EU NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Name of organism: ***Ondatra zibethicus***
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Risk Assessment Area: Europe

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EU CHAPPEAU	
QUESTION	**RESPONSE**
1. In how many EU member states has this species been recorded? List them.	Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark (Greenland and Faroe Islands excluded), Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Romania, Spain, Sweden, UK (Map in CABI website) (Bertolino *et al*, 2015; Elosegui, 2004; Genovesi, 2006; Triplet, 2015), Slovenia (pers. Comm.). In Spain, the species has recently arrived from the French populations through the Western Pyrenees pathway. It was first recorded around year 2003 in the Bidasoa river basin (Gipuzkoa, Basque Country). From that time the Spanish population has increased notably and the species has extended to the Urumea river basin (Navarra) and the Marshes of Jaizubía, (also in Navarra) (EuskadiNet, 2015; MAGRAMA, 2013). It is not present in Portugal.
2. In how many EU member states has this species currently established populations? List them.	Austria, Belgium, Bulgaria, Croatia, Czech Republic, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Romania, Spain, Sweden (Bertolino *et al*, 2015; Genovesi, 2006; Triplet, 2015). Successfully eradicated from Britain and Ireland in 1930's. (Genovesi, 2006). In Spain, the species is currently established in the Bidasoa basin (main river), from Txingundi Bay (Gipuzkoa) up to Mugairi (Navarra). It is likely that the species is distributed also in favourable tributaries of the Bidasoa. *O. zibethicus* is also established in the Marshes of Jaizubia (Gipuzkoa). It is also present at the headwaters of the Urumea river basin (Navarra) (Elosegui, 2004; EuskadiNet, 2015). In Italy the species spontaneously colonized the north-eastern side from Slovenia in the earlier 1990's and today there are naturalized populations of muskrats, although its distribution is still restricted (Bertolino *et al*, 2015).
3. In how many EU member states has this species shown signs of invasiveness? List them.	Austria, Belgium, Czech Republic, Finland, France, Germany, Lithuania, Netherlands, Sweden. (Butautytė-Skyrienė *et al.*, 2011; Triplet, 2015) In UK and Ireland it was invasive in the past, but it has been eradicated.

4. In which EU Biogeographic areas could this species establish?	According to present distribution the species is already established and very extended in the Alpine, Atlantic, Boreal, Continental and Pannonian biogeographic regions. It is also present, but not very extended in the Black Sea and Steppic regions. Its expansion in these regions is likely to happen. Also current ecological conditions favor its expansion towards the southern Boreal region of Sweden, and southern Continental region of Italy. For the moment it has not been recorded in the Mediterranean nor in the Macaronesian regions. In Spain it is present in the Atlantic region, in the Urumea and the Bidasoa basins, and the species could continue its expansion along the Atlantic region of Spain, towards Portugal. The Bidasoa basin neighbours other basins that belong to the Alpine and Mediterranean regions. Due to its vicinity it is not unlikely that the species reaches and expands though out the Alpine region of Spain, and even to some parts of the Mediterranean region. Climate change predictions would play different roles for the species depending on the region. Due to the species association to inland surface water habitats, under the climate change scenario foreseen for southern Europe it is expected a shrinkage and a shift northwards of the species distribution as more drier and hotter conditions arrive, especially in the Mediterranean and Atlantic region and secondarily in the Black Sea and Steppic regions (Rubel & Kottek, 2010). On the other hand, increasing foreseen precipitation in northern Europe may cause more frequent flooding and more wet areas, hence increasing habitat availability for muskrats.
5. In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them.	The species is already established in Austria, Belgium, Bulgaria, Croatia, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Spain, Sweden. If access will be facilitated to the species to UK and Ireland, it will re-establish populations there as it already did in the past before it was eradicated. It is noticeable that the species is kept as a pet in Ireland, with cases of escapes. Therefore there is a risk that establishment occurs in Ireland and the UK (particularly in Northern Ireland) (Information provided by the Scientific forum on this species' risk assessment)

	The species is already established in all European northern countries. According to the previous answer, climate change could favour habitat availability for the species causing its expansion in countries where it is already present. On the other hand, it could reduce its range, especially in the Western region of France where climate conditions will get much dryer than current ones (Rubel & Kottek, 2010).
6. In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)?	In Spain, Italy, Portugal, Greece the species could become invasive as long as there are inland surface water habitats available. Also there is a potential threat to Ireland and the UK (particularly in Northern Ireland) if more muskrat pet escapes occur in Ireland (Information provided by the Scientific forum on this species' risk assessment).

