Information on measures and related costs in relation to species considered for inclusion on the Union list

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This technical note provides information on the effectiveness of measures, alongside the required effort and resources, used to prevent the introduction, and to undertake early detection, rapid eradication, and management for the invasive alien species under review. Each table represents a separate measure.

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Species (scientific name)	**Genus: *Ameiurus* Rafinesque, 1820** *Ameiurus brunneus* Jordan, 1877 *Ameiurus catus* (Linnaeus, 1758) *Ameiurus melas* (Rafinesque, 1820) *Ameiurus natalis* (Lesueur, 1819) *Ameiurus nebulosus* (Lesueur, 1819) *Ameiurus platycephalus* (Girard, 1859) *Ameiurus serracanthus* (Yerger and Relyea, 1968)
Species (common name)	Bullheads; Bullhead catfish *Ameiurus brunneus*: snail bullhead *Ameiurus catus*: white catfish, white bullhead *Ameiurus melas*: black bullhead, *Ameiurus natalis*: yellow bullhead,

	Ameiurus nebulosus: brown bullhead, *Ameiurus platycephalus*: flat bullhead *Ameiurus serracanthus*: spotted bullhead
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Summary

Highlight of measures that provide the most cost-effective options to prevent the introduction, achieve early detection, rapidly eradicate and manage the species, including significant gaps in information or knowledge to identify cost-effective measures.

Prevention

At least four species of the *Ameiurus* genus are already present in Europe (24 European countries have recorded at least one *Ameiurus* sp.) but only two species are widespread, *Ameiurus melas* and *Ameiurus nebulosus*. Their main pathways of entry in recent years has been through fish farming and recreational angling practices. Banning the import, trading and keeping of *Ameiurus* species, and educating all stakeholders involved, are measures that can reduce the risk of new introductions and spread. During the last few decades, the interest of this species group for recreational fishing has declined and some countries have forbidden new entries of *A. melas* and *A. neboulosus*. There is scant evidence for establishment of other *Ameiurus* species in Europe (*Ameiurus catus* and *Ameiurus natalis)*, so it is possible that preventive measures could stop other *Ameiurus* species from entering and spreading.

Early detection

The *Ameiurus* species are still poorly studied in European waters. *A. melas'* dispersal mechanism is not clear but is likely to be associated with accidental and/or illegal introductions through stocking practices, followed by natural spread between neighbouring countries via natural and manmade water courses and drainage networks and also perhaps by aquarium releases. The recommended method for detecting *Ameiurus* catfishes is standard ichthyological surveying, particularly through the use of fyke net traps and a combination of these and other standard survey methods, including electrofishing. The effectiveness is good but requires that sufficient time be invested in targeting lentic habitats and wetlands especially. Involving recreational and professional fishers to track the presence of the species could also be useful. Novel methods such as eDNA detection should be further investigated and applied, especially since detection at initial colonization may go unnoticed when only fishing methods or routine sampling methods are used in surveys.

Rapid eradication

Once *Ameiurus melas*or *A. nebulosus*is are established, eradication is usually impossible and/or highly costly in large lowland river basin systems. This species group has been successfully eradicated only in small ponds and reservoirs using piscicides (such as rotenone) and/or drastically altering habitat (de-watering, pond draining). Eradication over larger areas with established populations is usually not practical due to the continual immigration of individuals from neighbouring populations. Piscicides sometimes need to be used in combination with water body/habitat changes such as near-complete de-watering. The fyke net trapping methods are well described and there is much experience in using them but eradication is usually not possible just based on mechanical removal of many fish. Piscicides are used in case-specific situations and may ensure total eradication with other management methods in small water bodies; the costs are usually very high.

Management

Targeted removal (using a combination of fishing methods and specific pisciside campaigns), targeted habitat alteration and creation of local barriers to dispersal are known to be important in management. Mechanical removal is unlikely to be effective in eradicating a population but it may reduce local populations in certain habitats where the species may have specific and/or severe impacts on biodiversity and to ecosystem services. To achieve long-term control of pressures/impacts caused by high-density bullhead catfish populations, removal efforts need to be applied indefinitely, unless eradication can be achieved. Site-specific attempts to manage the dispersal of the species (such as upstream/downstream containment barriers near river reservoirs) should complement any management scheme where lotic systems connect or are influenced by reservoir waters. Impoundments, such as reservoirs usually provide long-term refugia for the species in a wider river basin and more research into managing local eradication and containment in such water bodies is required. The effects of mechanical and/or chemical eradication campaigns (and habitat changes) will most usually have only localized results in this very adaptive and resilient species group. River basin scale management planning and case-specific adaptive management approaches will be required.

Prevention – measures for preventing the species being introduced, intentionally and unintentionally. **This table is repeated for each of the prevention measures identified.**	
Measure description Provide a description of the measure	**Awareness, education and training targeting unintentional introductions** The species was historically introduced for either aquaculture, recreational fishing or for ornamental purposes, but its spread within Europe could be a result of accidental or illegal introductions and secondary natural spread (Deputy Direction of Nature, 2016). An important problem is the spread of species in transboundary water bodies that may even provide ground for socio-political issues. For example in the Balkans the *Ameiurus* species have spread in many countries, FYROM and Bulgaria (Uzunova & Zlatanova, 2007; Kostov et al., 2015) and have recently colonized Greece through transboundary waters (Barbieri et al., 2015), however presence of

	catfishes are poorly monitored in fish farms or the wild in Greece or other Balkan countries (Economou et al. 2007; A. Apostolou, pers. comm.). Therefore to reduce the risk of further unintentional, accidental or illegal introductions awareness campaigns and best practice guidance for key stakeholder groups is required. Scientifically robust information, awareness raising and training is needed, for those stakeholder groups involved in aquaculture (better management practices in net cages, tanks, pond management, stocking), inland and recreational fisheries, and the aquarium trade. *A. melas* and other *Ameiurus* species have been accidentally imported amongst other fish during stocking, such as carp (*Cyprinus carpio*) or tench (*Tinca tinca*) from countries where they already widely occur, such as Hungary, Czech Republic and Romania (e.g. Musil et al., 2008). The priority target audiences include participants in the aquaculture production chain, i.e., regulatory and development agencies, fry producers and fish farmers. The key goals for aquaculture with respect to this species group should include: (i) stopping deliberate releases, (ii) reducing the incidence of accidental escapes and translocations with other fishes, and (iii) actively promoting the use of native species instead of exotic catfishes (e.g. Azevedo-Santos et al., 2015). These goals could be achieved via specific short-term courses that are fostered by government initiatives or by government research agencies. Case-studies and best practice must be promoted and publicised (i.e. to screening methods for unforeseen/ unintentional transfer with other species in stocking programmes). Audio-visual presentations (video, cartoon etc.) must be utilized to make training effective and the measures clear and comprehendible across a wide range of stakeholders. Prevention of spread can be developed through novel and best practice or demonstrative projects to engineer protection and disable escape and "accidental" translocations with commonly stocked fishes. Voluntary policy instruments such as codes of conduct have gained popularity in invasive species management and perhaps coalitions can be made to explore this kind of agreement among key stakeholders. Although *Ameiurus* spp. are not dominant in catfish culture, other catfish species (*Clarias* spp., *Ictalurus* spp.) are similarly extremely invasive. Because of this, a united campaign to protect against the establishment and spread of these alien catfishes should be coordinated. Since *Ameiurus* species are generally not currently widely targeted for recreational angling or fishing in Europe (Deputy Direction of Nature, 2016), the fishing and recreational angling industries will not have a keen interest in promoting them in most countries. However, ignorance of the threat posed by these highly invasive fishes could easily cause unwanted translocations by fishers and members of the public. The biggest threat is the introduction of fishes for so-called

