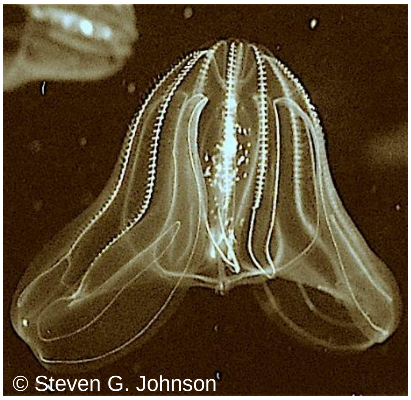
Updated: July 2019

American comb jelly (*Mnemiopsis leidyi*)

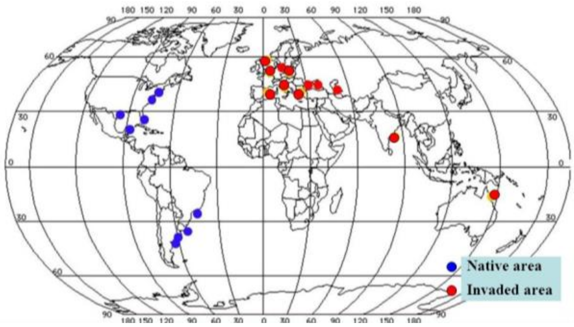
- A small marine comb-jelly (c. 10cm x 2cm) native to the Americas.
- Accidentally introduced to Black Sea (1980s) in ballast and subsequently spread to other European countries.
- Implicated in substantial ecological and economic damage as a predator of zooplankton (destabilising food-webs). Contributed to serious decline in fish stocks (particularly anchovy and sprat) either by predation or competition.
- Present in northern Europe and recently detected in British waters. Poses a potential threat to important fish spawning and nursery grounds.



History in GB

Introduced to the Baltic Sea in the 1980s and spread throughout the Mediterranean. Arrived in northern European waters in 2005 (France) and subsequently in the Netherlands, Denmark, Norway, Belgium, the Baltic Sea and Wadden sea. First detected in GB in 2014 (Wash estuary, North Norfolk) using eDNA analysis with visual identification in 2016.

Global Distribution (from Costello et al 2011)



GB Distribution

Sightings reported from the north sea around GB since 2014 (red dots).

Impacts

Environmental (major)

- Could cause substantial ecosystem deterioration by altering food webs via predation of zooplankton and competition with fish species.
- Can form large blooms, which are able to consume large numbers of nutrients.

Economic (major)

- Has potential to cause serious declines in fish stocks, as in other parts of Europe (particularly anchovy and sprat).
- The anchovy collapse in the Black Sea was estimated to cost $250M (USD); however, the extent to which this was caused by the comb-jelly is debated.

Social (minimal)

- Not harmful to human health.

Introduction pathway

Originally via ballast into Europe, but then into GB waters via natural currents. Ballast could continue to contribute.

Spread pathway

Natural (very rapid) – spread on east coast likely to be by natural current

Human-aided (rapid) – ballast water more likely to spread this species to west-coast

Summary

	Response	Confidence
Entry	VERY LIKELY	VERY HIGH
Establishment	VERY LIKELY	VERY HIGH
Spread	RAPID	HIGH
Impact	MAJOR	MEDIUM
Overall risk	HIGH	MEDIUM

Information about GB Non-native Species Risk Assessments

The Convention on Biological Diversity (CBD) emphasises the need for a precautionary approach towards non-native species where there is often a lack of firm scientific evidence. It also strongly promotes the use of good quality risk assessment to help underpin this approach. The GB risk analysis mechanism has been developed to help facilitate such an approach in Great Britain. It complies with the CBD and reflects standards used by other schemes such as the Intergovernmental Panel on Climate Change, European Plant Protection Organisation and European Food Safety Authority to ensure good practice.

Risk assessments, along with other information, are used to help support decision making in Great Britain. They do not in themselves determine government policy.

