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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Comments which could support improvement of this document are welcome. Please send your comments by e-mail to ENV-IAS@ec.europa.eu

Species (scientific name)	**Genus**: *Lepomis* (Rafinesque, 1819) *Lepomis auritus* (Linnaeus, 1758) *Lepomis cyanellus* Rafinesque, 1819 *Lepomis gibbosus* (Linnaeus, 1758) *Lepomis gulosus* (Cuvier in Cuvier and Valenciennes, 1829) *Lepomis humilis* (Girard, 1858) *Lepomis macrochirus* Rafinesque, 1819 *Lepomis marginatus* (Holbrook, 1855) *Lepomis megalotis* (Rafinesque, 1820) *Lepomis microlophus* (Günther, 1859) *Lepomis miniatus* (Jordan, 1877) *Lepomis peltastes* Cope, 1870 *Lepomis punctatus* (Valenciennes in Cuvier and Valenciennes, 1831) *Lepomis symmetricus* Forbes in Jordan and Gilbert, 1883

Species (common name)	Sunfishes *Lepomis auritus*: Redbreast Sunfish *Lepomis cyanellus*: Green Sunfish *Lepomis gibbosus*: Pumpkinseed *Lepomis gulosus*: Warmouth *Lepomis humilis*:Orangespotted Sunfish *Lepomis macrochirus*: Bluegill *Lepomis marginatus*: Dollar Sunfish *Lepomis megalotis*:Longear Sunfish *Lepomis microlophus*:Redear Sunfish *Lepomis miniatus*:Scarlet sunfish, Redspotted Sunfish *Lepomis peltastes*: Northern Sunfish *Lepomis punctatus*: Spotted Sunfish *Lepomis symmetricus*: Bantam Sunfish
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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.

<u>Prevention</u>

The centrarchid sunfishes (*Lepomis spp.*) main route of entry is recreational fishing and secondarily the ornamental fish trade; accidental introduction is widespread in Europe, especially with imports of carp fry used in stocking. In Europe concern focuses on the pumpkinseed, *Lepomis gibbosus*, which is now recorded in 23 European countries, while three other less widespread sunfishes also have established populations in at least three EU countries. The major components of prevention are stopping intentional and unintentional fish transfers and banning trade; educating stakeholders and the public about the impact of centrarchids is important since eradication is nearly impossible in large hydrographic basins once the species is/are established.

<u>Early detection</u>

The recommended method for detecting sunfishes is through frequent fish survey campaigns and surveys of fisher's catches. Novel eDNA methods can

supplement fishing surveys and have a great potential as a cost-efficient early detection approach.

Rapid eradication

Eradication is extremely difficult once *Lepomis* species are established, especially in open larger river basin areas. Centrarchid sunfishes have been successfully eradicated from only small and isolated water bodies (using chemical treatments). Especially in lowland warm waters, eradication over larger areas has not been practical due to the continual immigration of individuals from neighbouring populations.

Management

Centrarchid sunfishes are ecosystem-altering invasive alien species (IAS), which can alter the limnology and may degrade natural integrity in many types of European inland waters; their impact also effects native threatened aquatic species (invertebrates, amphibians, fishes).They are now already widespread throughout many EU states with many abundant and high density populations. Mechanical removal is unlikely to be effective in the long term but may help reduce local populations in certain habitats where the species may have specific and/or severe impacts on biodiversity. To achieve long-term control of impacts, removal efforts need to be applied indefinitely, unless local eradication can be achieved. Barriers to movement from reservoirs and weir impoundments may help in local situations. Scientific research on the cost-effectiveness and particular evidence-based outcomes of various population-reducing practices needs to be pursued. A sustainable and effective control program, that includes targeted effort for mechanical and localized chemical removal is possible when science, multi-jurisdictional coordination and outreach are integrated.

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 of import, keeping, release and stocking** According to EU non-native species risk analysis (Deputy Direction of Nature, 2017) the main pathway of introduction for *Lepomis* species are as an ornamental fish in water gardens and aquaria and then released intentionally into the wild; they have also been introduced for angling purposes as a sport and forage fish, and as a contaminant e.g. with carp/goldfish fry used in stocking. They can tolerate a wide range of climatic conditions meaning that they could establish across Europe, and one species, the pumpkinseed *L. gibbosus,* is already established in 23 European countries. The prevention of initial entry is paramount to prevent additional introductions to new areas since these species cannot be controlled effectively once established. A major component of preventing intentional introductions would be the banning of the species from trade, including the ornamental trade, and their use, or unintentional transfer through any kind of stocking (Soes at al., 2011).

	Banning the keeping of *Lepomis* species as aquarium species in tanks or ponds, would address one of the species main pathways of introduction (i.e. through intentional or unintentional introduction into the wild by aquarists (Nuneset al., 2015)). However, centrarchid sunfishes are now rarely kept in private small aquaria collections and most species that have been kept in the past are difficult to find in most aquaria shops (e.g. in UK they have "all but vanished from the trade" see www.tropicalfishfinder.co.uk/article-detail?id=103), and demand seems to have decreased (Deputy Direction of Nature, 2017). From internet forums it is clear that inexperienced buyers of *L. gibbosus* and other centrarchid sunfishes are regularly disappointed as they have not been well informed about the aforementioned downsides of keeping centrarchids, however some hobbyists in North America regularly promote these colourful and interesting fishes, especially the attractive pumpkinseed. Also centrarchid sunfishes can easily be "fished" and housed in room temperature for short or long periods in private aquaria; they are hardy fish and easy to keep, but newly-collected individuals may refuse freeze-dried processed foods or fish flakes/pellets. Also, these fish usually become aggressive towards other fishes and special aquarium assemblage decisions should be made to keep them in a "community tank" (some aquarists state on internet forums that they are usually "underappreciated" by hobbyists). While demand and availability of the species has probably declined, it remains that all centrarchid sunfishes that are kept in aquaria and traded over the internet in Europe (e.g. www.akfs-online.de) remain a serious potential threat if released into the wild. Furthermore, the interests of hobbyists may shift and these species could become of greater interest in the future. Banning species from trade can be achieved by legislation and furthermore by means of an agreement within code of conducts. If a broad social basis for legislation is lacking, illegal trade might increase significantly (see next Prevention table below).
Effectiveness of measure e.g. has the measure previously worked, failed	Such prevention measures have previously worked (e.g. for some aquatic plants), but there is scant specific knowledge about the frequency of the different types of human-aided dispersal actions of these species in Europe and this could vary among member states (i.e. the current interest in keeping the species in captivity seems to vary among member states). Due to the potential ornamental attractiveness of *Lepomis* spp. (especially pumpkinseed) the risk of human-induced dispersal is high (Sterud & Jørgensen, 2006) when even a small population is established, as fish may be easily taken from the wild to private property and released elsewhere. In addition, some anglers targeting big mouth bass (*Micropterus* spp.) might wish to stock *Lepomis* spp. (as prey) in reservoirs and ponds to increase their sport-fish stocks, and thus confront prevention measures.

