**Information on measures and related costs in relation to species included on the Union list - *Eriocheir sinensis***

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| **Species (scientific name)** | *Eriocheir sinensis* H. Milne Edwards, 1853 |
| **Species (common name)** | Chinese mitten crab |
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| **Date Completed**  | 19/09/2019 |
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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. |
| Aquatic IAS (invasive alien species) are generally difficult to manage, and *Eriocheir sinensis* is a catadromous species, making its management even more difficult. No 100% effective management measures have been identified for this species. **Prevention of unintentional introductions**As the species commonly arrives to new areas transported unintentionally in ballast waters, one of the suggested prevention measures is ballast water exchange in open seas and/or ballast water treatment. Ballast water management is not species-specific, thus the reported information for this measure refers to all the possible aquatic taxa transported by ballast waters. Although this measure is not 100% effective, it is the only way to tackle ballast water issues. The Ballast Water Management Convention entered into force in 2017, so the effect of its implementation should be further assessed. The species can also be unintentionally introduced via hull fouling of vessels, thus biofouling management is recommended to reduce the possibility of its introduction, following the IMO guidelines and the code of conduct on boating and IAS. The latter are not mandatory, but should be implemented at national level. **Prevention of secondary spread**As the species can be unintentionally transported and introduced into new areas by crafts, biosecurity measures (specifically the check/clean/dry campaign) coupled with public awareness should be promoted to reduce the probability of its spread. Young crabs and young adults actively migrate upstream and the species can disperse from neighbouring areas, or countries, through interconnected water systems, as has happened in Austria or Serbia. Installing barriers has been suggested to stop its movement, especially during migration phases. However, adults can disperse overland and climb barriers or banks to overcome the obstacle: Chinese mitten crabs are known to be one of the best climbers among crabs, making this measure not very effective. Intensive trapping can be conducted to prevent the spread of the species from the area of invasion into neighbouring areas. Different types of traps/devices are available, such as baited traps, fyke nets, ring nets, star traps and snare traps. These traps allow the animals to enter, but not to escape. Fyke nets (with or without leaders) seem to be efficient, and can be modified to avoid fish bycatch. Trapping is most effective during migration periods, by placing traps upstream (juvenile migration) or downstream (adult migration) of dams/weirs. Effectiveness of trapping is debated. Traps could be a partly effective tool to keep populations at low densities, but they cannot be the only measure used to prevent spread or eradicate a population.**Early detection**As the species can disperse through interconnected water systems from neighbouring countries or within a country, a network could be established to detect new populations. Networks may consist of watershed groups, volunteers, residents, anglers, commercial freshwater and marine fishermen, farmers or civil servants to monitor strategical points (such as fish passages and hydropower facilities, where the animals can congregate during migration period). Although no data are present in the literature on this measure’s effectiveness, it has been useful in detecting new alien crayfish, fish and other IAS in Europe. eDNA could also be used to detect species at low abundance. The use of eDNA as a monitoring tool in freshwater systems is becoming increasingly accepted and widely used for the detection of single species. Techniques are improving, so effectiveness of the measure will increase in the future.Ever more, citizen science is seen as essential to ensure the spatial and temporal resolution of IAS collection data, allowing for rapid response and the success of prevention and management programs. The Joint Research Centre of the European Commission has developed a dedicated smartphone app for the species of Union concern, so that data can be sent to competent authorities, in order to detect the species at an early stage of invasion. The first confirmed record of the species along the entire eastern USA, from Florida to Maine, was in Chesapeake Bay near Baltimore, Maryland, in 2005: this initial crab detection was reported by a commercial crabber, showing that citizen science can be considered an effective measure.**Rapid eradication**Aquatic IAS are very difficult to manage, and usually the combination of different techniques is recommended to achieve good results. Eradication is even more challenging, and can only be contemplated in a closed system. A combination of intensive trapping with the application of temporary fences/barriers along the area of intervention to delimit it could be used to eradicate the species at an early stage of invasion. Use of diversion and pitfall traps can also be considered. Drainage of water bodies cannot be considered, as this species can walk overland, and marked side effects on non-target species would likely occur. Chemical methods have never been tested for this species. Similarly, no biological control specific to Chinese mitten crab is known. Thus, only the combination of mechanical (traps) and physical (barriers, diversion) methods can be considered, although eradication of the species has never been reported.**Management**After attempting the use of barriers, intensive trapping and Integrated Pest Management, commercial use of the species can also be considered as a control tool. Commercialisation can reduce species abundance with minimal cost, although there are many negative side effects to the use of this measure (e.g. promoting the species for its economic value may decrease understanding of the need for its control). According to EU Regulation 1143/2014, art. 19 “The commercial use of already established invasive alien species may be temporarily allowed as part of the management measures aimed at their eradication, population control or containment, under strict justification and provided that all appropriate controls are in place to avoid any further spread”. This is a measure that should be carefully evaluated case by case. Finally, although the use of this measure as a control tool has elicited strong debate, as there is a risk for promoting further spread, in some cases it could represent the only viable option (e.g. when no other measures are successful, or possible, and populations have to be controlled). **Summary of proposed measures in this technical note****1) Prevention of unintentional introductions**Ballast water management Biofouling management**2) Prevention of secondary spread** Biosecurity measures and public awarenessInstalling barriers (also for rapid eradication and management)Trapping (also for early detection, rapid eradication and management)**3) Surveillance measures for early detection**Establish early detection networkseDNA monitoring Develop a citizen science program**4) Rapid eradication**Integrated Pest Management (IPM) (also for management)**5) Management**Commercial use |