The Non-native Species Secretariat (NNSS) manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. Risk assessments are carried out by independent experts from a range of organisations. As part of the risk analysis process risk assessments are:

- Completed using a consistent risk assessment template to ensure that the full range of issues recognised in international standards are addressed.
- Drafted by an independent expert on the species and peer reviewed by a different expert.
- Approved by an independent risk analysis panel (known as the Non-native Species Risk Analysis Panel or NNRAP) only when they are satisfied the assessment is fit-for-purpose.
- Approved for publication by the GB Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAP.

To find out more about the risk analysis mechanism go to: www.nonnativespecies.org

Common misconceptions about risk assessments

To address a number of common misconceptions about non-native species risk assessments, the following points should be noted:

- Risk assessments consider only the risks posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Risk assessments are about negative impacts and are not meant to consider positive impacts that may also occur. The positive impacts would be considered as part of an overall policy decision.
- Risk assessments are advisory and therefore part of the suite of information on which policy decisions are based.
- Completed risk assessments are not final and absolute. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

Period for comment

Draft risk assessments are available for a period of three months from the date of posting on the NNSS website*. During this time stakeholders are invited to comment on the scientific evidence which underpins the assessments or provide information on other relevant evidence or research that may be available. Relevant comments are collated by the NNSS and sent to the risk assessor. The assessor reviews the comments and, if necessary, amends the risk assessment. The final risk assessment is then checked and approved by the NNRAP.

*risk assessments are posted online at: http://www.nonnativespecies.org/index.cfm?pageid=143
comments should be emailed to nnss@apha.gov.uk

GB Non-native Species Rapid Risk Assessment (NRRA)

Rapid Risk Assessment of: *Mnemiopsis leidyi* (sea walnut)
Author: Dr. Sophie Pitois (Cefas)

Version: Draft 1 (*Feb 2016*), NNRAP 1st review (*Jan 2017*), Draft 2 (*May 2018*), Peer Review (*June 2018)*, Draft 3 (*July 2018*), NNRAP 2nd review (*Sep 2018*), Draft 4 (*Oct 2018*)
Signed off by NNRAP: September 2018
Approved by Programme Board: June 2019
Placed on NNSS website: July 2019

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

Guidance notes:

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

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

Response: *To rapidly assess the risk associated with this species in Great Britain following catastrophic impacts of previous invasions reported in other areas*

2 - What is the Risk Assessment Area?

Response: *Great Britain*

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

Response: *Mnemiopsis leidyi* (thereafter referred as *M. leidyi*) is commonly known as the "sea walnut", and also sometimes referred as the "American comb jelly".

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

Response: Yes.

Mnemiopsis leidyi is a planktivorous ctenophore. It is native to temperate and sub-tropical estuaries and coastal waters along the East Coast of the Americas, from New England to Argentina (GESAMP, 1997; Purcell *et al*., 2001).

M. leidyi was accidentally introduced into the Black Sea in the early 1980s, probably through ballast waters (Vinogradov *et al*., 1989; GESAMP, 1997; Reusch *et al*., 2010). The spread and invasion pathways of *M. leidyi* were comprehensively reviewed by Costello *et al*. (2012). *M. leidyi* spread from the Black Sea into Azov, Aegean and Levantine seas via the Sea of Marmara (Shiganova *et al*., 2001; Shiganova *et al*., 2004; Studenikina *et al*., 1992; Kideys and Niermann, 1994). The species then spread from the eastern Mediterranean to other regions of the Mediterranean; they were recorded in the northern Adriatic Sea in 2005 (Shiganova and Malej, 2009) and in 2009, blooms were reported in waters off the coasts of Israel (Galil *et al*., 2009), Italy (Boero *et al*., 2009), and Spain (Fuentes *et al*., 2010). In 1999, *M. leidyi* was also transported to the Caspian Sea, presumably with ballast water taken aboard in the Black Sea or the Sea of Azov (Ivanov *et al*., 2000).