	The role of ornamental species and aquaculture trade and practices in the spread of non-native species represents a multi-stakeholder challenge with various perceptions and interests; the risks of increasing entry and spread are significant (DFO, 2011) and have been also stated in the EU risk assessment (Deputy Direction of Nature, 2017). Therefore, the success of such bans depends on many factors including the participation of all relevant stakeholders and compliance to the proposed measures that could vary among Member States (Verbrugge et al., 2014). Code of conduct approaches (Verbrugge et al., 2014) and careful screening and monitoring must be ensured. Note however, information on escapes/unofficial introductions is difficult to monitor, and it is possible that some individuals will continue to keep *Lepomis* spp. in home aquaria or ponds despite a ban.
Effort required e.g. period of time over which measure need to be applied to have results	The measures and regulations need to be maintained indefinitely, and applied alongside awareness raising activities targeted primarily at the aquarium and sport fishing sectors (detailed in the following prevention table below) as it will be important to inform hobbyists, sport fishers and the public that it is forbidden to buy, keep and release the species into the wild. Surveillance of imports and stocks of aquarium retailers can be achieved, however the online market especially from companies outside Europe will be very difficult to monitor and stop.
Resources required[1] e.g. cost, staff, equipment etc.	There is little information available about the costs and the equipment required to implement trading bans, but it is a widely accepted that prevention is cheaper than management of an established species. The implementation of trading bans will require a good species knowledge, (including training for the development of identification skills) on the part of the responsible authorities. For other invasive species, DNA barcoding tools have been or are currently being developed to simplify species identification (e.g. water plants).
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	None known. Not assumed to generate any negative side effects.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	These measures should be acceptable to most stakeholders as the species is recognized as invasive throughout most of Europe. It is likely that most amateur and especially professional fishers will widely support the efforts to prevent intentional and unintentional introductions, as the species is often seen as a pest by anglers (GB NNSS, 2017). However, some professionals in the aquarium trade sector might oppose such a ban.
Additional cost information[1]	**-Cost of inaction:** The impacts of *Lepomis* species (via predation and competition) if widespread

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	could be considerable to native biodiversity, and may also lead to some loss of income to recreational fisheries (BG NNSS, 2017). **-Cost-effectiveness:** If the aim is to avoid the impacts from *Lepomis* species then prevention measures are the only realistic measure, and therefore the most cost effective, as once established it is almost impossible to eradicate. **-Socio-economic aspects:** The species are currently of relatively low importance to the aquarium trade, and to sport fishing, although this may vary among Member States (Sterud & Jørgensen, 2006). Therefore any impact to these sectors is likely to be minimal.
Level of confidence[2] See guidance section	**High**. There are few publications on the effectiveness of such aquarium fish bans, but regulations that have led to monitoring the implementation of bans, have usually led to better enforcement of bans and control of releases (e.g. Council regulation 708/2007/EC in Italy, Sicuro et al. 2016).

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 of key stakeholders** Awareness of the threats posed by *Lepomis* species by the public and key stakeholders is critical to reduce the risks of unintentional and intentional introductions. Two important sectors promote the species' spread: inland water fisheries (stocking practices) and the aquarium trade. The contamination of stocks of legally stocked species is the primary pathway for secondary spread of *Lepomis* species in many countries, particularly in the south of Europe (e.g. Perdikaris et al., 2010; Zogaris et al., 2012; Tarkan et al., 2015). Pumpkinseed is known to have been accidentally imported amongst other fish during stocking, commonly with such fishes as *Cyprinus carpio* (Tarkan et al., 2015) and salmonids (Przybylski & Zięba, 2011). Scientifically robust information and training to those involved in aquaculture and fisheries development (including better management practices, screening processing of stocked fishes, monitoring) would help prevent *Lepomis* species being accidentally introduced as a contaminant of legal fish stocking practices. Reducing the incidence of accidental translocations with other fishes, and actively promoting the use of native species instead of non-natives in stocking should be the key aims of any awareness and education programs (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 and other organizations. In addition, making it obligatory to report any stockings to a central, independent organization, such as the fish stock management commission (e.g. 'Visstandbeheerscommissies' in The Netherlands) would create insight into stocking practices and control or oversight of stocking procedures. This may not only serve policies on alien species, but may have an even greater use in fish disease prevention (Soes at al., 2011). Pumpkinseed (*L. gibbosus*) is not commonly sold in aquarium shops (see prevention table above), but the species is occasionally imported by special order and is sometimes used as an ornamental fish after being caught in the wild. There is increasing evidence that occurrences of ornamental and aquarium fish in the wild is due to human release of these fish that are kept in home aquaria (see Copp et al., 2005; Nunes et al., 2015). Developing awareness programmes with pet stores and garden shops can play a key role in raising public awareness of the risks of deliberately releasing fish into the wild, of legislation that may be in place making it illegal to do so, but also of how to ensure that fish don't accidentally escape from ponds. Such programmes would help reduce the risk of the release of ornamental fish.

