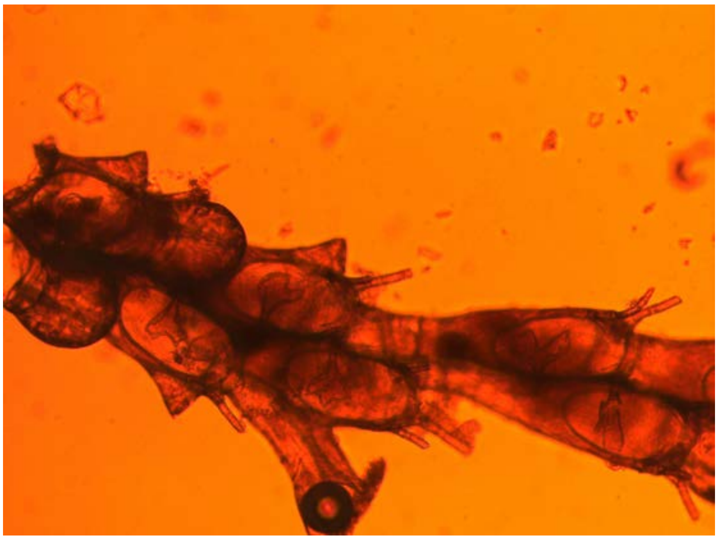

Figure 8 Microscopic image of a part of a colony of Tricellaria inopinata

4.5.1 Introduction

The bryozoan *Tricellaria inopinata* was first discovered in a restricted part of the Venice Lagoon in 1982, where it was thought to be a recent introduction. About 7 years later it was spread throughout the lagoon. The origin of the species is still not clear, related species are known from the coast of the USA, Canada, Japan and Australia. There is also a possibility that *T. inopinata* represents a hybrid between Pacific morphospecies united by anthropogenic translocation (Dyrynda et al., 2000).

Although the vector of transport that introduced these animals into the area is unknown, it has been hypothesized that the introduction could have occurred by shipping traffic, or in association with the shellfish fishery (Johnson et al., 2012).

During the 2013 inventory, bryoza that were identified as *Tricellaria inopinata* were observed in one of the four oyster basins and at three of the five field locations visited. The species was found attached to other organisms like oysters and a tunicate, or to non-living substrates like brick walls, and a large piece of plastic.

Figure 9 *Presence of the bryozoan Tricellaria inopinata around the Oyster basins in Yerseke, the Netherlands in September/October 2013. The circles roughly indicate the explored areas; Red circles represent oyster pits, yellow circles the (related) field locations. Filled circles indicate where the species was found.*

4.5.2 Biology

Bryozoa are small animals with a maximum size around 1 mm that can form colonies of thousands of individuals on all kind of hard substrates. In the Venice lagoon, *T. inopinata* was epibiotic on various other organisms, including mussels, sponges, ascidians, and barnacles (Johnson et al., 2012). As food, plankton is collected from the water column. Most bryozoa are sessile and reproduce via short lived larvae that have to settle within a few hours, this limits the dispersal capability (Johnson et al., 2012). As bryozoa colonies can develop on almost all hard substrates, transportation on floating parts of wood, plastic and ship hulls forms a substantial vector for dispersal over larger distances.

4.5.3 Environmental requirements

Given the successful colonisation it is clear that the Venice lagoon meets the environmental requirements of *Tricellaria inopinata.* Based on the data presented in Sfriso and Facca (2013) (Sfriso and Facca, 2013) this indicates that the species can flourish in an environment with an average water temperature of 19 °C and can withstand a temperature range from 4 to 30°C. The salinity in the Venice lagoon varies around 30 (range 27-32) ‰ and the chlorophyll-a concentrations range between 1 and 7 µg/L. The species further requires hard substrate for settlement, but does not seem to be critical on the type of substrate, as dead and living material is both occupied by this species.

4.5.4 Chances for colonisation of Eastern Scheldt / Wadden Sea

The short duration of the larval stage most likely prohibits that larvae that are produced in the Eastern Scheldt will reach the Wadden Sea directly via water currents, or even via ballast water transport. Therefore the most likely vector for *T. inopinata* to reach the Wadden Sea is by transfer of colonised material. This could either be floating wood or plastic, ships, or via shellfish translocations. In the latter case the fresh water treatment probably forms an effective tool to reduce this risk.