The first records in northern European waters date back to 2005 and originate from Le Havre harbour in northern France (Antajan *et al*., 2014). It has since been discovered and observed regularly in estuaries along the coast of the Netherlands (Faasse and Bayha, 2006), Denmark (Tendal *et al*., 2007; Riisgård *et al*., 2007), in the Baltic Sea (Hansson, 2006; Javidpour *et al*., 2006; Javidpour *et al*., 2009), along the Norwegian coast and in Norwegian fjords (Oliveira, 2007; Hosia and Falkenhaug, 2015), in the German Bight (Boersma *et al*., 2007), and the Wadden Sea (Van Walraven *et al*., 2013), in Belgian coastal waters (Van Ginderdeuren *et al*., 2012) and along the French coast of the Channel and North Sea (Antajan *et al*., 2014).

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

Response: *M. leidyi* was detected for the first time in 2014 in the Wash estuary (North Norfolk) using eDNA analysis of water samples (Créach, 2015). In February 2016, specimens were caught and visually identified as *M. leidyi*, during a plankton sampling survey as part of the IBTS (International Bottom Trawl Survey), in the North Sea UK waters between the Wash area and Hull (E. Antajan, personal communication). Preserved specimen were sent to Cefas for confirmation using eDNA. Records of *M. leidyi* in the Ouse Estuary were also reported in February 2016 (http://www.nonnativespecies.org//factsheet/factsheet.cfm?speciesId=3813)

Figure: Locations of first records of *Mnemiopsis leidyi* in the risk assessment area. *M. leidyi* was positively identified in the Wash area in 2014 (Créach, 2015). Other specimens in the North Sea were recorded in February 2016 during the Q1 IBTS survey (E. Antajan, personal communication)

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

Response: Yes. Most suitable habitats are shallow coastal areas, in particular sheltered bays and estuaries. As part of the MEMO project (*Mnemiopsis* Ecology Modelling and Observations, Interreg IVa-2Seas grant, 2010–2014), model predictions suggested that many coastal areas along the North Sea, in particular estuaries such as the Thames estuary and the Wash, a reserve European Marine Site in Norfolk, are suitable for *M. leidyi* reproduction due to a combination of high temperatures and high food concentrations (Collingridge *et al*., 2014). These studies focussed on the English Channel and North Sea area, because these areas would be the first to be reached if *M. leidyi* were to spread from the continental coast where it has been recorded regularly since 2005. However, as a result of the high plasticity of *M. leidyi*, other areas around GB are likely to be suitable, with shallow coastal areas and sheltered locations such as estuaries and bays offering the best conditions for the species to thrive and become established. First records of *M. leidyi* in GB are recent and in line with these predictions.

7 - Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment Area or sufficiently similar for the organism to survive and thrive?

Response: Yes

M. leidyi can be found in a wide range of temperatures (0 to 32°C) and salinities (2 to 39 PSU) (Purcell and Arai, 2001). It is this tolerance to a wide range of environmental conditions, together with rapid feeding, growth and reproduction rates and the ability to self-fertilise, that contribute to the success of *M. leidyi* as an invasive species (Costello *et al*., 2012; Fuentes *et al*., 2010; Jaspers *et al*., 2011). Furthermore, *M. leidyi* has been established along the eastern and southern coasts of the North Sea and English Channel, from France, through Belgium, the Netherlands, Denmark to Norway (Jaspers *et al*. 2014).

8 - Has the organism established viable (reproducing) populations anywhere outside of its native range (answer N/A if you have answered 'yes' to question 4)?

Response: N/A

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

Response: Both currents and shipping are likely methods of *M. leidyi* dispersal. Genetic information has confirmed the influx of *M. leidyi* to Europe in both northern and southern pathways, with the northern Europe population originating from Narragansett Bay (North-east of USA), and the southern population from the Gulf of Mexico (Ghabooli *et al*., 2013; Reusch *et al*., 2010). It has taken approximately three decades for *M. leidyi* to spread to most Eurasian waters from the time of first accidental introduction in the Black Sea (Jaspers *et al*., 2014; CIESM, 2015), thus proving *M. leidyi* a rapid and highly successful invader.