	A drawback of public awareness and education programs is that they need to be maintained over a long term period. Without active maintenance and creative advertising, the effects of awareness and education could quickly fade away. Since these species are generally not currently widely targeted for recreational angling in Europe, fishers will not have a keen interest in promoting them anywhere in Europe (CABI, 2011). However, ignorance of the threat posed by these highly invasive fishes could easily cause unwanted translocations by recreational and sport fishers. In the recent past, *L. macrochirus* and L. *gibbosus* have been stocked as forage fish for largemouth bass (*Micropterus salmoides)* populations (Deputy Direction of Nature, 2017). Therefore recreational fishers are a key sector to be engaged with to help guard from "unofficial" or other illegal introductions.
Effectiveness of measure e.g. has the measure previously worked, failed	The effectiveness could be high if implemented strategically, especially involving careful awareness campaigns, advertising and media work (many examples exist from the United States, e.g. Helfman, 2007; and Habitattitude campaign, www.habitattitude.net). In terms of effectiveness, research on the US Fish and Wildlife Services' Habit attitude Campaign found that awareness amongst hobbyists was low, and recommended that their behaviours may be increased by fostering hobbyist networks, creating materials that explain tangible, negative impacts and list prevention behaviours, and disseminate these materials through trusted information sources (Seekamp et al., 2016). Another example, while not directly related to invasive species, is the National Aquarium Workshop (NAW) and the British and Irish Associations of Zoos and Aquariums (BIAZA) run the 'big fish campaign' aimed at educating hobbyists that a number of fish grow larger than average home aquarium tanks can accommodate (see http://injaf.org/the-big-fish-campaign/). Education, training and advertising campaigns are frequently effective in many countries (e.g. many examples from the American continents; Helfman, 2007; Azevedo-Santos et al., 2015). In many countries, education and awareness of the problem is much more effective than the normative approach (i.e., laws and inspections) (Azevedo-Santos et al., 2015).These campaigns can change attitudes about invasive species but long term evaluation studies of outreach and educational campaigns are needed in Europe (Verbrugge et al., 2014). Contamination of imports of other fish is very difficult to control. Training and monitoring is important. Capacity at relevant levels (i.e. law enforcement, taxonomic expertise and communication) is critical for such prevention programmes based on training/education and awareness to be effective; some examples of developing programs have been published for Europe (Scalera &Zaghi, 2004; Soes et al., 2011; Tarkan et al., 2015; NOBANIS, 2016) and abroad (Mahala et

	al., 2008).
Effort required e.g. period of time over which measure need to be applied to have results	The measures ideally need to be maintained indefinitely. Assessment of stocking practices need to be better planned and surveyed (Ham & Pearsons, 2001). The fish farming sector must be made aware, informed and trained though specialized member state training programmes. Case-studies and best practice must be promoted and publicised (i.e. to screen for unforeseen/unintentional transfer with other species stocking programmes). Audiovisual presentations (video, cartoon etc.) should be utilized to make training effective and the measures clear and comprehensible 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. Implementation of a stock audit procedure (see Davies et al., 2015), and employing adequate effort by trained and experienced fisheries officials may reduce the extent of stock contamination by undesirable fish species such as the centrarchids and other IAS (Tarkan et al., 2015). Finally, an information campaign targeting fishers and other water body users on the threat of these invasive species should become widespread and be implemented for at least five years in each member state. Monitoring of the effectiveness of awareness of such a programme should be applied as well.
Resources required[1] e.g. cost, staff, equipment etc.	Ideally a framework and plan for education and awareness should be developed by each Member State, and this would be focused upon multiple invasive alien species. This could include an "education committee" or similar initiative to organize, develop and apply the specific awareness, media and marketing, training and education schemes. This campaign involves development of information packages, media work (web developments, etc), advertising strategy and educational seminars/training initiatives. The specific costs should be defined based on the degree and breadth of this initiative on a case-specific basis (Roy et al., 2014). Resources devoted to this measure should be in proportion to the high risk of rapid spread of the species (Pimentel et al., 2005). Protocols for stocking method containment procedures exist and should be incorporated in training and monitoring procedures (e.g. Ham & Pearsons, 2001). In Kentucky USA, the following costs where provided for the development of the Kentucky Aquatic Nuisance Species Management Plan (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) Povide 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) Also, among other aspects the plan calls for the funding of scientific meetings, dissemination, and building alliances among stakeholders (estimated costs of meetings etc: $6,000/year). Multiple invasive species could be covered by these campaigns, thus reducing the average cost per species. In addition to what is outlined above, a media development/advertising initiative would also be recommended, which is estimated by the author to cost ca. 20,000 € to 50,000€/year. Again, the media development would include several other invasive alien species with similar "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 effects may develop if the campaign is coupled with citizen science initiatives to promote early detection, and also due to the increase in public awareness about biological invasions in general and the impacts of additional invasive alien species.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	**Good.** The species group is already perceived by most stakeholders as an invasive /potentially invasive species in the wild.
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:** It would include setting up an organized central body and marketing and education team to build an awareness and educational campaign. The costs per member state will vary and a case-specific development should take place. Cost for such a campaign per Member State would probably exceed 50,000 €/year. In controlling contamination of other fish imports/stocking, greater effort and capacity will be required (and increased costs, increased handling time during stocking campaigns). **-Cost of inaction: High**. Inaction would probably lead to the spread of the species through aquaculture units and official or unofficial stocking and uninformed angler interest; the impacts would eventually incur high costs. **-Cost-effectiveness: High**. Informed public and stakeholder groups support prevention of species introduction, and this is cheaper than eradication (Verbrugge et al., 2014). **-Socio-economic aspects:** None known.
Level of confidence[2]	**High.** No detailed reports of information or awareness campaigns regarding the species are

See guidance section	collected for Europe (Przybylski & Zięba, 2011), however the information presented here is based on awareness campaigns for other species within Europe and globally.