	"recreational fisheries development" purposes of new reservoir areas which has been observed on islands in the Mediterranean (Battisti, 2017), and in the Balkans (author, pers. obs.). In addition, *Ameiurus* species are sometimes kept as pets in private or home aquaria and ponds (e.g. see http://www.tropicalfishfinder.co.uk/news-article?id=2367), and even small numbers of captive animals can be potential propagules. This potential threat can be addressed through increased conservation awareness raising activities, increasing public sensitivity to the threat of alien fish species. Finally an information campaign targeting fishers and other water body users /stakeholders on the threat of these invasive species should become widespread and be implemented for at least five years in each member state. The spread of the *Ameiurus* catfishes is very likely to continue, especially in the south of Europe (primarily due to climate suitability and existing populations especially in reservoir developments). Although distributional data is lacking and the species is poorly monitored, there are many small river basins in which it has not yet entered. Many of these areas are vulnerable due to the existence of reservoirs where the species could be stocked or unintentionally introduced (Garcia-de-Lomas et al., 2009), water transfer projects or transboundary waterways from where the species could spread. In the northern part of temperate Europe the species still has low invasiveness due to current climatic constraints (Deputy Direction of Nature, 2016). It remains geographically restricted in the north, however these conditions may be altered by climate change (Britton et al., 2010). Because of this, it is important to focus on prevention of entry into new water bodies and basins and education and awareness is one of the priority measures to achieve this (Piria et al., 2017).
Effectiveness of measure e.g. has the measure previously worked, failed	The effectiveness can be high if implemented strategically, especially involving careful scientifically robust material, awareness campaigns, advertising and media work (many examples exist from the United States, e.g. Helfman, 2007; McCaughan, 2015).
Effort required e.g. period of time over which measure need to be applied to have results	Such measures would need to be over the long-term to indefinitely. Monitoring of the effectiveness of sensitization/awareness of such a programme should be applied as well.
Resources required[1] e.g. cost, staff, equipment etc.	Each member state should build a framework for education and awareness development. Costs will vary based on case specific situation, risks and the vulnerability of entry and spread of this species

	within the member state. Resource requirements will also depend on knowledge base-lines for these species; the *Ameiurus* species are still poorly studied in most EU Member states and other European waters (Copp et al., 2017; Piria et al., 2017). Therefore accurate and up-to-date distributional data for each country would be needed which will require field research, interpretation work and a reporting framework. Ideally a national awareness programme should be guided by a scientific "education committee" or similar science-guided initiative to develop, plan and apply the specific awareness, media, marketing, training and education schemes. This campaign involves development of information packages, media work (web developments, etc.), advertising strategy and educational seminars/training initiatives and will necessary involve many actors through various disciplines. The specific costs should be defined based on the degree and breadth this initiative should reach on a case-specific basis (Roy et al., 2015). Resources devoted to the problem should be in proportion to the high risk of rapid spread of the species (Pimentel et al., 2005) and this differs among EU member states. In Kentucky USA, the following costs where provided for this category of educational development (Mahala, 2008): a) development of an alien invasive education specifically for the state: $15,000/year; b) target and educate key groups: $23,000/year; c) identify and secure outside funding to develop, maintain and continue the education/awareness program: $250/year; d) assess public and stakeholder awareness with surveys: $5,000/year; e) provide programs to assist against entry of species by appointing a coordinator position $5,800/year; f) annual review and update of plan to address gaps and needs (study, review): $1,000/year. g) among other aspects the plans calls for the funding of scientific meetings, dissemination and building alliances among stakeholders (estimated costs of meetings etc.: $6,000/year). It is important to note that multiple invasive species could be covered by these campaigns, thus reducing the average cost per species. In terms of resources for the central co-ordinating committees (which could include academics, educators and members of NGOs who are experts in outreach and conservation education) the

	costs of organizing the awareness and educational campaign would be approximately between €5,000 and €20,000 per year. We should add to this a media development/advertising initiative that could roughly cost €20,000 to €50,000/year (author's estimation). Again all the media material would include several other species with similar pathways of introduction and "guild" characteristics (i.e. in this case widespread unintentionally-stocked fishes/recreational fishing interests).
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	**No negative side effects**. Positive synergistic effects may develop if the campaign is coupled with citizen science initiatives to promote early detection (see below), and also due to the increase in public awareness about biological invasions in general and the impacts of invasive alien species. Such awareness campaigns can incorporate other invasive alien species, especially those that share the same pathways of introduction.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	**Medium.** The species group is already perceived by many stakeholders as an invasive /potentially invasive species in the wild. However there are some specialists and aquarium hobbyists who will continue to desire the species group as a pet. Trade in small-sized temperate catfishes is very difficult to completely control and some hobbyists are likely to continue to trade illegally.
Additional cost information[1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	**Implementation cost per member state:** (Stated above). **-Cost of inaction:** Medium. Inaction would very probably lead to the spread of the species through aquaculture units, uninformed stocking, uninformed angler interest and aquarium releases. The infestation of the species in reservoirs in southern Europe would create populations sources that could spread in other river water bodies fairly easily. In the absence of an assessment, a rough estimate of costs related to damage done by the continued spread of the species would be at least tens of thousands of Euros per year. **-Cost-effectiveness:** Medium. Although natural spread cannot be excluded, the informed public and stakeholder groups will support prevention of species spread, and this is cheaper than eradication. **-Socio-economic aspects:** The species group has a fairly low recreational angling interest in Europe, and provides very low socio-economic benefits in the pet trade (Deputy Direction of Nature, 2016).
Level of confidence[2] See guidance section	**High.** Education and advertising campaigns have been effective in many countries (e.g. USA and Canada); no reports of information or awareness campaigns regarding the species are found in Europe. These campaigns can rapidly change attitudes about particular invasive species. Education campaigns are the main ways to encourage fish importers, farmers, dealers, fishers, waterway users and aquarium hobbyists to prevent and discourage the accidental or purposeful introduction of this species group into local ecosystems. In many countries, education and public awareness is much more effective than the normative approach (i.e., laws and inspections) (Azevedo-Santos et al., 2015).