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| **Prevention of intentional introductions and spread** – measures for preventing the species being introduced intentionally. **This table is repeated for each of the prevention measures identified.** *If the species is listed as an invasive alien species of Union concern, this table is not needed, as the measure applies anyway.* |
| **Measure description**Provide a description of the measure, and identify its objective | *As the species is listed as an invasive alien species of Union concern, the following measures will automatically apply, in accordance with Article 7 of the EU IAS Regulation 1143/2014:**Invasive alien species of Union concern shall not be intentionally:* *(a) brought into the territory of the Union, including transit under customs supervision;* *(b) kept, including in contained holding;* *(c) bred, including in contained holding;* *(d) transported to, from or within the Union, except for the transportation of species to facilities in the context of eradication;* *(e) placed on the market;* *(f) used or exchanged;* *(g) permitted to reproduce, grown or cultivated, including in contained holding; or* *(h) released into the environment.**Also note that, in accordance with Article 15(1) – As of 2 January 2016, Member States should have in place fully functioning structures to carry out the official controls necessary to prevent the intentional introduction into the Union of invasive alien species of Union concern. Those official controls shall apply to the categories of goods falling within the Combined Nomenclature codes to which a reference is made in the Union list, pursuant to Article 4(5).]****Therefore measures for the prevention of intentional introductions do not need to be discussed further in this technical note.*** |