Compared to the Venice Lagoon the Wadden Sea has a lower average water temperature. The successful settlement in the Eastern Scheldt however indicates that temperature is not critical. Salinity in both the Venice lagoon and in the Eastern Scheldt is relatively high compared to the Wadden Sea. The remark in Johnson et al. (2012) (referring to Occhipinti-Ambrogi 1991), that the colonisation of the Venice Lagoon was seemingly only restricted by areas that routinely received an influx of fresh water, indicates at least some sensitivity to low salinity. This could indicate that *T. inopinata* will not be able to colonise parts of the Wadden Sea that do receive fresh water inflow. However, this will only exclude a relatively small part of the Wadden Sea area. Is seems thus possible that *T. inopinata* could potentially colonise the remaining area using hard materials as dikes, mussel and oysterbeds or debris as substrates. The relative high water turbidity in the Wadden Sea compared to the Eastern Scheldt and the Venice lagoon might prevent this. However, to our knowledge no information is available on the sensitivity of *T. inopinata* to this factor.

4.5.5 Potential ecosystem impact

The rapid colonisation of the Venice Lagoon by *T. inopinata*, despite the presence of numerous, previously established bryozoan colonies, indicates a competitive advancement. This could be due to early settlement/colonisation of the larvae and the ability to overgrow other organisms including other bryozoan. Within a year of its first observance in Eel Pond (Massachusetts, USA), *T. inopinata* had established itself as the dominant bryozoan despite the presence of several previously established species (Johnson et al., 2012).

The impact on the overall functioning of the ecosystem is probably limited, but if such a colonisation occurs in the Eastern Scheldt or the Wadden Sea, it may impact other bryozoan species. Johnson et al. (2012) suggest that *T. inopinata* will especially compete with bryosoan species that possess similar growth forms. In the Wadden Sea none such upwards growing bryozoan species are known, at least from the Western part (data from the Eastern Wadden Sea is scares. Pers. comment J. Cuperus IMARES), and impact will therefore probably be limited.

4.5.6 ISEIA score

Table 5 ISEIA-score (Belgian Biodiversity Platform, 2009) for Tricellaria inopinata

Tricellaria inopinata	Score	Comment
Dispersion potential or invasiveness	2 (Medium)	Short living larvae hamper fast dispersion
Colonisation of high conservation value habitats	2 (Medium)	No indications for specific preference for specific high valued habitats
Adverse impacts on native species	2 (Medium)	At least other bryozoan species with the same growth form (upwards) .
Alteration of ecosystem functions	1 (Low)	The impact of animals like bryozoans on overall ecosystem function is limited
ISEIA score	7	Category C

4.6 Pacificincola perforata

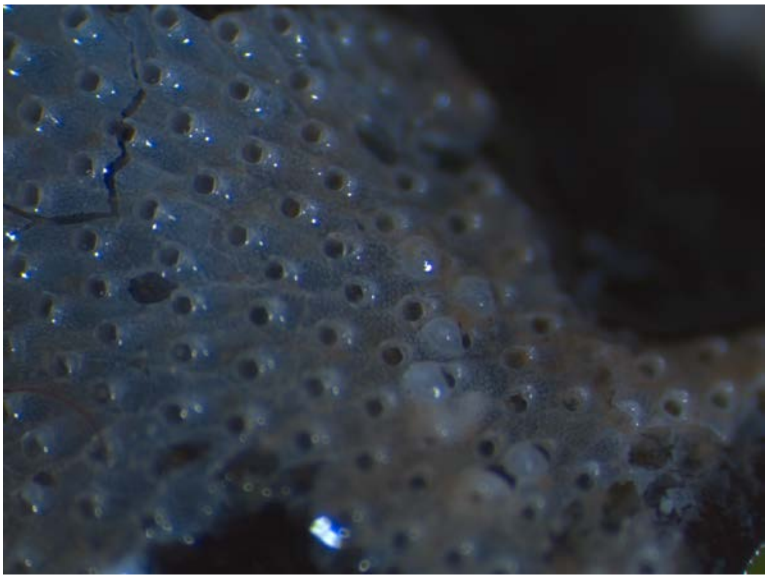

Figure 10 Colony of Pacificincola perforata (magnified)

4.6.1 Introduction

Pacificincola perforata is another bryozoan. It is regarded a native species of the eastern Pacific and is one of the common bryozoans in the coastal waters of the southern Chinese seas. Since the beginning of the 21th century the species is known to be present in the NE Atlantic. In 2006, *P. perforata* is commonly found at the lower shore of the eastern Scheldt at Yerseke. As the species was first found in the NE Atlantic at locations known as centres of shellfish culture it seems likely that this bryozoan was introduced with imported Japanese oysters (De Blauwe, 2006).