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE** **[chose one entry, delete all others]**	**COMMENT**
1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	Ondatra zibethicus, (L., 1766) Cricetidae (Muridae, Arvicolinae) **Synonyms:** Ondatra zibethica, Castor zibethicus, Fiber zibethicus, Myocastor zibethicus, Ondatra americana, Mus zibethicus, Mussascus **Common names:** Muskrat (Musquash) (GB), Swamp rabbit (GB), Marsh rabbit (GB), Marsh hare (GB), Bisam (DE), Bisamratte (DE), Moschusratte (DE), Zwergbiber (DE), Zibethratte (DE), Bisambiber (DE), Biberratte (DE), Sumpfkaninchen (DE), Sumpfhase (DE), Muschmaus (DE), Zibetmaus (DE), Wasserratte (DE), Bisamrotte (DK), Ondatra (EE), Piisamrott (EE), Piisami (FI), Rat musqué (FR), Moskusrotta (IS), Rata almizclera (ES), Ondatra (LT), Ondatra / bizamžurka (LV), Piżmak (PL), Онда́тра (RU).	Yes, this species can be adequately distinguished from other entities. It is the only species in genus Ondatra. Taxonomically it belongs to the subfamily Arvicolinae, family Cricetidae and order Rodentia.
2. If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	NA	
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	No risk assessment has been carried out for the whole of Europe. A Risk Assessment has been conducted in Belgium where the species is already acclimatised, naturalised and presents a widespread distribution, as a result of its high dispersion potential. For these reasons the species was included in the Black list, reaching the highest score (Score 12, A3) (Branquart *et al*., 2011).

		It is recommended for eradication by the Bern Convention on the Preservation of European Wild Plants and Animals and their Natural Habitats (Bern Convention Standing Committee, 1999), and is listed by DAISIE as one of the 100 worst invasive species in Europe (DAISIE, 2011), but its high rate of reproduction makes it difficult to control. It could also act as a reservoir of different pathologies and causes damages to agriculture and flood protection structures. The estimated costs of economical impacts caused by *O.zibethicus* in Germany were 12.400.000 euros in 2013 (Birnbaum, 2013), and 1-4 million euros in damage by digging in flood protection in the Netherlands (Gaaff *et al*., 2007).
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?		The Belgium assessment was updated in 2011 and hence it should still be considered valid, at least for that country and the 2 bioregions comprised within: the Atlantic and the Continental ones.
5. Where is the organism native?		It is native to North America.
6. What is the global distribution of the organism (excluding Europe)?		It is native to North America, from Northern Canada and South Alaska through the United States, except the arid regions of the Southwest and Texas, and the Florida peninsula. It has been introduced to Europe, Asia and South America (Argentina and Chile) (Nentwig *et al*., 2010)
7. What is the distribution of the organism in Europe?		The muskrat has successfully colonized many European countries from East Scandinavia, West France, North to Denmark, East to Ukraine, South

		to North Greece (Nentwig *et al*., 2010). Its distribution area in Europe comprises: Austria, Belarus, Belgium, Bosnia, Bulgaria, Croatia, Czech Republic, Denmark (Greenland and Faroe Islands excluded), European part of Russia, Estonia, Finland, France, Germany, Hungary, Italy, Ireland, Kosovo, Latvia, Lithuania, Luxembourg, Macedonia, Netherlands, Poland, Romania, Serbia, Sweden, Switzerland, UK (Map in CABI website) (Genovesi, 2006; Triplet, 2015). In Spain and Italy the species still has a restricted distribution (Bertolino *et al*, 2015; Elosegui, 2004; EuskadiNet, 2015 and there are also located sightings in Greece (listed on the DAISIE online factsheet (http://www.europe-aliens.org/speciesFactsheet.do?speciesId=52887#).
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?		From 1905 muskrats have been introduced in many countries of Europe, Asia and South America where they have successfully settled populations and expanded in numbers and range (Nentwig *et al*., 2010). It is a fast growing, gregarious species, with a high reproductive potential, very mobile and highly adaptable to different environment. It is proved to be invasive outside its native range (Birnbaum, 2013; Branquart *et al*., 2011; Genovesi, 2006, Nentwig *et al*., 2010; Triplet, 2015)
9. Describe any known socio-economic benefits of the organism in the risk assessment area.		Although *O. zibethicus* was farmed for fur in many countries in Europe, its economic value is currently almost nil because there is no demand for its fur (Triplet, 2015).

SECTION B – Detailed assessment

PROBABILITY OF ENTRY

Important instructions:

- Entry is the introduction of an organism into Europe. Not to be confused with spread, the movement of an organism within Europe.
- For organisms which are already present in Europe, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms which have entered in the past and have no current pathways of entry.