Prevention – measures for preventing the species being introduced, intentionally and unintentionally. **This table is repeated for each of the prevention measures identified.**	
Measure description Provide a description of the measure	**Banning trade, import, stocking and keeping of *Ameiurus* spp.** By banning the import, trade, stocking and keeping of *Ameiurus* species within the EU, the risks of intentional introductions through aquaculture, fisheries and pet trade would be reduced. Since the widespread *Ameiurus* species (*A. nebulosus, A. melas*) are considered two of the most important alien fish species in Europe and because they are extremely difficult to control once established in nature (Savini et al., 2010), every effort must be made to prevent escapees from aquaculture and to cease all stocking or human-mediated transfer of the species. In many cases, existing aquaculture units could easily contaminate nearby waterways. Since the fish are often capable of surviving well in poor transport conditions, they may be marketed alive and transported alive (e.g. Parisi et al., 2013; Roncarati et al., 2014). The species group is farmed usually in open farms that are close to wetland and river floodplains (production in Italy for 2010 estimated at 250 tons) (EFSA, 2011). This makes this species group especially liable to escape and entry into natural water bodies. The species group is also often unofficially stocked, especially in reservoirs. Since artificial impoundments within river basins have increased in number (and in some areas are continuing to increase) these environments (reservoirs, ponds, weir impoundments) are areas where *Ameiurus* spp. thrive. Various methods can be used to limit the use of alien bullhead catfish in fish farms; one initiative is to provide incentives to utilize native catfish instead in aquaculture. The catfish “group” has been of interest to producers in Europe (central and eastern Europe) because of their fast growth rates and efficient food conversion (Varadi et al., 2001). National approaches have also been very different, and the bullhead catfish production was initially limited to Italy and has experienced periods of stagnation (Varadi et al., 2001). Council regulation 708/2007/EC concerning alien and locally absent species in aquaculture sets a legal framework and obligates the member states to conduct risk assessments and issue permits ensuring that only those species that meet the requirements of a strict environmental assessment be allowed entry for aquaculture exploitation. National authorities are responsible for assessing each species "risk level" and for the enforcement of this measure. In some cases, the determination

	of a ban on some species has been influenced by various factors (Gualtier, 2017) so care is needed undertaking risk assessments, monitoring and tracking of the implementation and enforcement of the Council regulation (Copp et al., 2014). In some Member States it has been stated that the application of the regulation is not sufficient to prevent the diffusion of risk-prone aquatic alien species in aquaculture (e.g. Italy, Sicuro et al., 2016). Proposals for new policy instruments and better enforcement of the existing ones at the EU level have been put forward (Shine, 2010). Despite the serious risks to biodiversity, ecosystem integrity and socio-economic conditions, it is likely that the use of non-native species in aquaculture will increase, so special care with priority problematic species such as the *Ameiurus* catfishes is required (Copp et al., 2014). Although aquarium use of these species is limited, banning import and keeping of the species in the aquarium trade would reduce risks of future accidental introductions or release.
Effectiveness of measure e.g. has the measure previously worked, failed	Normative controls are standard practice to prevent introductions (Gualtier, 2017). They have worked in the past and in some states in Europe awareness of this species group's invasiveness has set a framework for restriction, containment and prevention. Preventive measures in marine aquaculture have been effective resulting to a marked decline in new alien species introductions in European Seas during the last decade (Katsanevakis et al., 2013).
Effort required e.g. period of time over which measure need to be applied to have results	It is not possible to put a cost on efforts of this measure, as they will vary and are often not applied to individual species. Each Member State that hosts these species has a different history and current situation of entry, potential spread, so a case-specific effort must be planned and executed at the MS level or within particular jurisdictions. All aquaculture and animal husbandry units (public aquaria, displays etc.) that house the species group must be inventoried. Stocking of individuals, even unintentional contamination, in all natural and artificial water bodies would need to be made illegal in all EU states, and ideally neighbouring transboundary waters, and relevant regulations fully enforced.
Resources required [1] e.g. cost, staff, equipment etc.	Exact costs are unknown. The scale of the enterprise would include changes to fish farming and aquarium trade in some Member States; this may include forced changes in aquaculture species. This will involve government-initiated planning particularly in administration and staff to maintain regulations. The costs would be much higher in countries where the species is farmed (i.e. Italy). Emphasis on the enforcement of legislation to cease and combat any stocking (even unintentional) should be put in all Member States where the species group is seen as potentially invasive.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	None known.

Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Catfish farmers in some areas of "traditional use" of the *Ameiurus* spp. are likely to oppose a total ban. Stopping fish farming of catfish in many eastern European countries may produce specific grounds for resentment (Varadi et al. 2001; Sicuro et al. 2016). Bullhead catfish are not among the species that historically dominated European aquaculture. The yearly European aquaculture production and value of *Ameiurus melas* (average of 2000–2004) was in the ninth position (473.4 tons) (Turchini et al., 2008) and is concentrated in Italy, where it has seen a recent decline (Parisi, 2013). The current situation in Italy is poorly reported but is still an issue of concern (Sicuro et al., 2016). Economic benefits from *Ameiurus* spp. aquaculture occurred primarily within eastern Europe (Belarus, Hungary) and Italy, although the magnitude of these benefits remains uncertain (Deputy Direction of Nature, 2016). Other ictalurid catfishes and locally *Clarias* sp. are preferred in several countries in Eastern Europe (e.g. Bulgaria; A. Apostolou, pers. com.). Introduced populations of *A. nebulosus* to Europe originally provided social benefits as sport fish (Welcomme, 1988), but their current social value as sport fish within their introduced range is low and has poor economic value (Deputy Direction of Nature, 2016). *A. natalis* is used as a laboratory animal for toxic chemicals and medical experiments so its aquaculture may be scattered and poorly inventoried.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	Costs will incur in communication and transboundary agreements among neighbouring states that share water bodies. Consideration must also be coordinated with other alien catfishes farmed widely in central and eastern Europe (*Clarias* sp., *Ictalurus* sp.).
Level of confidence [2] See guidance section	**High.** This is based on published information.

Early detection- Measures to run an effective surveillance system for achieving an early detection of a new occurrence (cf. Article 16 of the IAS Regulation). This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the early detection**