During the 2013 inventory, *Pacificincola perforata* was found in one of the four oyster basins, and at three of the five field locations visited. The observed colonies were attached to various hard substrates like stones and shells, but also on macro algae.

Figure 11 Presence of the bryozoan Pacificincola perforata around the Oyster basins in Yerseke, the Netherlands in September/October 2013. The circles roughly indicate the explored areas; Red circles represent oyster pits, yellow circles the (related) field locations. Filled circles indicate where the species was found.

4.6.2 Biology

No species specific information about the biology of this species was found in literature. We therefore refer to the information given in the previous paragraph (3.5.2) on the bryozoans in general.

4.6.3 Environmental requirements

Apart from the observation that *P. perforata* can form colonies on hard substrates and also on macro algae, no species specific information about the environmental requirements could be found.

4.6.4 Chances for colonisation of Eastern Scheldt / Wadden Sea

According to de Blauwe (2006), *P. perforata* is already commonly found in the Eastern Scheldt. Although the assumed short lifetime of the larval stages that is known from other bryozoan species will hamper distribution of the larvae by water currents, bryozoans that form colonies on floating materials (wood, plastics, macro algae) have high potential of being transported to other areas. In this way the Wadden Sea could be reached. This could also be the case when shellfish from the Eastern Scheldt with colonies of *P. perforata* are transferred to the Wadden Sea. Treatment with fresh water probably reduces the change that the bryozoans are transported alive.

With no knowledge about the specific requirements of this species it is not possible to determine the chance that they will be able to establish a population in the Wadden Sea. However, the rapid colonisation of the Eastern Scheldt indicates that *P. perforata* has a high potential to settle in a new area.

4.6.5 Potential ecosystem impact

The colonisation of the eastern Scheldt indicates that *P. perforata* has some competitive advantage above other bryozoan species. It is thus possible that the introduction of this species results in reduced numbers of other bryozoan species in the area. In the worst case this could result in loss of (bryozoan) species diversity. It is however unlikely that this will impact the overall functioning of the ecosystem.

4.6.6 ISEIA score

Table 6 ISEIA-score (Belgian Biodiversity Platform, 2009) for Pacificincola perforata

Pacificincola perforata	Score	Comment
Dispersion potential or invasiveness	2 (Medium)	Short living larvae hamper fast dispersion
Colonisation of high conservation value habitats	3 (High)	Eastern Scheldt was rapidly colonised
Adverse impacts on native species	2 (Likely)	Impact on at least other bryozoan species is likely
Alteration of ecosystem functions	1 (Low)	The impact of animals like bryozoans on overall ecosystem function is limited
ISEIA score	8	Category C

5. Synopsis and conclusion

For the six alien species that were observed in 2013 in the Eastern Scheldt near the shellfish centre of Yerseke and that are not yet or very recently known from the Wadden Sea, an assessment was performed for the chance that these species will reach the Wadden Sea, and affect the local native ecosystem.

The results are summarised in *Table 7* and indicate that only for the Manila Clam *Venerupis philippinarum* and the sponge *Hymeniacidon perlevis* it is likely that they can reach the Wadden Sea by larval dispersal via natural water currents. Dispersal of the other four species probably depends more on transportation of mature individuals that are attached to moving hard substrates like pleasure crafts or pieces of plastic, or to shellfish that are being transported.

Fresh water treatment of shellfish will not be sufficient to reduce the risk of viable Manila Clams and Japanese oyster drills being transported non-deliberately with other shellfish.

Most of the species already are established in the Eastern Scheldt and for none of them information is available that indicates that establishment in the Wadden Sea will not be possible. The sponge *Hymeniacidon perlevis* has already recently been observed in the Wadden Sea. For the two mollusc species it is considered likely that they will be able to become established in the Wadden Sea after introduction. For the bryozoan *Tricellaria inopinata* especially the lower salinity and the higher turbidity in the Wadden Sea compared to the eastern Scheldt could limit colonisation, although clear information to support this is lacking, this is also the case for the other bryozoan *Pacificincola perforata.* The potential of the annelid *Bispira polyomma* to develop sustainable populations in the Wadden Sea remains unclear.