QUESTION	RESPONSE [chose one entry, delete all others]	CONFIDENCE [chose one entry, delete all others]	COMMENT
1.1. How many active pathways are relevant to the potential entry of this organism? (If there are no active pathways or potential future pathways respond N/A and move to the Establishment section)	none	very high	In Europe the species has largely been introduced for fur farming since early 1900. Due to its limitations for successful captive breeding it has also been realised intentionally in several countries with the aim of establishing populations to be harvested for their furs (Genovesi, 2006). Nowadays, the market demand for muskrat fur is almost inexistent (Triplet, 2015) and hence economic beneficial is almost nil. It does not seem that entry through fur farming is still occurring neither that there still exist active farms in Europe, however it is not easy to find this information. For these reasons, it seems quite unlikely that humans favour voluntarily the entry of (more) muskrats into Europe. Moreover, muskrats are not zoo animals nor are commonly perceived as pets. Nevertheless, there are exceptions to this latter point as the species is kept as a pet in Ireland, where there have been cases of

			escapes(Information provided by the Scientific forum on this species' risk assessment). In Spain, introduction of the species is no longer legal for any purpose (including the commercial one) after the publication of Act 630/2013, 2nd August, that regulates the Spanish Catalogue of Invasive Alien Species. Therefore, the only pathway for the muskrat arrival is its natural expansion from neighbouring French populations. This pathway is already effective, and the first muskrats were detected in Spain more than 10 years ago. The species has also colonized North-east Italy from Slovenian populations.
1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways. For each pathway answer questions 1.3 to 1.10 (copy and paste additional rows at the end of this section as necessary).	Spread (natural dispersion)	very high	*O. zibethicus* arrival to Spain has taken place (and currently takes place) though the natural range expansion of the French populations across the westernmost side of the Spanish-French border (Elosegui, 2004; EuskadiNet, 2015). North-east Italy has also been colonized from Slovenian populations (Bertolino *et al*, 2015).
Pathway name:			
1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)? (If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)			
1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.			

1.5. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.			
1.6. How likely is the organism to survive existing management practices during passage along the pathway?			
1.7. How likely is the organism to enter Europe undetected?			
1.8. How likely is the organism to arrive during the months of the year most appropriate for establishment?			
1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?			
1.10. Estimate the overall likelihood of entry into Europe based on this pathway?			
End of pathway assessment, repeat as necessary.			
1.11. Estimate the overall likelihood of entry into Europe based on all pathways (comment on the key issues that lead to this conclusion).	NA		The answer is NA because the species has already entered into Europe more than a century ago. Muskrats are well established and spread in many European countries. In some others, like Spain and Italy, its arrival is quite recent, and not very extended yet. Nowadays natural spread from areas where the species is already established poses the most significant risk of expansion.

PROBABILITY OF ESTABLISHMENT

Important instructions:

- For organisms which are already well established in Europe, only complete questions 1.15 and 1.21 then move onto the spread section. If uncertain, check with the Non-native Species Secretariat.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.12. How likely is it that the organism will be able to establish in Europe based on the similarity between climatic conditions in Europe and the organism's current distribution?	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.13. How likely is it that the organism will be able to establish in Europe based on the similarity between other abiotic conditions in Europe and the organism's current distribution?	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.14. How likely is it that the organism will become established in protected conditions (in which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in Europe? Subnote: gardens are not considered protected conditions	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Europe?	moderately widespread	high	Muskrats inhabit inland surface water habitats. It includes mostly freshwater habitats, such as riverbanks with slow moving waters, lakes, ponds, marshes and wetlands. *O. zibethicus* can also be found in dikes along roads if they are close enough to water (Triplet, 2015), it is also able to live in estuaries, and can survive in brackish or salty habitats (McConnell and Powers, 1995).

			Overall, the kind of habitat the species needs is moderately widespread through Europe, especially in the atlantic, alpine, continental and boreal bioregions. Higher precipitation in Northern Europe is expected under a climate change scenario. This would create more wet habitats to be available for the species causing its expansion and population increase. On the other hand, in Southern Europe, the inland surface water habitats required by the species are expected to decrease, both in surface and numbers, as longer drought periods and dry summers become dominant and dry them up.
1.16. If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in Europe?	NA		The answer is NA because the species does not require an association to any particular organism.
1.17. How likely is it that establishment will occur despite competition from existing species in Europe?	very likely	very high	The species establishment has already occurred in most of the areas where it has been recorded in Europe. The main competitors are beavers and water voles which live in the same habitat and especially in the case of the latter, use the same food (Prūsaitė, 1988), but in for example the Netherlands these species coexist.
1.18. How likely is it that establishment will occur despite predators, parasites or pathogens already present in Europe?	very likely	very high	The species establishment has already occurred in most of the areas where it has been recorded in Europe, despite the presence of new predators, parasites or pathogens found in its non-native area. The American mink (*Neovison vison*), also introduced to Europe, is a primary predator of muskrat, which lives in the same habitat and decimates whole families of muskrats (Holmengen