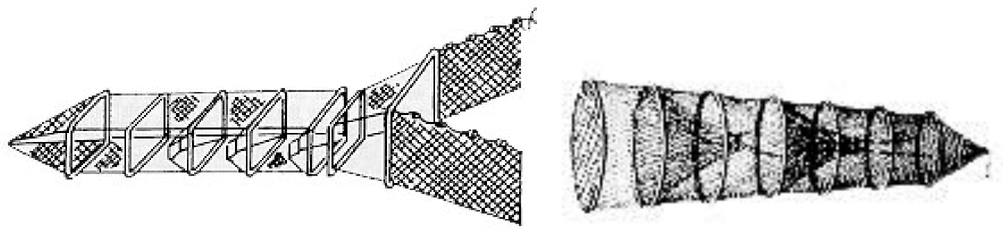
measures identified.	
Measure description Provide a description of the surveillance method	**eDNA monitoring.** Environmental DNA (eDNA) surveying is based on genetic material obtained directly from water or sediment samples; it is an efficient and non-invasive sampling approach (Thomsen & Willerslev, 2015; Leese et al., 2016). This method allows for surveying and monitoring without requiring collection of the living organism, creating the ability to survey organisms that are invasive and elusive. The content of an eDNA sample is usually analysed by amplification using polymerase chain reaction (PCR) and DNA sequencing. The amplification is done either by a single-species approach using specific primers or by multiple species approach using generic primers for a given focal group of organisms. Especially the fast advancing next-generation sequencing (NGS) technologies have made comprehensive biodiversity surveys possible for limited effort and costs (Ficetola et al., 2008). Molecular identification techniques hold the potential for rapid, accurate assessment of presence in a water body (Wong et al., 2011). In Europe, the taxonomy and distribution of *A. melas* and *A. nebulosus* have long created confusion due to the difficulty in identification (Wheeler, 1978). The unclear taxonomic status of both *A. melas* and *A. nebulosus* resulted in more recent doubts about the occurrence of these species in some countries (Hunnicutt et al., 2005; Rutkayová et al., 2013). Novel molecular tools would be expected to assist in clearing up the confusion as has taken place in the USA (Walter et al., 2014).
Effectiveness of the surveillance e.g. has the surveillance previously worked, failed	The overall sensitivity of eDNA detection is likely to vary between studies and among species due to differences in methods, environmental conditions and the target species behaviour (Furlan et al., 2016). Studies showed that short DNA fragments up to 400 base pairs could be detected in water and can be extracted from environmental samples (Matsui et al., 2001; Zhu, 2006). Population size of the target species affects the detectability of DNA from water samples (Ficetola et al., 2008). Detection success of aquatic species in these studies were found higher than visual surveys regardless of the population size and life stage of the target species. Other than higher detection rates, Michelin et al. (2011) indicated that traditional surveys cost 250% more in terms of expenditure and time. This has been confirmed but more research into the complementary use of different survey methods is required (Evans et al., 2017). There is a need for developing precise and effective monitoring tools that will help us to detect invasive species to take proper actions before the populations get established. The eDNA approach should be considered as a fast, cost effective and standardized way to obtain information on absence/presence or even relative abundance of the target species. Future studies on detection of

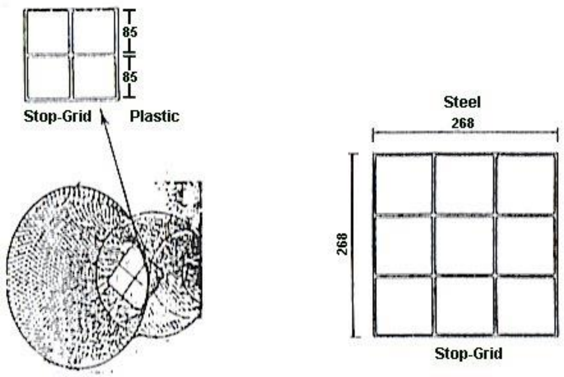
	invasive species from different ecosystems will widen our knowledge about the applicability of eDNA surveys.
Effort required e.g. required intensity of surveillance (in time and space) to be sufficiently rapid to allow rapid eradication	With eDNA approaches sampling for alien species can be relatively cheap and also wide-ranging as a screening procedure. Since much wider areas could be surveyed, costs for collecting samples in many different waterbodies and waterbody types would be considerable in order to establish a thorough and effective surveillance scheme. Effort for analysing water samples would depend on the number of water bodies sampled; in some Member states this will be large and a large bulk of lab work will need to be managed.
Resources required[1] e.g. cost, staff, equipment etc.	Costs of initial set up (laboratory work, staff, and equipment) for a single laboratory of a Member State will vary depending on the potential for invasive introduction and spread of the species group. The method requires an inventory of all available genetic forms of the fishes and the testing and calibration of the method usually with appropriate supervision. An estimate of €30,000 with consumables (€24,000 personnel and travel + €6,000 lab consumables) was given by Dr. Marlen I. Vasquez, Cyprus University of Technology (Pers. Comm.), assuming there is already an operational lab and there is no need for new equipment. This refers to six months development, 12 months sampling campaign and six months for analysis. Setting up the lab (PCR equipment etc) would cost a minimum of € 20,000. The method requires the collection of water samples (1 to 10 L of water) from strategically placed sampling sites to search for the targeted species. These costs are lower if a lab is already doing similar routine work (Evans et al., 2017). It should be noted that these costs do not refer only to *Ameiurus* species but to a large number of target species.
Side effects (incl. potential) i.e. positive or negative side effects of the method on public health, environment, non-targeted species, etc.	**Positive.** Positive side effects may include discovery of other rare, threatened, protected or alien species in water bodies.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	There is no negative impact to any human activity or biodiversity by sampling water for e-DNA analyses.
Additional cost information[1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction	Early detection is very important, and the *Ameiurus* species are known to escape detection when in low densities. Because of this efforts and costs will eventually be important in tracking introduction, establishment and spread. Cost of inaction in this vital tracking and monitoring activity will be high and will lower the effectiveness of eradication or management measures in the

- the cost-effectiveness - the socio-economic aspects	future.
Level of confidence [2] See guidance section	**Medium to high**. Since this method has only recently been developed, pilot and demonstrative projects are required. Prospects seem very good; research is essential.

Early detection- Measures to run an effective surveillance system for achieving an early detection of a new occurrence (cf. Article 16 of the IAS Regulation). This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the early detection measures identified.**	
Measure description Provide a description of the surveillance method	**Integrated mechanical means of detection using both fyke nets and electrofishing.** Fyke net trapping and electrofishing are widespread and well described mechanical means of collecting bullhead catfishes (Krueger et al. 1998; Hanchin et al. 2002; Ruetz III et al. 2007; Hubert et al. 2012; Bodine et al. 2013). Fyke nets (also known as hoop nets or barrel nets) are one of the most common stationary 'trap nets' used in commercial fishing. The smaller versions, more commonly called hoop nets, are tubular shaped nets with a series of hoops (usually 5 or more per net), tapered and spaced along the length of the net to keep it open like a funnel-shaped trap. The hoops themselves are usually either round (most common), square, or D-shaped; the net contains inward facing mesh funnels that allow fish to enter the net but not to leave. To trap fish with a fyke/hoop net, the net is staked out in a body of water (river, wetland, lake) and bait may be placed in the tail end of the net (un-baited fyke netting is also common). After a period of trapping time, often overnight, the net is then lifted out of the water and the catch is emptied on a boat. Several fyke nets are usually set for sampling/fishing each night; they are set from a small boat/skiff (usually 4 - 7 m.). Electrofishing for catfish is usually best practiced by boat (Bodine et al., 2013). This entails the use of a generator based electro-fisher and specially set anodes that create an electrical field at the bow of a small skiff (usually 5 -7 m). Fish are stunned by the electrical field and swept into the boat with dip-nets. Active gears such as boat-based electrofishing are mobile in space and time; samples collected with active gears can typically be obtained in a span of minutes to hours, producing larger sample sizes per unit of time. This method is definitely more selective than any stationary net or