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| **Prevention of un-intentional introductions and spread** – measures for preventing the species being introduced un-intentionally (cf. Article 13 of the IAS Regulation). **This table is repeated for each of the prevention measures identified.** |
| **Measure description**Provide a description of the measure, and identify its objective | **Ballast waters management (BWM)**The species is commonly introduced into new areas transported in ballast waters. BWM is not species-specific, thus the reported information for this measure refers to all aquatic taxa possibly transported by ballast waters. Before 2017, in the EU, different BWM approaches were developed at regional levels and were of voluntary nature (such as the HELCOM / OSPAR / REMPEC BWM approaches). The Ballast Water Management Convention (BWMC) was adopted in 2004, but entered into force only in September 8th 2017. From 2017, the BWMC applies to signatory countries, and ballast waters should be exchanged in open seas (BWE) or treated (BWT) with mechanical, physical, chemical or biological processes - such as filtration systems, chemical disinfection (oxidising and non-oxidising biocides), ultra-violet treatment, deoxygenation treatment, heat (thermal treatment), acoustic (cavitation treatment), electric pulse/pulse plasma systems and magnetic field treatment, either singularly or in combination – to remove, render harmless, or avoid the uptake or discharge of harmful aquatic organisms and pathogens within ballast water and sediments (Tsolaki & Diamadopulos, 2010; IMO, 2017). Modern BWT systems usually employ a two-step treatment approach (Stehouwer et al., 2015). The BWM Convention introduces two different regimes with sequential implementation: Ballast Water Exchange Standard (Regulation D1), requiring ships to exchange a minimum of 95% ballast water volume; Ballast Water Performance Standard (Regulation D2), which requires that ballast water discharged has a number of viable organisms below specified limits. Details and the list of approved and certified ballast water management systems can be found online.[[1]](#footnote-1)Another source of introduction for the species could be through the scrapping of old ships. This has been suggested as the source of mitten crab introduction in the Duddon Estuary in the UK (GBNN RA, 2011), thus safe disposal of ballast water while dismantling old ships could be an issue and requires further investigation. |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | As EU countries have ratified the BWMC[[2]](#footnote-2) , the scale of application of this measure should be at a national level and, ultimately, at a EU level. However, the convention has not been fully implemented yet. Moreover, there are some limitations in its application: BWE shall be conducted at least 50 nautical miles from the nearest land and in waters at least 200 metres in depth, conditions which are not met, for example, for intra-European shipping, or domestic shipping of many countries; otherwise, BWT should be applied (David & Gollasch, 2008). Treatments could be shipboard, or port based.  |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Effectiveness of measures*** | *Effective* |  | *Neutral*  | *X* | *Ineffective* |  | *Unknown* |  |

*Rationale*:BWM is a key component for the management of aquatic invasive species, but it is not 100% effective, depending on several parameters such as species life stages that are transported, salinity, physiological conditions, and structure of ship tanks. In 2011, the U.S. Environmental Protection Agency reported that “none of the assessed BWM systems can meet a standard that is 100 or 1000 times more stringent (EPA, 2011). Furthermore, it is not reasonable to assume that the assessed BWMS are able to reliably meet or closely approach a “no living organism” standard”. Bakalar (2016) showed that the various BWT systems have different effectiveness, considering their maintenance and ecological footprint, and that usually a combination of systems is adopted. In the Great Lakes and Chesapeake Bay (USA), Ruiz and Reid (2007) found that, when conducted according to requirements, BWE can be highly effective at removing coastal water and coastal planktonic organisms from ballast tanks, with mortality rates varying according to different tank size and shape; however, 100% mortality rates were not reached. A recent review by Molina and Drake (2016) reported that BWE generally showed an efficient volumetric exchange of ballast water, while the survey of reports evaluating biological exchange efficacy (by means of organism detection and quantification) indicated that organisms were not consistently removed from tanks following water exchange. An assessment of the practicability of conducting ballast water exchange, plus treatment, was performed by First and Drake (2017): analysing the records of ships arriving to USA ports from 2004 through 2014 to characterise the frequency and location of BWE, they found that in ports within the Great Lakes, only about 1% of vessels arriving—or 921 arrivals over 11 years—conducted BWE. They suggest combining BWE and BWT, even if this combination depends upon several factors, particularly on the time available to safely perform both operations in the appropriate area.  |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | BWM should be applied indefinitely.  |
| **Resources required 1**e.g. cost, staff, equipment etc. | BWM is costly. Costs vary according to the different adopted systems, different ballast water treatment plants, their installation on board, as well as operating and maintenance costs, pumps and the consumed fuel oil. Vorkapić et al. (2018) calculated the cost efficiency of two BWTs: assuming that a ship makes 12 trips annually, the estimated average annual cost of BWE applying a sequential method in accordance with D1 standard is $ 4,368.960, the estimated average annual cost of BWT according to D2 standard with UV irradiation is $ 2,885.592, while the estimated average annual cost of BWT according to D2 standard with electrochlorination is $ 623.616. Installation costs of BWM systems have been estimated by ship-owner organisation BIMCO (the largest of the international shipping associations representing ship-owners) as going up to $ 5 million per ship[[3]](#footnote-3).  |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Environmental effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |
| ***Social effects*** | *Positive* |  | *Neutral or mixed* |  | *Negative* | *X* |
| ***Economic effects*** | *Positive* |  | *Neutral or mixed* |  | *Negative* | *X* |