			et al., 2009). Red fox (Vulpes vulpes), otters (Lutra lutra), barn owls (Tyto alba) and harriers (*Circus* spp.) also prey on muskrats (Genovesi & Scalera, 2008). Parasites may reduce muskrat populations to a great extent. For example in Sweden, Tularemia disease (infection agent *Francisella tularensis*) was recorded as the cause of decrease in muskrats (Danell, 1996). Researchers have supposed that a genetic monomorphism of muskrat of European population may increase susceptibility to diseases and parasites (Zachos *et al*., 2007).
1.19. How likely is the organism to establish despite existing management practices in Europe?	likely	very high	The extend of *O. zibethicus* current distribution and population size in Europe and its high reproduction rate are such that for decades it has been obvious that eradication is no longer possible (Birnbaum, 2013; Triplet, 2015). Eradication is only possible on islands where there is no flow of individuals. In continental situations, it is possible to eradicate animals on one site, but pioneer movements of young individuals can result in the return of the species if a high pressure of capture is not maintained (Triplet, 2015). Continued control campaigns over years have proved to reduce harvest proportions for the same or even increased trapping effort in Belgium and the Netherlands. By these means, potential flooding risk of low lying country caused by muskrat damage is kept below a publicly acceptable level in the Netherlands (Bos & Ydenberg, 2011). Therefore, slowing the rate of spread and controlling the population size in critical situations remain the only realistic ways in

			which this species can be controlled. Control methods include trapping, shooting, poisoning, disturbance, hunting and exclusion (Kadlec *et al*., 2007). As an example, Finland has managed to reduce its population from 600.000 to 6.000 specimens (Information provided by the Scientific forum on this species' risk assessment). Nevertheless, successful muskrat eradications were carried out in UK and Ireland in the 1930's (Genovesi, 2006), so at a smaller scale and in isolated areas management practices have been proven to work.
1.20. How likely are management practices in Europe to facilitate establishment?	likely	very high	Current management practices in Europe do not prevent *O. zibethicus* from establishing. For this very same reason the inclusion of the species in the EU List of Invasive Species is decisive as it will create the obligation for common European actions. Only a unified and committed response will be capable of tackling this problem.
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in Europe?	likely	very high	Research cited by Kadlec *et al*. (2007) found that numerous studies indicated that a population could remain sustainable with 50-90% of animals harvested every year. So, due to the high reproduction rate of the species and to a high dispersal of young individuals eradication is only possible with very high control pressure (Triplet, 2015). Here we provide some data on reproductive parameters: gestation period expands from 30-47 days; litter size varies between 2- 14 pups; average number of litters per year is 2 or 3 (and up to 6 in favourable climatic and habitat conditions). Young become sexually mature the spring following birth

			(FACE, 2014; Genovesi, 2006). Nevertheless, successful muskrat eradications were carried out in UK and Ireland in the 1930's (Genovesi, 2006), so at a smaller scale and in isolated areas management practices have been proven to work. In the Netherlands, population densities are controlled through high and constant effort in areas where there is risk of flooding and in turn flooding damage is minimal.
1.22. How likely are the biological characteristics of the organism to facilitate its establishment?			
1.23. How likely is the capacity to spread of the organism to facilitate its establishment?			
1.24. How likely is the adaptability of the organism to facilitate its establishment?			
1.25. How likely is it that the organism could establish despite low genetic diversity in the founder population?			
1.26. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Europe? (If possible, specify the instances in the comments box.)			
1.27. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.			

1.28. Estimate the overall likelihood of establishment (mention any key issues in the comment box).			

PROBABILITY OF SPREAD

Important notes:

- Spread is defined as the expansion of the geographical distribution of a pest within an area.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.1. How important is the expected spread of this organism in Europe by natural means? (Please list and comment on the mechanisms for natural spread.)	massive	very high	Natural dispersal is the main component of range expansion for *O. zibethicus* (Triplet, 2015). The spreading front moves at a rate ranging from 0.9 to 25.4 km/year, corresponding to a diffusion coefficient ranging from 51 to 230 km2/year (Danell, 1977; Birnbaum, 2013; research cited by Kadlec *et al*., 2007). In France, the range expanded at a rate of 3300 km²/year in the 25 years prior to 1959 (Aubry, 1959). Muskrat introduction in Norway was accomplished between 1980 and 1988 and in 1996 it has spread almost over all parts of the country (Danell, 1996). *O. zibethicus* can migrate long distances (up to 160 km/day) by rafting, being carried long distances by river currents (Böhmer *et al*., 2001).
2.2. How important is the expected spread of this organism in Europe by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minimal	high	Nowadays, the market demand for muskrat fur is almost nonexistent (Triplet, 2015) and hence economic beneficial is almost nil. Moreover, muskrats are not commonly perceived as pets nor are zoo animals. For these reasons, it seems quite unlikely that humans favour voluntarily the expansion of muskrats in Europe. In Spain, introduction, possession or trade of the species is illegal under any purpose after the publication of Act 630/2013, 2nd August, that regulates the Spanish Catalogue of Invasive Alien Species.