For the sponge *Hymeniacidon perlevis,* the two bryozoan species *Tricellaria inopinata* and *Pacificincola perforata,* and the annelid *B. polyomma* it is considered unlikely that colonisation of a new area could result in substantial impact on the local ecosystem and conservation targets. Some impact of the Manila clam *Venerupis philippinarum* may be expected but probably only on a local scale. The highest risk for such substantial impact may be expected from the Japanese oyster drill *Ocenebra inornata* that has the potential to cause high mortality amongst habitat forming shellfish. This species is subject of an extended risk assessment that is being performed by Bureau Waardenburg BV. Therefore, the time spend on this species in this study was very limited. Our conclusions with respect to the Japanese oyster drill must therefore be reconsidered once the extended assessment is available.

Table 7 Summary of the expectations for the selected species to reach the Wadden Sea from the Eastern Scheldt, to develop a sustainable population in the Eastern Scheldt and the Wadden Sea, and to have substantial impact on the local ecosystem and conservation targets.

	***Venerupis philippinarum,* Manila clam**
Eastern Scheldt	
Chances for introduction	Sure; species is already present
Chances for establishment	Sure; species seems already established
Chances for expansion	Sure; numbers are increasing rapidly since 2008. But expansion area seems restricted to specific shallow, more or less sheltered areas
Impact on ecosystem and conservation targets	Not likely. Locally the species might compete for food and space with other shellfish. However *V. philippinarum* does not alter the local habitat structurally and is not expected to be able to colonise large areas.
Wadden Sea	
Chances for introduction	High, via larval transport with natural water currents or ballast water. In addition transportation of mature specimens with shell fish transfers is possible. *V.philippinarum* is expected to survive to fresh water treatment.
Chances for establishment	Likely
Chances for expansion	Likely, but restricted to specific shallow, more or less sheltered areas
Impact on ecosystem and conservation targets	Not likely. Locally the species might compete for food and space with other shellfish. However, *V. philippinarum* does not alter the local habitat structurally and is not expected to be able to colonise large areas.

	***Ocenebra inornata*, Japanese oyster drill** (assessment based on limited data see 4.2.1)
Eastern Scheldt	
Chances for introduction	Sure; species is already present
Chances for establishment	Sure; species seems already established
Chances for expansion	Sure; observations indicate that the species is expending through the Eastern Scheldt since 2007
Impact on ecosystem and conservation targets	Likely; As O. inornata has the potential to cause high mortality in shell fish reefs that form a habitat for many associated species substantial impact on the ecosystem cannot be excluded.
Wadden Sea	
Chances for introduction	Likely. Without a pelagic larval stage fast distribution over longer distances is only possible by transport of eggs or specimens attached to floating substrates. Shell fish transports form a potential vector for this species to reach the Wadden Sea. *O. inornata* is expected to survive the fresh water treatment, although the eggs will be affected.
Chances for establishment	Likely, given its successful colonisation of the eastern Scheldt
Chances for expansion	Likely, given its successful colonisation of the eastern Scheldt
Impact on ecosystem and conservation targets	Likely, As *O. inornata* has the potential to cause high mortality in shell fish reefs that form a habitat for many associated species substantial impact on the ecosystem cannot be excluded.

	Hymeniacidon perlevis
Eastern Scheldt	
Chances for introduction	Sure; species is already present
Chances for establishment	Sure; species is already present for many years
Chances for expansion	Sure; but slow and without becoming invasive
Impact on ecosystem and conservation targets	Not likely; until now the species seem not to have a strong impact on the ecosystem
Wadden Sea	
Chances for introduction	Sure; recently a specimen was observed in the Wadden Sea
Chances for establishment	Sure; it cannot be excluded that the species is already present for a longer period, but was not noticed before
Chances for expansion	Sure; but slow and without becoming invasive
Impact on ecosystem and conservation targets	Not likely; it's presence in the eastern Scheldt does not seem to have a strong impact on the ecosystem

	Tricellaria inopinata
Eastern Scheldt	
Chances for introduction	Sure; species is already present
Chances for establishment	Sure; species is already present for many years
Chances for expansion	Sure
Impact on ecosystem and conservation targets	Not likely; until now the species seem not to have a strong impact on the ecosystem
Wadden Sea	
Chances for introduction	Likely via colonised floating objects and ship hulls. Or with shell fish that are actively transported. The species is expected to be sensitive to the freshwater treatment. The short living larvae prevent rapid dispersion via natural water currents.
Chances for establishment	Unclear; high turbidity and low salinity might be limiting factors
Chances for expansion	Unclear; high turbidity and low salinity might be limiting factors
Impact on ecosystem and conservation targets	Not likely; the types of bryozoans that *T. inopinata* will compete with are not common in the Wadden Sea