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	**Environmental DNA.** Environmental DNA (eDNA) surveying is based on genetic material obtained directly from environmental samples (water samples) without any obvious signs of biological source material; it is an efficient, non-invasive sampling approach (Thomsen & Willerslev, 2015; Leese et al., 2016). eDNA methods are developing rapidly and new techniques provide the opportunity to have more accurate and specific detection of alien species (Roy et al., 2017). eDNA methods may represent a cost-effective means by which to establish broad-scale patterns of occupancy for *Lepomis* spp. (Davison et al., 2016). Molecular species identification techniques hold the potential for rapid, accurate assessment of presence in a water body (Wong et al., 2011). There is still a need for developing precise and effective monitoring tools that will help detect invasive species early enough to allow actions to be taken before the populations become established. The eDNA approach should be considered as a fast and cost effective 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.
Effectiveness of the surveillance e.g. has thesurveillancepreviously worked, failed	The overall sensitivity of eDNA detection is likely to vary between studies due to differences in field and laboratory methods, environmental conditions and the target species (Furlan et al., 2016). Population size of the target species affects the detectability of DNA from water samples. 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). 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. Hybridization is common among centrarchid fishes so this makes the task of identifying difficult and could require further use

	of molecular techniques (Soes et al., 2011).
Effort required e.g. required intensity of surveillance (in time and space) to be sufficiently rapid to allow rapid eradication	The method requires an inventory of all available genetic forms of the fishes and the testing and calibration of the method usually within an academic institution. Since all suitable water bodies would need to be investigated, the number of samples may be very large depending on the member state and the scale and overall framework of the survey.
Resources required[1] e.g. cost, staff, equipment etc.	An estimate of costs of initial set up (laboratory work, staff, and equipment) of eDNA application for a small MS in the EU 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: approximately € 30,000 with consumables (€24,000 personnel and travel + €6,000 lab consumables). This should equate to six months development, 12 months sampling campaign and six month analysis. 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. If a lab facility does not exist, a small lab and instruments (PCR machine etc) cost about €30,000.These costs are lower if a lab is already equipped and doing similar routine work (Evans et al., 2016). Other examples of cost estimates relate to work in the USA, where the cost of detection through eDNA of a single reptile species per site have been given as approximately US $500 (Davy et al., 2015). This is definitely less than most electrofishing or sampling campaigns using nets/traps. Other than higher detection rates, Michelin et al. (2011) indicated that traditional surveys cost 250% more in terms of expenditure and time. It should be noted that these costs do not refer only to *Lepomis* spp. but to a larger 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.	**Positive.** 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 - the cost-effectiveness - the socio-economic aspects	**-Cost of inaction: High**. See prevention tables above **-Cost-effectiveness: High**. Environmental DNA screening is a promising method for detecting scarce species because it is more sensitive than traditional sampling methods (nets, electrofishing, etc.) (Hoffman et al., 2011; Evans et al., 2016), does not cause any serious by-catch problems, and is well suited to surveys across a broad spatial scale. **-Socio-economic aspects:** None known.

Level of confidence[2] See guidance section	**Medium to High**. Since this method has only recently been developed, pilot and demonstrative projects are required. There are many publications documenting its efficiency in surveying as compared to other survey techniques (e.g. Evans et al., 2016).

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	**Standard ichthyological surveying through mechanical removal.** In nearly all EU countries there is a lack of substantial coordinated monitoring programmes to document the entry, establishment and spread(and to assess impacts) of invasive centrarchids, despite the evidence existing for their negative impacts on ecosystems and their invasive expansion in Europe in recent years. Although the pumkinseed is fairly well studied in Europe (e.g. Copp et al., 2004, 2005, 2007, 2009) little effort has been made into optimal detection methods. New colonizations are especially taking place in warmer European inland waters, in many areas of the Mediterranean (Clavaro et al., 2004) and even in many of the island reservoirs (Zogairs et al., 2012); so many water bodies where the species have not yet been introduced are vulnerable. Early detection is therefore required in order to combat further spread. The method described here involves routine scientific ichthyologic surveying using electrofishing, seine netting, and gill netting. These methods are known to be effective in sampling a wide range of species assemblages and they are now well standardized with published protocols (e.g. West et al., 2007). Electrofishing is preferred since native fish are not usually harmed, however in deeper lotic waters gill nets are a standard procedure in surveying. Areas to be prioritised for surveying should be those water bodies hydrologically connected, or close to established populations, or other areas at high risk of introductions (e.g. where there are stocking programmes where *Lepomis* species could be introduced as a contaminant, or near urban areas where people may have the species in aquaria or ponds) and perhaps in areas where the species may have a serious impact, e.g. areas of high biodiversity value.
Effectiveness of the surveillance e.g. has thesurveillance previously worked, failed	Effectiveness is usually high; *Lepomis* species are usually easily detected, as they school in shallow waters (author's opinion).