2.3. Within Europe, how difficult would it be to contain the organism?	very difficult	very high	The extend of *O. zibethicus* current distribution and population size in Europe and its high reproduction rate are such that for decades it has been obvious that eradication is no longer possible (Birnbaum, 2013). Other sources recognized that eradication is only possible with very high control pressure (Triplet, 2015). Slowing the rate of spread and controlling the population size in critical situations remain the only realistic ways in which this species can be controlled. Control methods include trapping, shooting, poisoning, disturbance, hunting and exclusion (Kadlec *et al*., 2007). Nevertheless, successful muskrat eradications were carried out in UK and Ireland in the 1930's (Genovesi, 2006) within 10 years of introduction, so at a smaller scale and in isolated areas management practices have been proven to work.
2.4. Based on the answers to questions on the potential for establishment and spread in Europe, define the area endangered by the organism.	All continental Europe where there are freshwater habitats	high	*O. zibethicus* is already spread throughout most of the EU. Only in the southern most countries it has an incipient distribution. Such is the case of Spain (Elosegui, 2004; EuskadiNet, 2015) and Italy and Greece, also listed on the DAISIE online factsheet (http://www.europe-aliens.org/speciesFactsheet.do?speciesId=52887#). The spread of the species is likely to happen along the Continental region of Italy and the Atlantic region of Spain, allowing, in this case, the expansion of the species along the northern part of Spain and its arrival to north Portugal. In Spain and Italy, it could also spread its distribution to humid areas of the neighbouring Mediterranean region. It is of major importance to avoid the spread of the species in these

			countries (mainly Spain and Italy), and to act as soon as possible, before the chance to control it gets absolutely out of reach as it is already in the rest of Europe.
2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of Europe were the species could establish), if any, has already been colonised by the organism?	90-100	very high	About 90% of the area is suitable for establishment. See answer above.
2.6. What proportion (%) of the area/habitat suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	90-100	very high	If the species spread is not controlled in Spain, Italy and Sweden it will likely continue its expansion along the Continental region of Italy, south of Sweden and the Atlantic region of Spain, allowing, in this case, the spread of the species along the northern part of Spain and its arrival to north Portugal. In Spain and Italy, it could also spread its distribution to humid areas of the neighbouring Mediterranean region.
2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in Europe? (Please comment on why this timeframe is chosen.)	40	medium	Taking into account the dispersion rates given in answer 2.1, the spread of the species front from its settlements in Spain (close to the border with France), to the NW corner of Spain would take at least 30 years (estimated time for 700km distance with a rate of 25km progress of the distribution front per year).
2.8. In this timeframe what proportion (%) of the endangered area/habitat (including any currently occupied areas/habitats) is likely to have been invaded by this organism?	90-100	very high	About 100% of the area suitable for establishment.
2.9. Estimate the overall potential for future spread for this organism in Europe (using the comment box to indicate any key issues).	rapidly	very high	Field data on dispersion and spread of the front distribution of the species have proved that muskrats have a high potential for continuing its expansion across Europe and reach the small part of the suitable area still unoccupied (See answer 2.1). Natural spread is already reaching new regions of Europe where the species was not present 25 years

			ago, such as North-Eastern Italy and Northern Spain. Due to similar climatic and ecological conditions to other areas where the species has successfully spread and established, the expansion of *O. zibethicus* over the whole Atlantic region of Spain, and its continuation into Portugal, and over the whole Continental region of Italy is a real risk. The dispersal of *O.zibethicus* southwards in Sweden is also a fact (Birnbaum, 2013). If climate change predictions are met, more precipitation on Northern Europe will favour availability of wet habitats for the species, which will not take much time to be colonized by the species.

PROBABILITY OF IMPACT

Important instructions:

- When assessing potential future impacts, climate change should not be taken into account. This is done in later questions at the end of the assessment.
- Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).
- Note questions 2.10-2.14 relate to economic impact and 2.15-2.21 to environmental impact. Each set of questions starts with the impact elsewhere in the world, then considers impacts in Europe separating known impacts to date (i.e. past and current impacts) from potential future impacts. Key words are in bold for emphasis.

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.10. How great is the economic loss caused by the organism within its existing geographic range, including the cost of any current management?	massive	very high	Muskrats cause extensive damage to crops, irrigation structures, roads, railroads and dams. They also cause damage to flood protection structures (destabilization of flood dikes). In some cases they undermine fences or cause bogging of machinery. It has also a potential impact on aquaculture industry (chewing through nets and fish traps) (Birnbaum, 2013). *Ondatra zibethicus* could weaken riverbanks with their burrowing activities; this impact is especially important for the first species (Panzacchi et al., 2007). Control methods include trapping, shooting, poisoning, disturbance, hunting and exclusion (Kadlec *et al*., 2007). In Germany the estimated cost of the economic loss caused by muskrats was more than 12 million euro in 2003 (Reinhardt *et al*., 2003). Only management costs in the Netherlands rose to 35 million euro per year in 2007 (Bos & Ydenberg, 2011). Extrapolating these amounts to all EU countries where the species is present yields more than 13 million euro that is the threshold for considering a *massive* cost