As a result, *M. leidyi* is listed among the world 100 worst invaders (http://www.issg.org/worst100_species.html). Model predictions (MEMO project) suggest that it is possible for *M. leidyi* to be transported via currents over considerable distances, from the continental coasts France to Denmark, to reach the UK coastline; and for populations to be established along the continental coasts of the English Channel and North Sea (Van der Molen et al., 2015). Recently records for *M. leidyi* in UK waters have corroborated these model predictions.

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

Response: Yes. In the Black Sea, in the late 1980s, the presence of *M. leidyi* together with eutrophication and overfishing were reported to cause the deterioration of the ecosystem and the economic loss/collapse of pelagic fish populations, in particular affecting anchovy and sprat fisheries (Kideys, 1994; Kideys, 2002; Oguz *et al*., 2008; Knowler, 2005; Daskalov *et al*., 2007). $250 million losses were estimated (NIMPIS, 2002) from the anchovy fisheries collapse in the region following *M. leidyi* population explosions in 1989 and 1995. (https://www.nobanis.org/globalassets/speciesinfo/m/mnemiopsis-leidyi/mnemiopsis_leidyi.pdf)

Owing to its reputation as a threat to fish stocks gained following events in the Black Sea, the establishment of *M. leidyi* in northern Europe (including UK waters) is cause for concern as these waters are amongst the most important fishing grounds in the world. These waters are known to be the spawning and nursery grounds of commercially important fish stocks (Ellis *et al*., 2011).

Few other negative direct reports exist on the appearance of *M. leidyi* beside the impact of large numbers on desalination plants in the Mediterranean Sea, and the 2008 killing of farmed fish in Norway (http://www.nrk.no/hordaland/denne-har-tatt-livet-av-tusener-1.6241751). However, *M. leidyi* is listed among the 100 worst invaders in the world (http://www.issg.org/worst100_species.html).

Entry Summary

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

Response: *very likely*
Confidence: *very high*

Comments (include list of entry pathways in your comments):
M. leidyi has already been very recently recorded in the Risk Assessment Area, its arrival suspected to have been via water currents, from areas along the eastern North Sea coast where it has been regularly recorded since the mid-2000s. It is likely that this process of entry to UK waters will continue. It is unlikely that *M. leidyi* will spread UK western areas via currents but spread via ballast water is possible.

Establishment Summary

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

Response: *very likely*
Confidence: *very high*

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

M. leidyi is characterised by the following life history traits: hermaphrodism, high fecundity (in excess of 2,000 and up to 12,000 eggs per individual per day reported in several areas (Costello *et al*., 2006; Costello *et al*. 2012; Finenko et al., 2006; Purcell et al., 2001), and rapid growth (at favourable temperature (15-30°C and food (>25 µg C per liter), eggs can hatch and develop into reproducing adults within 14 days (Reeve and Walter, 1978). These features, in combination with the high plasticity of *M. leidyi*, which can thrive in a wide range of temperatures (0 to 32°C) and salinities (2 to 39 PSU), have made this species a very successful invader.

Model predictions in the North Sea suggest that many coastal areas, in particular estuaries such as the Thames and the Wash, are suitable for *M. leidyi* reproduction due to a combination of suitable temperatures (water temperatures of 20°C are regularly recorded in the summer) and high food concentrations (Collingridge *et al*., 2014). As *M. leidyi* has already been recorded in and outside the Wash, it is likely that it will become established there. It is also likely that it will spread and become established in other suitably sheltered areas such as estuaries and bays.

However, feeding, growth and reproduction rates are highly dependent upon temperature and prey densities (Purcell *et al*., 2001). Although, individuals of *M. leidyi* can survive through the winter months, reproduction is thought to be possible only where temperatures exceed 12°C and salinity exceeds ~10 PSU (Lehtiniemi *et al*. 2012; Jaspers *et al*. 2011). Thus, the appearance of blooms is limited by temperature and salinity as well as the quantity of prey available. This implies that during several months of the year, temperatures in GB waters are below the reproductive threshold for *M. leidyi*. The length of a lifecycle (from egg to adult) is thought to be approximately 40 days at 15°C (Salihoglu *et al*., 2011), and modelling work have suggested that a maximum of 2-3 lifecycles could be completed in a year along the North Sea and English Channel GB coasts (Collingridge *et al*., 2014).