Effort required e.g. required intensity of surveillance (in time and space) to be sufficiently rapid to allow rapid eradication	The effort required for high-probability, early detection of aquatic non-native species is substantial (Hoffman et al., 2011) and this is why it is important to involve other wider survey methods, such as citizen support for early detection (see early detection table below).Coordination of surveillance with other sampling schemes in Europe (e.g. EU Water Framework Directive fish sampling) and participation of amateur and professional fishers should be developed. The survey work, monitoring and audits need to be developed and effort will vary among Member States depending on the local conditions (the species is spreading quite rapidly in the south).
Resources required[1] e.g. cost, staff, equipment etc.	Costs are not possible to estimate since each Member State (MS) may have different procedures already set for standard fish monitoring schemes (conservation, fisheries, water management etc.). The amount of resources required depends on the area of potential spread in each MS. Each MS must create a strategy and build a research and implementation plan to survey for the species group. Mechanical removal can be expensive. In Europe, electrofishing sampling costs between €380 and €2,900 per 100 to 500 meter of lotic ecosystem sample (Schmutz et al., 2007) depending on stream type, equipment used and other parameters. If a general given cost of €1,500 per sample, the estimation of survey effort can be generally calculated. Gill net sampling may cost approximately the same per unit or more depending on specific conditions; gill netting has more processing time which is why electrofishing is usually preferred.
Side effects (incl. potential) i.e. positive or negative side effects of the method on public health, environment, non-targeted species, etc.	**Negative**: Gill nets are known to have a very high by-catch which may affect protected and/or threatened fish species. Another potential risk is losing any nets/traps in rivers (leading to ghost fishing effects).Gill and seine 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. Efforts to totally disinfect the fishing tools need to be made and strictly enforced. **Positive**: In combination with less destructive methods such as electrofishing, netting or trapping can work well to explore lentic and large river fish assemblages (Ruetz III et al., 2007). Seine netting usually does very little harm to most fishes in the catch relative to gill net and trapping.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Mechanical removal as a survey/monitoring method is acceptable by most stakeholders as the species is considered highly invasive.
Additional cost information[1] When not already included above, or in the species Risk Assessment.	Implementation cost per member state: Government fisheries and relevant research and academic institutes may utilize this measure of detection in the framework of existing activities, and thus there will be no substantial additional costs to those already occurring for other monitoring

- implementation cost for Member States - the cost of inaction - the cost-effectiveness - the socio-economic aspects	programs (e.g. for the implementation of the Water Framework Directive). -**Cost of inaction**: Early detection is extremely important in eradication and management actions. -**Cost-effectiveness**: The species is easily detected, even in low densities. If surveys are mostly planned in the framework of existing monitoring programs, cost effectiveness will be high. -**Socio-economic aspects**: None known.
Level of confidence[2] See guidance section	**High**. These methods have been widely applied in the EU and are known to be effective in sampling a wide range of species assemblages; they are well standardized with published protocols (e.g. West et al., 2007).

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	**Participation of fishers/citizen science contribution.** The history of the species use and its perceived threat to ecosystems varies among EU countries. Initially, pumpkinseed was introduced mainly as an ornamental fish and stocked in garden ponds as well as aquaria; it was released through accidental or deliberate releases to different water bodies. For angling purposes it was introduced as a sport fish but later as a forage fish for piscivorous fishes, especially for American centrarchid basses (*Micropterus* spp.) (Przybylski, et al., 2011). However, today the species is spreading widely probably because it can be easily introduced unintentionally, with imports of stocked fish fry (Tandon, 1976). Demand for aquarium and ornamental use for *Lepomis* spp. has decreased, but because these fishes are easy to keep in aquaria and water gardens, they are easily released or re-released in a great variety of water bodies. Due to the above circumstances in many EU Member States, the effort required for high-probability, early detection of aquatic non-native species such as *Lepomis* spp. is substantial (Copp et al., 2007; Hoffman et al., 2011) and this is why it is important to involve citizen science support for early detection. Recreation and water users are usually easily aware of the easy-to-catch species such as the *Lepomis* spp. Given proper training, citizen scientists should be able to participate in the detection of invasive fishes in their local area, and with a working validation system in place, the data they collect can be used with confidence by professional scientists to track and respond through early detection (Gallo & Waitt, 2011). So citizen involvement in early detection in essential.
Effectiveness of the surveillance	Effectiveness is high; the species is usually easily detected and already known to be widespread in

e.g. has thesurveillance previously worked, failed	many jurisdictions (e.g. Piria et al., 2017).
Effort required e.g. required intensity of surveillance (in time and space) to be sufficiently rapid to allow rapid eradication	Coordination of surveillance with other sampling schemes in Europe (WFD) and participation of amateur and professional fishers is required. Efforts for citizen science development are very new in Europe; the potential is high but initial work required will be demanding. The amount of needed resources depends on the area of potential spread in each Member State. Each MS must create a strategy and build a research and implementation plan to survey for the species group.
Resources required[1] e.g. cost, staff, equipment etc.	Citizen science or information sourcing platforms may have relatively high organizational costs and need careful planning and start-up. The amount of resources required depends on the area of potential spread in each MS. Each MS must create a strategy for specific and measurable monitored citizen science involvement. At the very least, each MS should organize a program that trains citizen scientists to detect the arrival and dispersal of invasive freshwater fishes in their local areas and to report them into an online, state-wide mapping database with scientific coordination. The cost of this kind of set-up and coordination is roughly estimated at least at 80,000 per year (one coordinator, training, meetings, website development-maintenance). Several programs such as this exist for invasive abroad (e.g. Gallo & Waitt, 2011).
Side effects (incl. potential) i.e. positive or negative side effects of the method on public health, environment, non-targeted species, etc.	**Negative**: No negative attributes to citizen science involvement. **Positive**: Citizen science initiatives build wider awareness and understanding among the public and specific stakeholder groups providing for positive synergies in combating aliens.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Public perception is increased and positive outcomes for stakeholder acceptability of a variety of other forms of alien species issues are usually gained (Gallo & Waitt 2011).
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 cannot be estimated per species; this must be developed in a strategy to include a wider number of targeted alien fish species in inland waters. -**Cost of inaction**: The only opportunity to successfully combat this species group is through early detection, so the cost of inaction is high. -**Cost-effectiveness**: Organization and early detection requires high cost operations for surveillance; participation through a citizen science framework should greatly assist detection. -**Socio-economic aspects**: None directly affecting public.
Level of confidence[2] See guidance section	**High**. There is relatively little reference to the effectiveness of the proposed measure in most Member States of Europe, but the use of citizen science for detection is widespread abroad (Helfman, 2007; Gallo & Waitt, 2011).