			according to the classification provided in the 'Impact Assessment Guidance' from UK.
2.11. How great is the economic cost of the organism currently in Europe excluding management costs (include any past costs in your response)?	massive	medium	According to the generic scoring system that compares the impact of alien mammals in Europe developed by Nentwig *et al* (2010), *O. zinbethicus* is the second species (after *Rattus norvegicus*) out of 34 species assessed with a highest economic actual impact in Europe. In Germany the costs of economic impacts caused by *O. zibethicus* are estimated to be 12,400,000 euros per year (€ 4.6 mln/yr for sanitary aspects, € 2.3 mln/yr for maintenance of waterways, € 1.9 mln/yr for impacts to hatcheries and fish breeders by damaging ponds and dams. The difference is allocated to control measures that are excluded from this section) (Reinhardt *et al*., 2003). Germany represents about one third of the area where the species has shown signs of invasiveness (see answer to question 3), and hence economic cost at the European level have been extrapolated to be massive. In Spain, economic costs have not been quantified, but are expected to be minor due to the reduced extension of the species, for the moment.
2.12. How great is the economic cost of the organism likely to be in the future in Europe excluding management costs?	massive	high	There are not future estimates on the economic loss caused by *O. zibethicus* in Europe (nor in Spain), but it is quite likely that current levels (or higher) experience no change.
2.13. How great are the economic costs associated with managing this organism currently in Europe (include any past costs in your response)?	massive	medium	The strategy to manage muskrat populations in the Netherlands over the past four decades has been to kill/capture animals during the whole year, all over the country at a cost of 35 million euro per year in 2007 (Bos & Ydenberg, 2011).

			Cost of eradication efforts in Germany are estimated to over € 3 mln/year (Reinhardt *et al*., 2003). Although those references offer very divergent data, it is clear that managing this species across all Europe would have an estimated *massive* cost, since just control measures in the Netherlands exceeds the 13 million euro threshold according to the classification provided in the 'Impact Assessment Guidance' from UK. Yearly control cost is 30 million euro in the Netherlands (Information provided by the Scientific forum on this species' risk assessment) In Spain, where the populations is still small and under control, yearly management cost is estimated to be *minimal*, according to the classification of the 'Impact Assessment Guidance' from UK..
2.14. How great are the economic costs associated with managing this organism likely to be in the future in Europe?	massive	low	There are not estimates on the economic cost associated with managing *O. zibethicus* in Europe (nor in Spain) in the future. It all depends on how strong the will of the authorities to control the species is.
2.15. How important is environmental harm caused by the organism within its existing geographic range excluding Europe?	major	very high	The environmental harm caused by muskrat outside its native range is massive. The species impacts biodiversity components in different ways: • Impact on habitats: *O.zibethicus* feeds mainly on plants of the reed belt communities (Diemer, 1996), particularly on common reed (*Phragmites communis*). Although *O. zibethicus* is considered a generalist species in terms of its diet, it predominantly eats only a few species (Ramsgaard, 2005), and just one animal is capable of cropping 1,5m^2 per night (Burghause, 1988). The result is that an overabundance of *O. zibethicus* can modify the vegetal

			landscape (Kadlec *et al*., 2007) causing changes in the composition and structure of littoral vegetation and reed beds decline (Danell 1977, 1979). This change in vegetation affects communities of aquatic invertebrates (Nummi *et al*., 2006) and destroys fish nurseries (Branquart *et al*., 2011). Muskrats also like to dig for roots of water plants (eg. *Helianthus tuberosus*) in river plains (Burghause, 1996), and this burrowing activity degrades river banks and affects river flow. • Impact on species: *O. zibethicus* may sometime feed on bivalves, crustaceans and insects, and can exert a strong predation pressure on endangered taxa, such as *Anodonta, Unio,* and the freshwater pearl mussel *Margaritifera margaritifera* (Hochwald, 1990; Zimmermann *et al*., 2000). This indirectly affects rare fish species that deposit their eggs in bivalves, such as the bitterling (*Rhodeus amarus*). Especially severe impact on threatened mussel populations is noticeable in Luxembourg and Austria (Information provided by the Scientific forum on this species' risk assessment). It also impacts on fledglings as well as on adult ground-nesting birds, and on fishes (Triplet, 2015). It could also act as a reservoir of different parasites, affecting the heath of both humans and of domestic animals and causes damages to agriculture (Branquart *et al*., 2011).
2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in native species communities, hybridisation) currently in	major	very high	Same as answer to question 2.15