	trap; but works best in shallower lotic or lentic waters; efficacy is limited to waters less than 3 m deep (Porreca et al., 2013). Since this benthic catfish species group is not immediately apparent along waterways when introduced it may go unnoticed even if it has colonized specific water bodies for several years (e.g. in the Strymon and Vardar rivers; see Barbieri et al., 2015; Kostov et al., 2015). Therefore to be used as an early detection tool frequent surveys are required at high risk sites, particularly during low flow (base-levels) of lotic and lentic water bodies (Porreca et al., 2013). This search-find technique becomes more effective when intensified and the suitable habitats are targeted.
Effectiveness of the surveillance e.g. has the surveillance previously worked, failed	Generally, the fyke net methods (including hoop nets) are not commonly used in monitoring fish species in most rivers; they are routinely used for harvesting fish in large rivers, wetland and lakes. The types of fyke or hoop nets vary (Hubert et al., 2012) and specific adaptations may need to be made to target *Ameiurus* species depending on water body and local conditions. When compared with gill nets, fyke nets were more effective at capturing larger numbers of *Ameiurus species* (Hanchin et al., 2002) and they are known to be much better at capturing benthic species or species in dense cover (Naismith & Knights, 1990; Krueger et al., 1998). The combined use of small-mesh fyke nets and boat-based electrofishing better represented fish species composition and size structure than either gear alone (Ruetz III et al., 2007). The species group is usually more difficult to locate using other conventional capture methods, such as gill-nets (Ruetz III et al., 2007). Gill nets may be used and they are also quite effective for this species (Hanchin et al., 2002) but electrofishing by boat is a preferred and widely used method that complements the static nets/traps in most water body types. Electrofishing is important since it can explore a greater variety of habitats and screen for species presence over a much wider area than even a large number of nets/traps. Electrofishing by boat is one of the most widely used methods to sample for ictalurid catfish management in North America (Michaletz & Dillard, 1999).
Effort required e.g. required intensity of surveillance (in time and space) to be sufficiently rapid to allow rapid eradication	It is important to develop the fishing/sampling equipment and standardize the techniques. For many years sampling methods for ictalurid catfish have been varied with little effort towards standardization, even in the USA and Canada where many agencies specialize on catfish monitoring (Michaletz & Dillard, 1999; Krueger et al., 2011). Fyke nets can easily be employed for the purposes of catching benthic fishes but a research and development project is required to apply a standardized approach that is best suited for this mission. It is important to standardize certain types of fyke net targeting the species group. Special effort should be been made to develop nets/traps which have less effect on the non-targeted fauna, as the bycatch (e.g. of aquatic reptiles) in fyke nets can be high (Fratto et al., 2008).

	Intensity of surveillance must usually be high to have higher certainty of describing benthic assemblages and locating rare or recently established species (Hanchin et al., 2002). Each trapping effort (called a night-net) must be geared to the particular circumstances and harvesting intensity should be designed in a management plan or adaptive monitoring (Cucherousset et al., 2006).
Resources required[1] e.g. cost, staff, equipment etc.	The amount of required resources depends on the area of potential spread in each Member State. Each MS must design a research and implementation plan to survey for this species group. Fisheries scientists have recommended specifications for a standard fyke net for sampling warm water fishes in standing waters of North America (Miranda and Boxrucker, 2009; Pope et al., 2009) and since fyke netting is widely used for eels in many lowland water bodies in Europe they could be widely available for this kind of survey use. Smaller fyke or hoop nets targeting catfish and other benthic fishes (1.5 m. length) cost ca €120 each while typical large fyke nets cost between €300 and €1,500. Smaller fyke or hoop nets (typical eel pot trap nets, 1.5 m long) are effectively used to control *Ameiurus* in France (Cucherousset et al., 2006).  Typical large fyke net (left) and related hoop net (right).

	 In areas where otters and aquatic turtles (terrapins) exist, stop-grids on the fyke or hoop nets should be used (source: Madsen & Søgaard, 1994). The catch-efficiency of the fyke nets with stop grids should not affect the entrance of rather elongated benthic fishes, such as bullhead catfishes. Other modern fyke net can be bought with mammalian escape hatches. Electrofishing usually requires a small boat. An on-board 9.0 GPP electrofisher on a small custom made boom boat (4.5 or 5 m length) should be made operational for at least one fisheries/academic agency within each member state (cost ca. 60,000 €, including trailer – author estimation). Electrofishing sampling generally costs between 380 € to 2,900 € per 100 meter of lotic ecosystem sample (Schmutz et al., 2007) depending on stream type, equipment used and other parameters (this does not include staff costs or institutional support).
Side effects (incl. potential) i.e. positive or negative side effects of the method on public health, environment, non-targeted species, etc.	**Negative**: Fyke nets/ hoop nets are known to have a by-catch effect on protected species (such as aquatic snakes, turtles, terrapins, diving ducks and otters) (Reuther, 2002; Prott et al., 2006). Special effort has been made to develop traps which have less effect on the non-targeted fauna (Fratto et al., 2008). Some researchers have mentioned that fyke or hoop netting should be avoided in lowland lakes and swamps that contain large turtle/terrapin populations (Michaletz & Sullivan, 2002). Effort must be made to use them only with the stop grids (Madsen & Søgaard, 1994) and remove/check them at very frequent intervals. Another problem is losing any nets/traps in rivers; the ghost net effect of fyke nets is a serious problem (S. Zogaris, personal observations from Greece and other Balkan countries). Fyke/hoop nets like any nets carry large quantities of biotic material after use and can thus be vectors for human-induced dispersal of alien biota if used in many river basins for consequent sampling. Efforts to totally disinfect the fishing tools need to be made and strictly enforced.

	Positive: In combination with less intrusive methods such as electrofishing the use of fyke/hoop nets can work well to effectively survey lentic systems and large river benthic fish assemblages (Ruetz III et al., 2007).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Important animal welfare considerations and by-catch costs have been associated with fyke net fishing since otters and turtles are prone to accidental drowning in fyke and hoop nets (Reuther, 2002). Mandatory use of stop grids in fyke nets is essential when carrying out mechanical removal for research and monitoring purposes; this will make public perception and conservation-relevant acceptability more positive.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	**Implementation cost per member state**: Intensity of detection measures will vary based on risk of introduction and potential for spread in each MS. -**Cost of inaction**: Early detection is extremely important in eradication and management actions. -**Cost-effectiveness**: Routine sampling tools may not identify the presence of small numbers of invading catfishes; intensity and cost may need to increase in areas where the species spread may be expected (e.g. transboundary waters). -**Socio-economic aspects**: None directly affecting public (see side effects, above).
Level of confidence [2] See guidance section	**Medium**. Until recently, regular monitoring of rivers in Europe does not frequently employ fyke nets; for this species group they are deemed useful and efficient (Cucherousset et al., 2006). In lentic waters different size panel multi-meshed gill nets are now regularly used, these being quite selective and restricted to cover a very short area of water/habitat and may not capture benthic species, such as initial invasion stage *Ameiurus* populations.