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.** When established, centrarchid populations can in most instances only be eradicated with rigorous and costly measures, including locally with piscicides. Rotenone is the most widely used piscicide; it is being used towards halting the decline of native fish species, managing the spread of unwanted fish species, and controlling the outbreak of any damaging fish disease (Ling, 2003). Rotenone does not dissolve in water. In order for practitioners to disperse it in water so that it can be effective at low concentrations, rotenone must be formulated with solvents. Two commercial product formulations containing rotenone as the active ingredient are considered here. One is called Nusyn-Noxfish®, the other is called 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). In general, no eradication project should begin unless a site-specific assessment has shown its technical feasibility (Britton et al. 2011). An important constraint is the lack of species-specific eradication techniques to be applied to fish (Scalera & Zaghi, 2004), and tools such as piscicides require research-based guidance to be most effective (e.g. Ling, 2003; Ferreras-Romero et al., 2016). In many cases, chemical control measures are not feasible because native fishes occupy the same or adjacent habitat and the damage to native protected/threatened populations may be considerable (Tyus & Saunders, 2000). For effectiveness and ease of use piscicides such as rotenone is probably the best choice in small enclosed water bodies (ponds, reservoirs, canals). After treatment, invertebrate fauna and amphibians will recolonize relatively rapidly - particularly if not all ponds or water bodies are treated in the same year. Piscicides may be even more effective if combined with other management initiatives. The physical removal (like seining with a small mesh net and electrofishing), combined with drawdown (if possible) to decrease area affected and to increase predation or limit spawning habitat.

	EU/national/local legislation on the use of plant protection products and biocides needs to be respected.
Effectiveness of measure e.g. has the measure previously worked, failed	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 organisms, 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. In Australia, rotenone has been used to successfully eliminate carp from Tasmania in the 1970s and for the local eradication of trout from streams in south-eastern Australia (West et al., 2007). But when established in a large river system, *Lepomis* spp. are nearly impossible to eradicate. Escapement of pumpkinseed propagules from hydrologically connected waterbodies is likely to increase under climate change scenarios (Fobert et al., 2013). An important aspect in any such campaign is a close linkage between monitoring and the eradication programme. Adequate monitoring should assess the progress of the campaign and assist decision making about its duration and the frequency of chemical treatments.
Effort required e.g. period of time over which measure need to be applied to achieve rapid eradication	Often an adaptive approach with careful monitoring and qualified ecologists is required in eradication operations. Efficient monitoring methods such as eDNA analysis are needed to assess the efficacy of an eradication attempt and to provide evidence that the species is unlikely to be present in the other connected waterbodies (Davison et al., 2017).
Resources required[1] e.g. cost, staff, equipment etc.	Extensive manuals and risk assessment procedures are available for rotenone piscicide (e.g. Finlayson et al., 2000; Turner et al., 2007). In some countries and within protected areas the use of piscicides such as rotenone may be illegal. Any such work must include Environmental Impact Assessment (EIA) costs especially at the initial application within the member state, where the costs of expert guidance will be usually required. However, after the first application, the overall costs should be substantially reduced since local experience will be developed (Impson et al., 2013). When local protocols have been established, a precedent set, and a team trained, the costs can reasonably be expected to be much less in future.

	Chemical removal is especially difficult and costly but may have local success quickly. For example, the eradication of two invasive species (*Cyprinus carpio* and *Gambusia holbrooki*) in an endoreic lake (37 Ha) in southern Spain cost about 600.000 € (Ferreras-Romero et al., 2016). A successful project in South Africa used rotenone to eliminate centrarchids in a four-km stretch of an upland stream. The cost was the equivalent of approx. 213 882 €. In this case weirs created upstream boundaries so the centrarchids could not recolonize. Downstream of the weir, rotenone was de-activated using potassium permanganate so native fish could not be affected (Impsonet al., 2013). In this case restoration work was combined with alien riparian wood clearing. Member state costs will vary significantly based on the assessment and organization of initiatives for rapid eradication.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	**Positive**: The process of ecosystem disturbance is short term, invasive alien eradication is usually possible (in contrast to most mechanical forms of removal where there is a large and costly bycatch problem for long periods). Other physical methods of removal are unlikely to be 100% effective and will result in significant pressures to native fishes, fisheries and habitat destruction. Also since there are no serious effects on the invertebrate life of the streams; the action is an important conservation measure that does not harm these macrozoobenthos communities- many of which suffer from the predation pressures of centrarchid sunfishes (Van Kleef et al., 2008). **Negative**: Chemical removal can harm native fishes (e.g. Finlayson et al., 2000; Turner et al., 2007). Piscicide applications are often inappropriate when the area of invasion has high conservation value, such as habitats of protected fish species (Britton et al., 2011).
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Although evidence for negative human health effects or other serious toxic effects to biodiversity have been well reviewed and are shown to be minimal (Ling, 2003), the use of rotenone often remains controversial and there is poor experience in most European countries. There are serious negative public perception issues and animal welfare considerations are also possible. Although the centrarchid sunfish species are a group of colourful and beautiful fish, public perception is generally negative where they have become established. They have negatively impacted many commercial fisheries (Balkan lakes, Zogaris pers. obs.; Özcan, 2007), and usually people are not negatively predisposed to protecting water bodies that have problems with serious alien invasives such as this species group.