Europe (include any past impact in your response)?			
2.17. How important is the impact of the organism on biodiversity likely to be in the future in Europe?	major	very high	Unless strong action to control the species is developed, no change in impact trend to biodiversity is expected in Europe (nor in Spain) in the future.
2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism currently in Europe (include any past impact in your response)?	major	high	Muskrats strongly affect aquatic vegetation dynamics through grazing, causing changes in composition and structure of vegetation and creating mud-flats. Overall plant biomass decreases. This alters the habitat of species such as fishes and aquatic invertebrates which are more exposed to predators (Birnbaum, 2013; Triplet, 2015). Also, destruction of the wetland vegetative infrastructure may result in loss of some water quality parameters such as water temperature, dissolved oxygen, pH, conductivity and sediment organic content indicating that muskrats alter abiotic conditions (Szalay and Cassidy, 2001). Soil nitrogen dynamics is also affected, being this an important component of wetland function (Connors *et al*., 2009). Lodge building can also impact wetland hydraulics (Danell, 1996). Its burrowing activity can weaken riverbanks and dikes causing them to collapse, with the risk of exposing human settlements and crop fields to flood damages (Becker, 1972).
2.19. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism likely to be in Europe in the	major	high	Unless strong action to control the species is developed, no change in impact trend to ecosystem function is expected in Europe (nor in Spain) in the future.

future?			
2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism currently in Europe?	major	medium	*O. zibethicus* may also reduce the ecological value of wetlands of interest to nature conservation and potentially to SAP and SAC consistenting mainly of vegetated meadows linked to inland shallow water masses, and in a less extend to WFD by destroying the reed belts, feeding on endangered plant species and preying upon rare freshwater bivalves, fledglings and adult ground-nesting birds. The animal moves four times its own weight in gnawed off plants daily. About a quarter of this is eaten by the animal, creating quite a lot of dung which usually goes into the water (Birnbaum, 2013). Its activity can also alter water quality parameters that affects mainly to the invertebrate community, and soil nitrogen dynamics.
2.21. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the future in Europe?	major	medium	Unless strong action to control the species is developed, no change in impact trend to conservation status of sites is expected in Europe (nor in Spain) in the future.
2.22. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their economic, environmental or social effects more serious?	minimal	high	The risk of interbreeding is not a threat to be considered.
2.23. How important is social, human health or other harm (not directly included in economic and environmental categories) caused by the organism within its existing geographic range?	minor	medium	Its burrowing activity can weaken riverbanks and dikes causing them to collapse, with the risk of exposing human settlements and crop fields to flood damages (Becker, 1972). It could also act as a reservoir of different parasites, affecting the heath of both humans and of domestic animals and causes damages to agriculture (Branquart *et al*., 2011). In fact, according to Hoffmann (1958), *O.*

			zibethicus is host to a great number of parasites (41 species of trematodes, 22 species of cestodes, 27 species of nematodes, and others), notably various species capable of infesting humans, such as the fox tapeworm (*Echinococcus multilocarus*), the dog tapeworm (*Taenia hydatigena*), the cat tapeworm (*Taenia taeniaformis*), and the dwarf tapeworm (*Echinococcus multilocuralis)* (Böhmer *et al*., 2000). The presence of muskrat undoubtedly increases the risk to humans of fox tapeworm infection, via muskrat-to-housepet-to-human transmission (Reinhardt *et al*., 2003). Muskrats can also transmit tularaemia disease, Muskrats may also be a source of water contamination with parasites which cause diseases of interest in relation to human health such as giardiasis and leptospirosis (Hatler *et al*. 2003). *O. zibethicus* only occasionally affects humans directly. This occurs in situations when the animals are cornered. They defend themselves vigorously and may even attack humans (Danell, 1996). Reservoir of *Leptospira interrogans, Francisella tularensis, Echinococcus multilocularis* (Meerburg et al. 2009)
2.24. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	minimal	medium	Muskrats are a frequent prey for American minks (*Neovison vison*), another invasive alien species introduced to Europe (Holmengen *et al*., 2009).
2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		

2.26. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Europe?	major	high	The American mink (*Neovison vison*), which is now spread throughout Europe, is an important predator of *O. zibethicus* (Holmengen *et al*., 2009). Other natural enemies are martens, European polecats, weasels, foxes, lynxes and various birds of prey and large owls; however, the populations of these predators have been anthropogenically decimated, so that their predation pressure on *O. zibethicus* is low. *O. zibethicus* is difficult to catch for most of the predators since it spends most of its time in the water. *O. zibethicus* individuals taken by the mentioned predators are often sick or young animals which spend more time on land (Ramsgaard, 2005).
2.27. Indicate any parts of Europe where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Spain Italy Sweden	high	All described impacts and costs associated with *O. zibethicus* already occur in most part of Europe, and are particularly likely to start occurring soon in Northern Spain, Northern Italy and Southern Sweden The species has already arrived by natural dispersion to Spain from France, through the westernmost side of the Spanish-French border. And in Italy the species spontaneously colonized the Northeast side from Slovenia and it still has a restricted distribution in the country (Bertolino *et al*, 2015), but could continue its expansion along the whole Italian Alpine region. Southern Sweden has good ecological conditions for the spread of the species from the Northern part of the country where is already widely distributed.