*Rationale*:Some BWTs can cause environmental pollution, i.e. introduction of contaminants into the natural environment that could cause adverse change, especially if they use active substances. There is indeed a classification of environmental friendliness of a particular BWT, and the used methods should be approved and certified after a test process. Even if chemical methods effectively reduce the risk of aquatic species invasions, they have the most likely negative side effects: for example, oxidative water treatment forms disinfection by-products that may harm humans and marine biota (Werschkun et al., 2014). A positive environmental side effect is that other potential IAS can be tackled using this measure.Finally, as reported above, BWM is costly, so it can have negative economic effects on ship companies. The costs differ according to the BWT systems used and can be reduced over the ship’s lifetime, but the initial investment is certainly costly.  |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Acceptability to stakeholders*** | *Acceptable* |  | *Neutral or mixed* | *X* | *Unacceptable* |  |

*Rationale*:There could be some resistance from ship owners or companies due to the cost and type of systems to be applied on the ship (e.g. chemical methods, even if more effective, could elicit some health issue concern for people working on the ship). |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | The implementation cost for Member States depends on the number of ships to be treated and the adopted systems. Surely, the cost of inaction would be higher, as new potential invasive species will continue to arrive and need to be managed.  |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

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| *Inconclusive* |  | *Unresolved* |  | *Established but incomplete* | *X* | *Well established* |  |

*Rationale*:Different studies and recent reviews agree on BWM importance, even if they recognise the weak points of this measure. There are no specific studies on effectiveness of prevention of unintentional introductions for Chinese mitten crab by BWM. |

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| **Prevention of un-intentional introductions and spread** – measures for preventing the species being introduced un-intentionally (cf. Article 13 of the IAS Regulation). **This table is repeated for each of the prevention measures identified.** |
| **Measure description**Provide a description of the measure, and identify its objective | **Biofouling management**The species can also be unintentionally introduced via hull fouling of vessels (Gollasch, 2011). Fouling communities on ships are usually composed of sessile species; however, sometimes mobile species can be transported: for example, specimens of *E. sinensis* have been reported in empty cirriped shells on ship hulls. In July 2011, after three years of consultation among International Maritime Organization (IMO) Member States, the Guidelines for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species (Biofouling Guidelines) were adopted by the Marine Environment Protection Committee (MEPC) (resolution MEPC.207(62))[[4]](#footnote-4). They intend to provide a globally consistent approach to the management of biofouling and represent the first international action addressing ships’ biofouling with the goal to reduce the accumulation of micro- and macro-organisms (not only the Chinese mitten crab) on the outside of ships by choosing the appropriate coating, by conducting in-water inspections and cleaning, as well as proper removal during dry-docking. According to this document, anti-fouling systems are considered “a coating, paint, surface treatment, surface or device that is used on a ship to control or prevent attachment of unwanted organisms”[[5]](#footnote-5). Antifouling coating systems are broadly categorised as biocidal or non-biocidal: the first prevent the attachment and growth of biofouling organisms through the release of biocides, such as copper and zinc compounds, with copper being the most commonly used biocide; the second have physical properties to impair attachment (e.g. silicone-based fouling release coatings) or allow regular or abrasive cleaning with minimal effect on the surface (Scianni & Georgiades, 2019). Ships are required to follow a biofouling management plan and to keep a record book. The guidelines also provide recommendations for the management of biofouling waste in land-based facilities. Although the guidelines are non-mandatory and not legally enforceable at a global level (Bouyssou & Madjidian, 2014), they will be implemented by the GloFouling Partnerships Project[[6]](#footnote-6), launched in December 2018, because reliance on self-management with limited oversight and enforcement is insufficient for the vector’s control (Galil et al., 2019). It is, however, noteworthy that the application of antifouling coatings and the treatment of internal water systems are measures that could have been adopted by the shipping industry for reasons of fuel efficiency and vessel safety rather than preventing the spread of marine alien species (Arthur et al., 2015). In 2012, IMO also approved the Guidance for minimising the transfer of invasive aquatic species as biofouling for recreational craft[[7]](#footnote-7). Recently, ICES underlined the necessity of adopting antibiofouling systems to mitigate alien species introductions. In particular, they stressed: “Urgent implementation of the IMO generic guidelines for the control and management of biofouling on vessels, with new and more detailed guidelines, should be developed for different vessel types; ship designs should aim to reduce the potential for biofouling; all vessels, whether recreational, domestic, decommissioned, derelict, or abandoned, should adhere to the same standard for the control and management of biofouling; performance measures should be implemented to assess management practice, in order to evaluate efficacy and guide adaptive management”[[8]](#footnote-8).This measure can also be used for preventing secondary spread of the species (see table below). In that case, the European code of conduct on recreational boating and invasive alien species[[9]](#footnote-9) should be implemented at a national level. |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | The scale of application of this measure should be at a national level and, ultimately, at an EU level.  |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Effectiveness of measures*** | *Effective* |  | *Neutral*  | *X* | *Ineffective* |  | *Unknown* |  |