Rapid eradication- Measures to achieve rapid eradication after an early detection of a new occurrence (cf. Article 17). This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the eradication measures identified.**	
Measure description Provide a description of the measure	**Habitat modification, temporary drainage (de-watering) and barriers to movement** The *Ameiurus* catfishes are a very hardy group of species that will survive in polluted and degraded conditions in various water bodies (Novomeska & Kovac, 2009). Pond draining may be effective as a means of biomanipulation and non-native fish control if the majority of fish are removed after draining and their natural recolonization is successfully restricted (Usio et al., 2013). Drainage of river reservoirs and de-stocking in the USA and Australia have been effective (Beatty & Morgan, 2017), this kind of drainage could be applied in the seasonally semi-arid areas of southern Europe

	(i.e. taking advantage of drought years to facilitate temporary draining). Barriers to movement of alien fishes may help this and should be associated with artificial reservoir systems (Dugdale et al., 2006). Case-specific planning and adaptive management approaches are called for, in order to achieve eradication principally with this method. Artificial impoundments and dams enhance this alien species (Kostov et al., 2015) so measures must be taken not to create habitats that favour its establishment and survival or may provide refuge for these species (Lentsch, 1996); sometimes the species may go undetected in the reservoirs (Barbieri et al., 2015). Habitat modification can also be used in combination with other eradication measures to help eradicate or lower catfish numbers (Cucherousset et al., 2006).
Effectiveness of measure e.g. has the measure previously worked, failed	Drainage can be efficient and cost-effective, but is only feasible in some types of water bodies (e.g. fish ponds, small river reservoirs) and can be very destructive when rare or valuable fish species and other aquatic biota are negatively affected. Setting up any kind of barriers to dispersal will obviously negatively affect the movement of native fishes. Scant evidence was found for reducing or controlling bullhead population size by habitat manipulation on invasive bullhead populations. Changing the salinity of an invaded water body may offer a tool for localised eradication or population reduction of bullheads, provided potentially negative effects on native species are managed carefully (Aldridge et al., 2017). Draining also may not have serious effects if re-watering allows aliens again into the system (Usio et al., 2013). More research into habitat modification (e.g. flow regime changes etc.) would be important within adaptive management procedures.
Effort required e.g. period of time over which measure need to be applied to achieve rapid eradication	In small water bodies, such as ponds, small impoundments above weirs and reservoirs the effort required for a complete de-watering may be fairly low and low-cost. In some river reservoirs emptying for de-silting or remedial works in the reservoir already takes place (Water Development Department, Cyprus).
Resources required [1] e.g. cost, staff, equipment etc.	Costs and staffing for such a measure are case specific. The cost of the enterprise will depend on the specific actions taken, in relation to local conditions and opportunities/threats that can demonstrate the effectiveness of habitat manipulation and barrier developments within the Member state. Some states with many small river reservoirs systems may develop plans for an adaptive management initiative that includes frequent draining to combat a variety of non-native invasive species. Costs will be incorporated within the management of these reservoir systems but must include full environmental impact studies.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on	**Positive**: de-watering in small river reservoirs or in small ponds can be fairly easy and quickly brings results if combined with collection procedures (e.g. electrofishing, piscicides).

public health, environment, non-targeted species, etc.	**Negative**: Some aquatic species may be very sensitive to desiccation of a pond, reservoir etc. so the action may have serious implications to native species if not planned correctly. **Negative**: Drainage is obviously only feasible in some types of water bodies (e.g. fish ponds, artificial canals and reservoirs). Drainage can be very destructive when rare or valuable fish species cannot be collected at the drainage outlet (Louette & Declerck, 2006). Setting up any kind of barrier to dispersal will obviously negatively affect the movement of native fishes.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Bullhead catfishes are considered voracious predators of newly hatched gamefish (CABI, 2015a) and are known to exert serious pressure on native fishes (Deputy Direction of Nature, 2016). Usually, fisheries-related stakeholders would want the course fish to be replaced by species of higher angling interest. Hence, nearly all recreational stakeholder parties would not be disturbed by eradication initiatives. However, some stakeholders will question effects on native wildlife/aquatic biota. The benefits to natural integrity and native biota should far outweigh any perception issues, including animal welfare issues.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	Costs should be developed along a case-specific structure per member state. The need for refining methods through adaptive research-based demonstrations for these species is high in Europe (Deputy Direction of Nature, 2016).
Level of confidence [2] See guidance section	**Medium.** Experience in Europe is low but the prospects of using these habitat-based alteration techniques are good in combination with population suppression actions where deemed necessary.

Rapid eradication- Measures to achieve rapid eradication after an early detection of a new occurrence (cf. Article 17). This section assumes that the species is not currently present in a Member State, or part of a Member State's territory. **This table is repeated for each of the eradication measures identified.**	
Measure description Provide a description of the measure	**Chemical removal.** Chemical removal is now in relatively widespread use against invasive fishes and there are mixed successes. At least one study mentioned that *Ameiurus* is "resistant to rotenone" (Vasquez et al., 2012), however effective campaigns to eradicate the species have been completed. Chemical

	removal of the species requires careful planning; more research and demonstrative studies are needed in Europe. It is important to note that EU/national/local legislation on the use of plant protection products and biocides needs to be respected. Rotenone is a tool which could be used towards halting the decline of native fish species, eradicating unwanted alien fish species, and controlling the outbreak of any damaging fish disease. Rotenone does not dissolve in water and thus must be formulated with solvents. Two commercial product formulations containing rotenone as the active ingredient are Nusyn-Noxfish® and CFT Legumine® (Ott, 2006). When rotenone formulations intended for piscicidal applications are administered to rivers and streams for the removal of invasive fishes, the resulting concentrations of ingredients, including rotenone, are of little concern regarding human health, or the welfare of other mammals and birds that may come in contact with the rotenone-treated water. Rotenone is fairly quickly detoxified by degradation pathways involving photolysis and hydrolysis, and has a short half-life in the environment. Excess rotenone may be converted to products of lower toxicity by introduction of potassium permanganate (Ott, 2006). Furthermore, the need to eradicate species in response to disease outbreak is another reason why rotenone use in lotic systems is of interest. Dealing with the incursion of a new disease is much like controlling a new species of invasive fish – early detection, and if possible swift and decisive eradication whilst the invader has a small and restricted population offers high potential for elimination (Pham, 2013).
Effectiveness of measure e.g. has the measure previously worked, failed	Success in restoring aquatic biota through elimination of predatory invasives has been well documented (e.g. Beatty & Morgan, 2017). While rotenone is not highly toxic to humans, other mammals, and birds if ingested orally, rotenone is highly toxic to fish. The toxicity of rotenone is because of its efficacy in interrupting mitochondrial electron transport which hinders the utilization of oxygen in respiratory organs, leading to cell death and eventually to the death of the organism if the dose is high enough. Because the respiratory mechanism of fish is directly linked to water through the gills, rotenone may pass directly into the bloodstream of fish, leading to death. Rotenone is much less toxic to mammals and birds because the route of ingestion is through the gut where much of the compound is broken down to less toxic components before toxic quantities can enter the bloodstream (Ott, 2006). A risk assessment for piscicidal formulations of rotenone suggests that mortality of bullheads can be achieved with 5-100 parts per billion of rotenone active ingredient, or 100-200 parts per billion of rotenone active ingredient in organic-rich ponds, diluted in 38 litres of water (Turner et al., 2007). A study from 2001-2003 in two ponds in Illinois, USA (Towey, 2007) found that rotenone successfully eradicated black bullhead *Ameiurus melas*, but one pond required two separate doses