Spread Summary

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

Overall response: *rapid*
Confidence: *high*

Sub scores:

Natural spread only:
Response: *very rapid*
Confidence**:** *high*

Human facilitated spread only:
Response: *rapid*
Confidence**:** *medium*

Comments (in your comments list the spread pathways and discuss how much of the total habitat that the species could occupy has already been occupied):

M. leidyi has only recently been recorded in UK waters, i.e. the Wash estuary in 2014 and further north in coastal area near Scarborough and Hull in 2016. If the species is already established in the Wash estuary (no monitoring could be performed in 2015), then it is likely that this area is acting as a source location for *M. leidyi* to spread outwards via currents. Considering *M. leidyi*'s success as an invader in other seas (i.e. Black, Mediterranean, Baltic, eastern North Sea), it is very likely to spread further from those areas.

The introduction of *M. leidyi* in other areas of the UK via ballast waters is also a possibility, given that this vector was responsible for the species' first entry into the North Sea.

Impact Summary

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

Overall response: *major*
Confidence: *medium*

Sub-scores

Environmental impacts:
Response: *major*
Confidence**:** *medium*

Economic impacts:
Response: *major*
Confidence: *medium*

Social impacts:
Response: *minimal*
Confidence: *high*

Comments (include list of impacts in your comments):

The main impact of *M. leidyi* is environmental due to its ability to form blooms and its high predation rate on zooplankton (Purcell and Decker, 2005, Riisgård, 2007), thus potentially destabilising ecosystems and food webs (Condon and Steinberg, 2008; Daskalov et al. 2007; Dinasquet *et al*., 2012). Blooms of *M. Leidyi* have been recorded in Northern Europe; for example, in the western Baltic Sea (densities up to 92 individuals/m^3 in November 2006, Javidpour *et al*., 2006), in Danish waters (numerous reports of "mass occurrence" in 2007 (Tendal *et al*., 2007), and densities up to more than 800 ind./m^3 in Limfjorden (Riisgård, 2007)), in Netherlands water during the late summer of 2006 (Faasse and Bayha, 2006), in the Baltic Sea during October 2009 (Jaspers *et al*., 2013), in the Dutch Wadden Sea (density of up to 912 ind./m^3 in August, van Walraven *et al*., 2013), in the Belgian part of the North Sea during the period 2009-2011 (densities of up to 17 individuals/m^3, Van Ginderduren *et al*., 2012). Except for the Baltic Sea, which is characterised by low salinities values, all other area display similar environmental conditions to those encountered in GB waters, and it is likely that blooms will occur in the future.

There is an ongoing debate about the impact of *M. leidyi* on fish populations, whether it impacts negatively through direct predation on fish eggs and larvae, or whether low fish stock allow *M. leidyi* to attain high biomass due to reduced competition for abundant food resources (CIESM, 2015). Laboratory-based experimental studies have shown very little feeding of *M. leidyi* on fish eggs (Jaspers *et al*. 2011; Hamer *et al*. 2011). So, it is likely that *M. leidyi*'s main impact on fish populations is via competition for food with fish larvae.

Environmental impacts (via ecosystem function effects), and economical impact (via fisheries lossess), are potentially major, as demonstrated by the late 1980s events in the Black Sea mentioned in earlier sections. However, it is also possible that *M. leidyi* populations growth may be controlled by the presence of natural predators or food competitors. For example, the compass jellyfish *chrysaora sp*. is known to control *M. leidyi* population in the Chasapeake Bay, USA (Purcell and Decker, 2005), species of the jellyfish *Cynea* sp. are also known predators in Danish waters (Riisgård, 2007), and predation by another ctenophore (*Beroe* sp.) is well known (Purcell, 1991; Galil *et al*. 2013; Shiganova *et al*., 2014)). Overall little is still understood about the mechanisms involved in the interaction of M. leidyi with the other components of the ecosystem; this is reflected in the confidence score.