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	**Cost for Member States**: Eradication from small water bodies is possible but further projects depend on particular member state strategy for eradication. **- Cost of inaction:** Rapid eradication may be important in certain circumstances; this depends on local conditions and opportunities for a successful treatment. In these cases, inaction is linked to higher costs related to the impacts of the species and to managing an established population. **- Cost-effectiveness:** Cost-benefit ratio depends on particulars and case-specific situations. **- Socio-economic aspects:** Eradication at high population densities in small and isolated water bodies is a demanding project work. Under a scenario of rapid eradication it is only a short term event and will not have significant negative effects on society if it is well interpreted and communicated.
Level of confidence[2] See guidance section	**Medium.** Evidence in Europe is scant for this species, however the use of piscicides on other invasive alien fishes is increasing.

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	**Aquatic habitat alteration: dewatering water bodies and barriers to species movement.** In most instances centrarchid sunfishes can only be eradicated with rigorous measures; dewatering in small canals, stream stretches and especially in artificial ponds and reservoirs is a site-specific localized action that may be locally effective. This drastic aquatic habitat alteration action should often be associated with barriers to the species movement, in order to ensure that re-entry or spread into the treated water body does not take place. It is important to have structures or mechanisms preventing the movement of sunfishes and other predatory fishes from the contaminated waters to uninvaded water bodies (Tyus & Saunders, 2000). Small water bodies, such as artificial ox-bow lakes, floodplain ponds and reservoirs have also been proposed as refuges for threatened fish species in areas where the main stem of river basins is currently dominated by predatory invasive alien fishes. These artificial refuge areas (usually smaller than 2 ha) have been proposed to be "drainable" in order to eradicate invasive non-natives including centrarchids (Mueller, 2005).

	In some small reservoirs, de-watering is a frequent form of management especially during the dry season (e.g. in Cyprus), during some drought years, or where small ponds are traditionally managed through dewatering (Usio et al., 2013).
Effectiveness of measure e.g. has the measure previously worked, failed	In small streams, lakes or ponds, control and eradication techniques could be successfully employed to locally extirpate non-native fishes (Ling, 2003; Britton et al., 2010; Davies and Britton, 2015). But when established in a large river system, *Lepomis* spp. are nearly impossible to eradicate. Escapement of *L. gibbosus* propagules from hydrologically connected waterbodies has been demonstrated and is likely to increase under climate change scenarios (Fobert et al., 2013); so barriers during flood events (or other water movements etc.) are important to consider. The main constraint is the lack of species-specific eradication techniques to be applied to fish (Scalera & Zaghi, 2004). An important aspect in any such campaign is a close linkage between monitoring and the eradication programme. Adequate monitoring should assess the outcome of the campaign and assist decision making about its duration and the frequency of dewatering actions.
Effort required e.g. period of time over which measure need to be applied to achieve rapid eradication	Rapid eradication may require an organized decision support framework and good coordination. In order for the species to be contained, action must take place in the short term. This means required studies such as EIAs will need to be organized with efficiency and coordinated stakeholder involvement.
Resources required[1] e.g. cost, staff, equipment etc.	Resource requirements will depend on the opportunities and priorities set to develop these procedures.
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	**Positive: Disturbance** will be short term and irregular over a period of several years. **Negative:** Habitat changes will affect local native ichthyofauna and may affect other biota that are intolerant of a total desiccation event.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	Although the species are a group of brilliantly coloured an attracted fishes, public perception is generally negative where they have become established. They have negatively impacted many commercial fisheries (Balkan lakes, Zogaris pers. obs.; Özcan, 2007) and usually people are not negatively predisposed to protecting wetlands and water bodies that have problems with serious invasive aliens such as this species group.
Additional cost information[1] When not already included above, or in the species Risk Assessment. - implementation cost for Member States	**Cost for Member States**: Eradication from small water bodies is possible (depending on local circumstances) but further projects to ensure success and to keep the species from re-entering depend on particular state strategy for extirpation or control. Maintaining and protecting small reservoirs, ponds etc. may have costs that are not easy to assess, since they are site-specific.

- the cost of inaction - the cost-effectiveness - the socio-economic aspects	**- Cost of inaction:** When opportunities are optimal for eradication cost of inaction may be significant since the species group may spread. Usually reservoirs and enclosed waters (ponds, small lakes) may provide opportunities to eradicate the initial population upon entry and thus avoid the higher costs related to the impacts of the species and to managing an established population. **- Cost-effectiveness:** Cost-benefit ratio depends on the site's particulars and case-specific situations. **- Socio-economic aspects:** Eradication at high population densities in small and isolated water bodies is a demanding project work. Under a scenario of rapid eradication it is only a short term eventand should have a superficial socio-economic cost.
Level of confidence[2] See guidance section	**Medium.** The references to successful de-watering are scant, but it has been shown to be a commonly referred method abroad (e.g. Mueller, 2013) and in some jurisdictions it is commonly practiced in small ponds and reservoirs. Published sources of its use in Europe for invasive alien species eradication are few.

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	**Mechanical removal.** When established in wider basin areas, centrarchid sunfish populations can only decline with rigorous measures, such as overfishing (mechanical removal). Mechanical removal of centrarchid sunfishes can be done by gill netting, seine netting and electrofishing. Protocols for removal are well developed (West et al., 2007) but electrofishing is preferred because it has the least amount of bycatch and damage to native fish populations. In Europe concern focuses on the pumpkinseed, which is now recorded in at least 25 European countries and regarded one of the most serious invasive species. Effort must focus on optimal management of this species (Tomoček et al., 2007) and on integrated planning (e.g. see Mueller et al. 2005). Three other less widespread sunfishes include: redbreast sunfish *Lepomis auritus* (Germany (Elvira, 2001), Italy (Welcomme, 1988; Elvira, 2001; Bianco, 2014), Czech Republic (DAISIE, 2016); green sunfish *Lepomis cyanellus* Germany (Elvira, 2001) and longear sunfish *Lepomis megalotis* Germany (Geiter, 2002); these must be managed on a case-specific approach. However, increasing water temperatures may favour the centrarchid sunfishes' expansion and change the situation in the future (Zięba et al., 2010). In general, no management project should begin unless a specific assessment study has shown its technical and financial feasibility.