	due to an incomplete initial kill. In the UK the Environment Agency Invasive Species Action Group (2014) reported that with the use of a piscicide containing rotenone eradication of black bullhead *Ameiurus melas* was achieved. The piscicide was applied using a boat and a bank based application system. Dead fish were removed using nets. During and after the operation, regular water samples were taken to monitor the level of rotenone however specific aspects of this work have not been published (Aldridge et al., 2017). Experience in the use of rotenone for restoration and invasive fish control is developing (Britton & Brazier, 2006) however more research is needed especially within adaptive management frameworks.
Effort required e.g. period of time over which measure need to be applied to achieve rapid eradication	The application of rotenone may take very little time (depending on the waterbody). Results are fast and even if applications need to be repeated within a few days a small reservoir or pond will be treated. Experience in the use of rotenone for restoration and invasive fish control is developing, however more research is needed especially within adaptive management frameworks.
Resources required [1] e.g. cost, staff, equipment etc.	Global data are not available but in the UK the eradication of *Ameiurus melas* has been documented (http://www.nonnativespecies.org/news/index.cfm?id=151). The operation to remove the catfish from a very small pond cost approximately £5,000, or a total of ca. £11,000 including manpower costs. Similar costs have been given for carp eradication in small lakes, such as in Spain. Costs must include a scientific study of impact assessment and procedures to explore negative impacts on the native fish populations (Davison et al., 2017). Studies such as this could cost in the range of €5,000 to €15,000 (author's estimation).
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	The human health risks for those undertaking the treatment are minimal if applied correctly. Rotenone ingestion through inhalation results in significantly higher toxicity, as there is a more direct pathway into the bloodstream. This is why professionals must use appropriate respiratory protection while handling concentrated formulations containing rotenone during preparation of materials for piscicidal applications. Once the compound is diluted in the water column, the risk of ingestion via inhalation is insignificant because of the very low concentrations of rotenone added to the water, and the remote chance of humans, mammals, or birds aspirating treated water in huge quantities into the lungs. Beyond the intended target fish, some direct effects are expected on certain other fish species, certain aquatic invertebrates, primarily zooplankton, and indirect effects can be expected as well (Turner et al., 2007; Pham, 2013). To fully understand and minimize rotenone effects on non-target taxa, targeted research, including more laboratory studies should be carried to determine survivorship of several macroinvertebrate and zooplankton taxa at different stages of their development and assess how they are impacted by rotenone. With careful design in application, the impact on native fish populations may be regulated, however the risk of serious damage to

	native populations is present.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Rotenone has become more acceptable as most stakeholders become well informed (McClay, 2000; Rayner & Creese, 2006; Environment Agency Invasive Species Action Group, 2014). Targeting both the species, and the appropriate conditions (water body types) may reduce impacts to other aquatic biota, however some stakeholders will continue to see this action as unacceptable if large numbers of native fishes (and other biota) are sacrificed.
Additional cost information [1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	It is important to consider that in most European countries a communication and interpretation framework must be developed for each treatment campaign; the public is usually sensitive to chemical treatments of water bodies.
Level of confidence [2] See guidance section	**Medium.** Although there are some uncertainties, the available data and the extensive use experience with rotenone for fish control purposes indicate that it can be used safely in certain circumstances. An important aspect in any such campaigns is a close linkage between the research and eradication programme. The researchers should monitor planning and progress of the campaign and estimate the variables necessary to model the population or institute adaptive management approaches. This should allow improvements to be made in eradication techniques and strategy (Koike et al., 2006).

Management- Measures to achieve management (cf. Article 19). This section assumes that the species is already established in a Member State, or part of a Member State's territory. **This table is repeated for each of the management measures identified.**	
Measure description Provide a description of the measure	**An integrated approach using mechanical removal and containment structures** Fyke and/or hoop nets have been effective in removing large numbers of *Ameiurus* catfish and are a standard method to collect this species in many jurisdictions, e.g. New Zealand (Barnes & Hicks, 2003) North America (Miranda & Boxrucker, 2009; Pope et al., 2009) and Europe (Louette & Declerck, 2006; Cucherousset et al., 2006). A combination of fyke or hoop nets and electrofishing

	are considered good forms of mechanical removal for bullhead catfishes (Pot et al., 2006; Miranda & Boxrucker, 2009). Double fyke nets, consisting of two conically shaped fyke nets (mesh-size of 8 mm) of which the mouth openings are connected with a vertically hanging net (length, 11 m; height, 09 m), have been used effectively in France (Louette & Declerck, 2006). Smaller and cheaper hoop nets are widely used in the USA. This targeted "overfishing" application is a standard method of lowering population density and could have positive effects on the native biota and ecosystem integrity (e.g. Chadderton, 2001; Wittmann & Chandra, 2015). Depending on local circumstances, mechanical removal can be combined with methods of habitat alteration in ponds and reservoirs; water-level drawdown is such a management practice in waters in which the water level can be manipulated. Open season fishing for *Ameiurus* is a good incentive and the fish can be caught using many methods available to recreational and commercial fishermen (e.g. regular lines, beach seine, fyke nets or other trap nets). One such measure is the obligation for all fishers to eliminate all captured individuals, as is done in France (Cucherousset et al., 2006). Targeting the removal of the young-of-the-year when in schools would limit the local population density and negative impact of this species; electrofishing can be used to achieve this. Fyke nets and electrofishing can be used to capture benthic fish when water levels are relatively low. Containment or restriction of dispersive movements through barriers to dispersal is perhaps a method that may help deter the dispersal of this genus. This infrastructure can be combined with "overfishing" mechanical removal methods outlined above. Mechanical removal and control should involve, if possible, physical isolation of introduced populations, which may require physical barriers (e.g., block nets, electricity barriers, or other containment structures; especially important below and above dams. More research into this is urgently needed since devices may be developed that may more effectively contain some species, guide them into traps and ultimately affect their dispersal (Johnson et al., 2016). One way to locally assist biodiversity conservation and biota restoration measures is to build in enclosures where the fish have been removed (Dugdale et al., 2005).
Effectiveness of measure e.g. has the measure previously worked, failed	A promising method to control bullhead catfishes is mechanical removal, however there is little empirical evidence of it permanently suppressing populations or leading to eradication on its own. Once bullhead catfish populations are established in large waterbodies eradication may be impossible and not cost-effective. The application of fyke/hoop net trapping and electrofishing for controlling black bullhead *Ameiurus melas* was relatively effective in a French lake/marsh system as