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	very likely	very high	The species was introduced to Europe from North America for fur farming purposes from 1905 onwards. Colonization was also deliberately fostered to enhance the fur trade in these animals' pelts (Böhmer *et al*. 2001). It is widely spread now throughout most of its suitable area in most European countries. *O. zibethicus* arrival to Spain has taken place (and currently takes place) though the natural range expansion of the French populations across the westernmost side of the Spanish-French border. The first sightings date from around year 2002. The species has also colonized the north-eastern side of Italy from Slovenia in the earlier 1990.
Summarise Establishment	very likely	high	The species is widely established throughout most of its suitable area in most European countries. In Spain, the species is currently established in the Bidasoa basin (main river), from Txingundi Bay (Gipuzkoa) up to Mugairi (Navarra). It is likely that the species is distributed also in favourable tributaries of the Bidasoa. *O. zibethicus* is also established in the Marshes of Jaizubia (Gipuzkoa). It is also present at the headwaters of the Urumea river basin (Navarra).
Summarise Spread	rapidly	high	Natural dispersal is the main component of range expansion for *O. zibethicus*, and the species is highly mobile, adaptable to different environments and has a high reproduction rate.

			In less than 15 year the spread of the species in Spain is still contained, but is getting larger progressively. It is now present in at least the Urumea and the Bidasoa basins, in the Atlantic region, and there is a high chance that its expansion continues along the Atlantic region of Spain and reaches Portugal. The Bidasoa basin neighbours other basins that belong to the Alpine and Mediterranean regions, where the species could continue its expansion if it finds suitable habitats. In North-East Italy there are naturalized populations of muskrats, although its distribution is still restricted.
Summarise Impact	major	very high	According to the generic scoring system that compares the economic and environmental impact of alien mammals in Europe developed by Nentwig *et al* (2010), *O. zinbethicus* is the second species (after *Rattus norvegicus*) out of 34 species assessed with a highest overall score in Europe. Overgrazing by muskrat causes the local extinction of aquatic plants and the destruction of reedbeds and fish nursery areas. Due to its burrowing activity, it degrades river banks and affects river flow. It can exert a strong predation pressure and threaten freshwater mussel and crustacean populations. It could also act as a reservoir of different pathologies and causes damages to agriculture. It undermines banks, dams, and road and railway embankments, causing their collapse during floods. No significant impacts have been detected in Spain yet, but known impacts of the species in other areas are likely to occur if muskrat population increases.
Conclusion of the risk assessment	high	high	The species was first introduced into Europe in 1905 for fur purposes. Currently it is spread throughout most of

			its adequate habitat in most of the EU countries. Long lists of scientific papers and field records prove its negative impacts and its invasive character in many regions throughout Europe as they cause economic, human (health and safety) and environmental impacts. Management practices are implemented in just a few countries, such as the Netherlands and Belgium and consist on systematic trapping in order to reduce muskrat densities and hence the damages/impacts they cause. This management is locally successful but it will not attain eradication. To achieve eradication a common and committed response from all EU countries is required. The inclusion of *Ondatra zibethicus* in the 'EU List of invasive species' is decisive to create this unified commitment. This commitment should have as a long term goal the eradication of the species from the EU, and as a short term goal, the prevention of muskrats further spread to some countries where the species is not present yet or has arrived recently (ca. 20 years ago) from neighbouring countries and where its distribution is still restricted. Such is the case of Northern Spain, colonized from French muskrat populations crossing through the Western-most side of the Pyrenees, and of North-east Italy, colonized from Slovenian populations. Muskrats are also expanding to Southern Sweden, and scattered sightings have been recorded for Greece. Due to similar climatic and ecological conditions to other areas where the species has successfully spread and established, the expansion of *O. zibethicus* over the whole Atlantic region of Spain, and its continuation into Portugal, and over the whole Continental region of Italy is a real risk.

			The impacts on these regions are expected to be the same as those occurring in other areas of Europe, where it is proven to be an invasive species. Ireland and the UK (as for Northern Ireland) are also under threat, due to muskrat pet escapes in Ireland.

ADDITIONAL QUESTIONS - CLIMATE CHANGE			
3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	- Higher precipitation - Higher frequency of floods - Droughts and dry summers	high	Tidal fluctuations, periodic flooding or droughts limit species distribution. Dry summers and severe winters have detrimental effects (Genovesi, 2006).
3.2. What is the likely timeframe for such changes?	20, 50,	low	
3.3. What aspects of the risk assessment are most likely to change as a result of climate change?	Distribution Abundance	high	If climate change predictions are met, these would play different roles for the species depending on the region. Foreseen increased precipitation in the North of Europe will increase availability of wet habitats and food for the species. On the other hand, in Southern Europe a shrinkage and a shift northwards of the species distribution as more drier and hotter conditions arrive, could be expected, especially in the Mediterranean and Atlantic region and secondarily in the Black Sea and Steppic regions (Rubel & Kottek, 2010).
ADDITIONAL QUESTIONS - RESEARCH			
4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here.	[insert text]	low medium high very high	

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