	Pacificincola perforata
Eastern Scheldt	
Chances for introduction	Sure; species is already present
Chances for establishment	Sure; species is a common species since 2006
Chances for expansion	Sure; Eastern Scheldt was rapidly colonised
Impact on ecosystem and conservation targets	Not likely; until now the species seem not to have notable impact on the ecosystem or biodiversity
Wadden Sea	
Chances for introduction	Likely via colonised floating objects and ship hulls, or with shell fish that are actively transported. The species is expected to be sensitive to the freshwater treatment. The short living larvae prevent rapid dispersion via natural water currents.
Chances for establishment	Unclear; high turbidity and low salinity might be limiting factors
Chances for expansion	Unclear; high turbidity and low salinity might be limiting factors
Impact on ecosystem and conservation targets	Not likely; Its presence in the eastern Scheldt does not seem not to have notable impact on the ecosystem or biodiversity

	Bispira polyomma
Eastern Scheldt	
Chances for introduction	Sure; species is already present
Chances for establishment	Sure; species is already present for many years
Chances for expansion	Sure; but slow and especially on vertical hard substrates at low water depth
Impact on ecosystem and conservation targets	Not likely; until now the species seem not to have notable impact on the ecosystem or biodiversity
Wadden Sea	
Chances for introduction	Likely via colonised floating objects and ship hulls, or with shell fish that are actively transported. The species is expected to be sensitive to the freshwater treatment. It is unclear if *B.polyomma* produces pelagic larvae that are able to reach the Wadden Sea with natural water currents
Chances for establishment	Unclear; high turbidity and low salinity might be limiting factors
Chances for expansion	Unclear; but it will probably not be fast and restricted to vertical hard substrates at low water depth
Impact on ecosystem and conservation targets	Not likely; its presence in the eastern Scheldt does not seem not to have notable impact on the ecosystem or biodiversity. In addition, as *B. polyomma* seems only to reach high densities on vertical substrates, the competition for space with typical Wadden sea/tidal flat species will be limited.

When the assessment is summarised as the ISEIA scores, two species are allocated to the moderate risk level (Category B-Watch list), and three species are not considered a threat for native biodiversity and ecosystems (Category C). Due to an almost complete lack of data for one species, *Bispira polyomma*, no ISEIA score could be assessed.

It must be noted that for all species with exception of *Tricellaria inopinata* we feel that insufficient data is available for a highly reliable assessment. Following the ISEIA guideline in this cases the maximum score per section can be 2 (likely) instead of 3 (High Risk) that is possible when sufficient information is available. As a consequence, lack of information could result in an underestimation of the actual risk. For three of the assessed species, this could result in a higher risk category as indicated in Table 7.

Table 8 ISEIA-scores (Belgian Biodiversity Platform, 2009) of the six species that were assessed in this study.

Species	**ISEIA score**	**Comment**
Venerupis philippinarum, Manila clam	10 Category B (Watch list)	Insufficient information (sufficient information could result in a maximum score of 12 (category A, Black list)
Ocenebra inornata, Japanese oyster drill	9 Category B (Watch list)	Insufficient information (sufficient information could result in a maximum score of 10 (no category change)
Hymeniacidon perlevis	6 Category C (No threat)	Insufficient information (sufficient information could result in a maximum score of 10 (Category B, Watch list)
Tricellaria inopinata	7 Category C (No threat)	Sufficient information
Pacificincola perforata	8 Category C (No threat)	Insufficient information (sufficient information could result in a maximum score of 9 (category B, Watch list)
Bispira polyomma	Deficient data, no score	Insufficient information to derive a score

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We thank the managers/employees of the Oyster basins and the shell fish processing industries at Yerseke that allowed us to work at, or near their properties. We also like to thank Arjan Gittenberger and Marco Faase for the provided information on species and their presence in the Eastern Scheldt and the Wadden Sea and their help with (confirmation of) the determination of specific species, and Arjan Gittenberger for his useful comments after reviewing the draft report.

7. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

Report number : C014.14
Project number : 430.51127.01

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Drs. J.E. Tamis
Researcher

Signature:

Date: February 13, 2014

Approved: Drs. F.C. Groenendijk
Head of department

Signature:

Date: February 13, 2014