	no compensatory responses were recorded (Cucherousset et al., 2006). In contrast, compensatory responses were detected in *A. melas* populations elsewhere following mass removals (Hanson *et al*., 1983). Thus, where the management aim is suppression of invasive fish populations then removals may provide a short-term measure. Its medium and long-term effectiveness is, however, reduced substantially if the remaining fish exhibit compensatory responses, such as increased survival, growth and fecundity (Davies & Britton, 2015). Fyke and hoop net efficiency has been well reviewed (Krueger et al., 1998, Prott et al., 2006). Benthic fishes such as the *Ameiurus* spp. are trapped in these gears more easily than by using gill nets but this varies with habitat and other parameters. Double fyke nets can be a very efficient tool to catch this species in shallow water bodies (Louette & Declerck, 2006). Standardization of sampling devices and strict sampling protocols are necessary to reduce variation among samples and to detect possible changes in stocks that are the result of management efforts or environmental effects. Research into the most situation-specific and appropriate methods to suppress populations in various water body types is needed in Europe. Little work on containing *Ameiurus* spp. with weirs or other barriers has been published, although it has been proposed in river basin plans with many reservoirs (e.g. Lentsch et al., 1996). The progress of any such campaign should be carefully monitored and there should be a process for continual improvement based on case-specific knowledge gained, results and feedback (Koike et al., 2006). More research driven work to assess effort and cost effectiveness is required through active practice and adaptive management frameworks in Europe. Louette and Declerck (2006) experimentally showed that this kind of fyke net trapping may potentially be a cost-effective tool for the mass removing of brown bullhead (*Ameiurus nebulosus*). Fyke nets are easy to handle and cause relatively little damage to other fish species (Portt et al., 2006). Louette and Declerck (2006) state: "When repeatedly applied to a brown bullhead populations, double fyke nets should enable managers to accomplish a substantial reduction of the number of reproductive individuals in 1 year. When efforts are consequently continued during a number of subsequent years, the method may prevent smaller size classes from reaching sexual maturity and may eventually lead to a substantial reduction or even extinction of the brown bullhead populations on a longer term". The results showed that the catch efficiency of fyke nets for brown bullhead is relatively high compared to that for other fish species and that large proportions (up to 80%) of the larger size classes (>8 cm) can be removed from small ponds in a

	time span of 2 days with a minimum of effort. The use of this single mass removal management measure is most usually not sufficient to regulate the population. Scoppettone et al. (2005) demonstrated that habitat restoration and alteration could be valuable to control non-native fish species. Consequently, managers should continue the systematic mass removal but in conjunction with integrated natural habitat restoration to more efficiently regulate the *Ameiurus* populations.
Effort required e.g. period of time over which measure need to be applied to have results	Effort required is usually substantial (Cucherousset et al., 2006) and long-term results of mechanical removal campaigns are poorly documented in Europe. Effort usually depends on type and size of water bodies. Depending on the degree of infestation, the actual removal of the population from a small isolated water body could be completed in a few weeks. The widespread *Ameiurus* species have established populations within large lowland river basins and control in these areas may not be feasible.
Resources required[1] e.g. cost, staff, equipment etc.	*Ameirus melas* and *Ameiurus nebulosus* are difficult and costly to control (CABI, 2015a; Deputy Direction of Nature, 2016). Data on detailed specifics and costs are generally lacking and are case-specific. In the absence of data for these species, costs for the control of other species of fish are included in an indicative way: - Current efforts to control topmouth gudgeon in GB amount to £190,000 over 4 years (http://invasivespeciesireland.com/wp-content/uploads/2010/07/Economic_Impact_Assessment_FINAL_280313.pdf) - In 2010 alone, the US federal government committed $78.5 million in investments to prevent the introduction of Asian carp to the Great Lakes, where they would threaten Great Lakes fisheries and could negatively impact remaining populations of endangered or threatened aquatic species. (https://www.fws.gov/verobeach/PythonPDF/CostofInvasivesFactSheet.pdf). -In Europe, electrofishing costs vary between 380€ to 2,900€ per 100 meter of lotic ecosystem sample (Schmutz, 2007) depending on stream type, equipment used and other parameters. If a general cost of 1500 € per sample is given, a general estimation of cost can be made.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	Mechanical removal usually involves substantial bycatch of native fish and other aquatic biota. A serious problem associated with many passive entanglement and entrapment gears is continued capture of animals by the gear if it is lost—a process called ghost fishing. A concern with the use of passive sampling gears is the unintended spread of invasive species while

	sampling (Jacks et al., 2009). Measures to decontaminate sampling gear, boats, and other equipment used in sampling prior to moving among water bodies are advised. Mechanical removal usually has less negative side effects than other standard means of fish harvesting or eradication applications. Chemical or other mechanical removal techniques, such as the use of rotenone or gillnets are usually not deemed appropriate in restoration projects, because of their low efficiency for the target species and because of the significant damage they may cause to populations of other species (Louette & Declerck, 2006). Barriers to dispersal set up for this species group will unfortunately block passage of native species, so this may create further degradation of the fish community; strategic scientifically-led planning is therefore required.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	*Ameiurus* spp. introductions have the potential to hinder local commercial and sport fisheries through competition with target species (CABI, 2015b) so it is conceived that the management would be supported by local angling interests and fishing recreation stakeholders. The *Ameiurus* also are capable of changing food webs and degrading ecological integrity and ecological potential of natural and novel ecosystems. The management of *Ameiurus* catfish may be more acceptable to stakeholders if the evidence base is substantial and well interpreted (with research into the justification for management and its effectiveness), and if control targets obvious risks to environment and/or human health issues; where cost-effectiveness is demonstrated and disseminated clearly in local society. Criticism by some stakeholders on the reasoning behind actions for the removal of established alien populations has recently increased (e.g. Bonanno, 2016). Evidence-based justification and conceptual frameworks must be provided in the local strategy for alien species management (Copp et al., 2005). This pertains particularly to widespread naturalized invasive species such as *Ameiurus* spp.
Additional cost information[1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	Costs should be estimated on a case-specific basis per member state. The need for refining methods through adaptive research-based demonstrations for these species is high in Europe (Deputy Direction of Nature, 2016).

Level of confidence [2] See guidance section	**Medium.** The management of catfish may be more acceptable to stakeholders if the evidence base is substantial and well interpreted (research into the justification for management and its effectiveness), and if control targets obvious risks for public benefits, where cost-effectiveness is demonstrated and are adequately disseminated in local society. Part of management is a well-organized communication strategy (which obviously allows for synergies with prevention of entry and spread as well). Although only a few studies claim that fyke nets could be a cost-effective tool for the mass removal of non-indigenous bullhead populations (Louette & Declerck, 2006), research in mechanical removal of catfish in Europe is lacking.

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See guidance section

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Notes

1. Costs information. The cost information depends on the information available.

2. Level of confidence provides an overall assessment of the confidence that can be applied to the information provided for this method.

- **High**: Information comes from published material, or current practices based on expert experience applied in one of the EU countries or third country with similar environmental, economic and social conditions.
- **Medium**: Information comes from published data or expert opinion, but it is not commonly applied, or it is applied in regions that may be too different from Europe (e.g. tropical regions) to guarantee that the results will be transposable.
- **Low**: data are not published in reliable information sources and methods are not commonly practiced or are based soley on opinion; This is for example the case of a novel situation where there is little evidence on which to base an assessment.

3. Citations and bibliography. The APA formatting style for citing references in the text and in the bibliography is used.
e.g. Peer review papers will be written as follows:
In text citation: (Author & Author, Year)
In bibliography: Author, A. A., & Author, B. B. (Publication Year). Article title. *Periodical Title*, Volume(Issue), pp.-pp.

(see http://www.waikato.ac.nz/library/study/referencing/styles/apa)