*Rationale*:Antifouling systems are diverse and their effectiveness depends on the system applied and the type of vessel. For example, non-toxic paints may have a shorter lifespan than organotin paints and, consequently, may need to be applied more often and may be less efficient in preventing biofouling. Another drawback of biocide free coatings is that they may not be sufficiently robust for some ships following intercontinental routes (revised in Bouyssou & Madjidian, 2014). Mechanical grooming is helpful in reducing fouling on submerged surfaces coated with fouling release coatings (Hearin et al., 2016). Low saline treatments can be highly effective at reducing biofouling (even by 100%, although it depends on the situation) and can be used in conjunction with antifouling coating systems (revised in de Castro et al., 2018). However, once the ship is stationary for any length of time, the effectiveness of anti-fouling coatings diminishes, with rapid colonisation of assemblages of aquatic organisms becoming attached to the hull. For example, “a 200-metre long merchant ship is capable of acquiring 20 tonnes of bio-fouling if stationary for a prolonged period” (reported in Hydrex[[10]](#footnote-10)).  |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | Biofouling management should be applied indefinitely.  |
| **Resources required 1**e.g. cost, staff, equipment etc. | Costs vary according to the different systems adopted and the type of treated ships, as well as to different operating and maintenance costs. For example, even if high pressure washing in dry-dock is very effective for removing fouling, it is not practical for a ship to be dry-docked frequently, because it is too expensive, and therefore ship owners will simply avoid it (reported in Hydrex). However, it is important to underline that the primary cost associated with fouling is the increased fuel consumption attributable to increased frictional drag, while the costs related to hull cleaning and painting are much lower than those (Schultz et al., 2011).For example, Schultz et al. (2011) reported that for a mid-sized naval surface ship (Arleigh Burke-class destroyer DDG-51) “the costs related to hull cleaning and painting are much lower than the fuel costs. The overall cost associated with hull fouling for the Navy's present coating, cleaning, and fouling level is estimated to be 56 million USD (ca. 50 million EUR) per year for the entire DDG-51 class (56 ships) or 1 billion USD (ca. 0.9 billion EUR) over 15 years”.A recent report estimated that, in Australia, regulatory costs to the commercial vessel sector (considering that annually close to 27,000 vessels enter Australian territory from 600 overseas ports; reported in Department of Agriculture and Water Resources, 2019) for implementing effective biofouling management practices over 10 years (i.e. requiring vessels to implement effective and vessel-specific biofouling management practices consistent with the direction set by the International Maritime Organization) would be 10,519,000 AUD (ca. 6,510,000 EUR) (Department of Agriculture and Water Resources, 2019). The benefits due to fuel saving are not provided, but most probably outweigh these costs.  |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Environmental effects*** | *Positive* |  | *Neutral or mixed* |  | *Negative* | *X* |
| ***Social effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |
| ***Economic effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |

*Rationale*:Some antifouling systems can cause environmental problems: for example, one of the most effective anti-fouling paints, developed in the 1960s, contains the organotin tributylin (TBT), which has been proven to cause deformations in oysters and sex changes in whelks. TBT was indeed banned in 2008. However, other biocides are used in antifouling systems, despite their potential impacts on the marine ecosystems (de Castro et al., 2018). For this reason, the development of new non-toxic antifouling solutions is promoted. Although chemical treatments, the use of heat or of UV light all work as anti-fouling, they can be costly or pose health and safety risks, and also increase corrosion of hulls (de Castro et al., 2018). |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Acceptability to stakeholders*** | *Acceptable* | *X* | *Neutral or mixed* |  | *Unacceptable* |  |

*Rationale*:There could be some resistance to some biofouling measures by ship owners or companies due to the cost and type of systems to be applied on the ship. However, as mentioned above, effective anti-fouling systems can save money by reducing fuel consumption and this can favour the acceptability of the measure.  |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | The implementation cost for Member States depends on the number of ships to be treated and the adopted systems. Surely, the cost of inaction would be higher, as new potential invasive species will continue to arrive and need to be managed. Economic effects of biofouling go far beyond the cost of control and eradication efforts. They encompass added maintenance costs to shipping and marine infrastructure, damage to valuable fisheries and aquaculture, and added fuel and emission costs (Galil et al., 2019). The costs differ according to the adopted systems used, but Fernandes et al. (2016) estimated that the proportion of the overall costs that mitigation measures for management of biofouling in Europe will represent on shipping implementing the guidelines recommended in the coming years can vary between 0.28 to 1.01, depending on the country of ship origin and type of vessel. According to Branson (2012), in Australia and California, in total over the 50 years from 2013 to 2062, the adoption of mandatory and voluntary standards to manage biofouling could deliver additional net benefits of 520 million USD (ca. 470 million EUR), and 865 million USD (ca. 780 million EUR), respectively (considering to avoid the potential of IAS on initial incursion response, aquaculture, commercial and recreational fishing, coastal infrastructure, marine tourism and recreation, recreational use of beaches, human health and indigenous biodiversity). |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

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| *Inconclusive* |  | *Unresolved* |  | *Established but incomplete* | *X* | *Well established* |  |

*Rationale*:Different studies and recent reviews agree on the importance of biofouling management, even if they recognise that the measure should be better implemented. There are no specific studies on the effectiveness of prevention of unintentional introductions for Chinese mitten crab by biofouling management. |

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| **Prevention of secondary spread of the species** – measures for preventing the species spreading once they have been introduced (cf. Article 13 of the IAS Regulation). **This table is repeated for each of the prevention measures identified.** |
| **Measure description**Provide a description of the measure, and identify its objective | **Biosecurity measures and public awareness**Regulatory measures should be coupled with voluntary measures (e.g. code of conducts) in order to change people’s mentality and behaviours, thus promoting their active participation in tackling invasive alien species. As the Chinese mitten crab could be unintentionally transported and introduced into new areas by boating, the IMO guidance on recreational craft and the European code of conduct on recreational boating and IAS should be implemented at a national level (INBO, 2017). Similarly to what is recommended by the GB NNSS campaign[[11]](#footnote-11), ‘check, clean and dry’ equipment and clothing when moving between waterways represents one of the recommended measures to decrease the possibility of moving IAS into new areas. In the code, it is also recommended to encourage responsible recreational boating through targeted information, education and training. Informative materials should be firstly placed where aquatic IAS are an issue, but as underlined in the code “measures should be implemented by everyone, everywhere, every time”. |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | The scale of application refers to all aquatic systems of national territories. |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Effectiveness of measures*** | *Effective* |  | *Neutral*  | *X* | *Ineffective* |  | *Unknown* |  |