M. leidyi is hard to see due to its transparency, and likely to be invisible to the untrained eye. It is not harmful to humans.

Climate Change

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

Response: *high*
Confidence: *medium*

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

European seas are warming at present, and water temperature is likely to affect the distribution, seasonality and timing of appearance of *M. leidyi*, particularly in northern areas where the winter temperature falls below the level at which *M. leidyi* can reproduce (≈ 6°C; CIESM, 2014). Other laboratory studies have suggested that temperatures below 7–8°C could limits *M. leidyi* growth (Gambill *et al*., 2015). Under predicted climate change scenarios, greater winter/spring warming in the southwestern North Sea, and summer/autumn warming in the Celtic Sea and North Sea are forecasted (Tinker *et al*., 2015). As environmental conditions that currently limit survival and reproduction will become less restrictive in the coming decades. This could lead to wider dispersal along GB's coasts, where *M. leidyi* populations could maintain growth even in winter months. This would permit the species' northward dispersal, which is predicted within the European shelf seas for the next 40 (≈50 km) and 70 (≈60 km) years (Townhill *et al*., unpublished).

There is always a certain level of uncertainty when attempting to make climate change impact predictions, due in part with the uncertainty of the climate projections themselves as well as the uncertainty of how species will be affected (there will be winners and losers) and how they will interact with each other.

Conclusion

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

Response: *high*
Confidence: *medium*

Comments:
M. leidyi is established along the eastern North Sea coasts and has been recently recorded in GB waters in the Wash estuary (a reserve European Marine Site) and further north along the coast. The success of this non-native species as an invader in other EU waters suggest that it is very likely that *M. leidyi* will continue its expansion in the risk assessment area, and will become established in the most favourable locations (i.e. shallow, coastal and sheltered such as bays and estuaries). Owing to its high feeding, growth and reproduction rates, and its reputation as a threat to fish stocks gained following events in the Black Sea in the late 1980s, the establishment of *M. leidyi* in GB waters is cause for concern as these sustain some important fishing grounds and comprise some important spawning and nursery areas. However, there has been few negative direct reports on the appearance of *M. leidyi,* and little is understood on the interaction of *M. leidyi* within its ecosystem, including possible predation of other ctenophores species, which may thus control populations of *M. leidyi*. This is reflected in the confidence rankings.

Management options (brief summary):

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

Response: No intentional management has been attempted. However, following the introduction, also via ballast water of *Beroe ovata* (another ctenophore native of North America) in the Black Sea, populations of *M. leidyi* were shown to be controlled (Shiganova *et al*. 2014). *M. leidyi* may also be controlled by other native ctenophores as well as some species of jellyfish: *Beroe gracilis* and *Beroe cucumis* (both native and common around the UK coasts) have been shown to prey on *M. leidyi* (Hosia and Titelman, 2011; Riisgård and Goldstein, 2014). Other predators native of UK waters capable of feeding on *M. leidyi* include *Cyanea capillata* (lion's mane jellyfish) and *Chrysaora hysoscella* (compass jellyfish) (Hosia and Titelman, 2011). These gelatinous predators may thus contribute to the control of *M. leidyi* in the risk assessment area.

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

Response: There is little information available on control/eradication options: Biological control by predators of *M. leidyi* is in theory possible but biocontrol in marine habitats is risky: it poses many more uncertainties because specificity cannot be guaranteed and may result in unintended consequences (Secord D. 2003).

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

Response: Natural spread of *M. leidyi* via currents is impossible to control. In order to control to introduction of *M. leidyi* in new areas, ballast water management is needed.

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

Response: Control of *M. leidyi* expansion is unlikely to work because of its rapid spread via natural currents and the ease and which the species becomes established. We suggest that efforts should be focussed on monitoring and further our understanding on how this species interact with its environment.

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

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