	The species group warrants management attention because it definitely creates serious problems for ecological integrity and biodiversity in many inland water types in Europe (e.g. Almeida et al., 2009, 2014). The spread of the species depends on its life-history and habitat areas (Fox et al., 2007). The degree and type of intervention should be on a case-specific basis. Although physical control methods via commercial and recreational fishing are not considered the most successful ones for affecting populations, they are often the only possibility for control and containment (Thresher, 1997).Obliging anglers to euthanize caught fish may also contribute to targeted mechanical removal. In Australia it is forbidden by law to release caught carp (*Cyprinus carpio*); this is also widely practiced in the USA. Case-specific opportunities for effective management may be found. In the northern countries, abundant self-sustained populations sometimes occur only in water heated by electric plants (Przybylski & Zięba, 2011), these areas may be targeted for population management. Centrarchid sunfishes will continue to be problematic in Europe and mechanical control could be a costly application, therefore careful planning and integration of this management practice with eradication initiatives and outreach is required. Climate change will assist the future spread of the centrarchid sunfishes in Europe (Copp et al., 2009; Britton et al., 2010; Zieba et al., 2010, 2015).
Effectiveness of measure e.g. has the measure previously worked, failed	Despite limited documentation of successes using mechanical removal, many conservation actions continue to focus on overfishing control methods as a tool to minimize local impacts of non-indigenous fish (e.g. Cucherousset et al., 2006). Overfishing of warm water fishes in some lake systems and large river systems is widespread IAS procedure in the USA (Wittmann et al., 2015a). Also, in some cases the effectiveness of the mechanical removal has been questioned and negatively criticized (Mueller, 2005). In contrast, chemical treatments although they have shown to be successful in certain circumstances, can be wrought with controversy that may impede conservation efforts. Scientific planning is required for the ability to determine whether eradication or containment at a site or species-specific objective is a key step to setting goals for any IAS management plan. Further, as potential control options or technologies are introduced, it will be helpful to know which could be used for eradication or which could be used for control.
Effort required e.g. period of time over which measure need to be applied to have results	The effort and effectiveness of mass mechanical removal or any removal campaigns will be case-specific. In Europe there is scant understanding of effort required for this particular tolerant and widespread alien. Science-guided efforts to manage the species with mass removal abroad have focused on specific actions where impacts of centrarchids may be thwarted by population decline

	(Wittmann & Chandra, 2015). A sustainable and effective control program, that includes targeted effort for mechanical removal is possible when science, multi-jurisdictional coordination and outreach are integrated (Wittmann et al., 2015b).
Resources required[1] e.g. cost, staff, equipment etc.	The management of these species will have high economic costs (Britton et al, 2008). Mechanical removal techniques are a common practice that requires large amounts of resources and constant and heavy suppression efforts. Mechanical removal can be expensive. In the San Juan river, USA, predatory fish removal (including centrarchids) has continued for more than a decade, with costs rising to about $250,000 USD per year (Mueller, 2005). In Europe, electrofishing sampling costs 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 given cost of 1,500 € per sample, the estimation of effort can be generally calculated. Specific costs are difficult to assess since this action is case-specific and must be applied to situations and should have targeted outcomes (Mueller, 2005).
Side effects (incl. potential) i.e. positive or negative side effects of the measure on public health, environment, non-targeted species, etc.	**Positive**: Lowering populations should restore ecological conditions and community assemblages of native fishes and other species. The mechanical removal is usually preferred to chemical. Chemical means, such as piscicides may create public protest and may harm native fishes; in any case there may be instances where killing large number of native fishes may occur (however every effort must be made not to unnecessarily harm native fish populations). **Negative**: Mechanical removal, other than electrofishing will have serious bycatch pressure. These are usually unwarranted and must be monitored. Any other control method to be applied in parallel with mass mechanical removal should be planned carefully. For example, barriers to dispersal set up for this species group will unfortunately block passage of native species as well, so this may create further degradation of the fish community; strategic scientifically-led planning is therefore an imperative to limit negative side effects.
Acceptability to stakeholders e.g. impacted economic activities, animal welfare considerations, public perception, etc.	The control of *Lepomis* spp. populations may be more acceptable to stakeholders if the evidence base for the management actions are substantial and well interpreted (research into the justification for management and its effectiveness); and if control targets obvious risks to water body degradation and ecosystem services, where cost-effectiveness is demonstrated.
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 for Member States:** costs of control (including the option of mass removal) shall vary regionally, and so do risks, and costs of inaction. The species is present in a great variety of water body types, producing various pressures on biodiversity and ecosystem services. Each MS should develop a particular strategy to apply mass removal for this important invasive species. **- Cost of inaction:** cost of inaction usually depends on local conditions and situation-specific conditions. **- Cost-effectiveness:** A detailed analysis taking into account these factors is not available. A

	comparison with the case of complete removal or management to prevent damage, is based on expert judgment. The cost-effectiveness of predatory fish persecution in large un-enclosed waters has been criticized (Mueller, 2005) so extra care is required to document, monitor and audit all applications. **- Socio-economic aspects:** The prevention of severe limnological alteration, degraded ecosystem integrity and fisheries resources is important but this varies on a case-specific basis and among different spatial scales.
Level of confidence[2] See guidance section	**Medium.** Experience with the above mentioned control methods is generally lacking or poorly reported in most EU countries. As a result it is unclear to what extent the methods are effective in regulating *Lepomis* species densities. Furthermore, it is unknown how these methods affect other organisms and it is not generally easy to interpret how these compare to the detrimental effects of pumpkinseed invasions. To improve efficiency of control methods, they should be properly evaluated by monitoring and the results should be communicated with the wider management issues (Soes at al., 2011). Research, through adaptive management initiatives, alongside the mass removal actions is essential.

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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.

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