*Rationale*:In July 2009, a research study concluded that the Check, Clean, Dry campaign undertaken in New Zealand was successful in changing attitudes and behaviours of New Zealand’s fresh waterway users: of those surveyed, 89% of high-risk users agreed that the diatom didymo (*Didymosphenia geminata*) was a serious threat for New Zealand; 100% of high-risk users in the South Island and 99% of high-risk users in the North Island were able to identify an action they could take to help stop the spread of didymo. Of those, 71% always Check, Clean and Dry and 21% sometimes Check, Clean and Dry. Although it was not possible to be absolutely sure whether the spread of didymo slowed down due to the implementation of the Check, Clean, Dry campaign, it is important to note that didymo has not yet been detected in the North Island[[12]](#footnote-12). In the UK, the use of hot water as a decontamination method to prevent the accidental movement of aquatic invasive species resulted to be 99% effective in killing alien aquatic plants and invertebrates (Anderson et al., 2014). |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | This measure should be applied indefinitely.  |
| **Resources required 1**e.g. cost, staff, equipment etc. | Costs include informative materials and social campaigns needed to promote the biosecurity measures that should be implemented, plus the resources needed to clean the crafts and dispose the removed materials. In New Zealand, total expenditure on social marketing activities in the first three years of the check, clean, dry campaign in response to the diatom didymo was approximately 4.55 million NZD[[13]](#footnote-13) (approximately 2.6 million EUR). In the UK, eight water companies have been investing £150,000 per annum (approximately 170,000 EUR) from 2017 to tackle aquatic invasive species through an enhanced Check, Clean, Dry work programme[[14]](#footnote-14). |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Environmental effects*** | *Positive* | *X* | *Neutral or mixed* |  | *Negative* |  |
| ***Social effects*** | *Positive* | *X* | *Neutral or mixed* |  | *Negative* |  |
| ***Economic effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |

*Rationale*:The implementation of biosecurity measures and public awareness campaigns can have positive side effects on native species and the environment, as these measures can also tackle other alien species. Another positive consequence is that citizens become proactive and feel involved in the management of IAS.  |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- |
| ***Acceptability to stakeholders*** | *Acceptable* |  | *Neutral or mixed* | *X* | *Unacceptable* |  |

*Rationale*:Some initial resistance could be raised due to the cost of the biosecurity measures to be applied.  |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | The cost of inaction would be high. In 2006, an economic impact assessment found that a 2-year delay to the arrival of didymo to the North Island of New Zealand would represent a cost saving of between 34.5 and 167.9 million NZD (approximately 19.7 and 95.8 million EUR) over the period of 2004/05 to 2013/14. The same assessment estimated that the cost saving to New Zealand delaying the spread of didymo to the North Island to June 2008 had been 2.15 NZD (1.2 EUR) for every 1 NZD (0.57 EUR) spent on social marketing[[15]](#footnote-15).  |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *Inconclusive* |  | *Unresolved* |  | *Established but incomplete* | *X* | *Well established* |  |

*Rationale*:Check, clean and dry biosecurity campaigns are increasing in numbers, as they are one of the easiest and most effective means to tackle the spread of aquatic IAS. However, up to now, there are no specific studies on the effectiveness of prevention of secondary spread of the Chinese mitten crab using these measures. |

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| **Prevention of secondary spread of the species** – measures for preventing the species spreading once they have been introduced (cf. Article 13 of the IAS Regulation). **This table is repeated for each of the prevention measures identified.** |
| **Measure description**Provide a description of the measure, and identify its objective | **Installing barriers**The species can disperse through interconnected water systems from neighbouring areas or countries, invading new ones, as has happened in Austria or Serbia. Young crabs and young adults actively migrate upstream (Gollasch, 2011). In their native distribution area, living crabs have been found many hundred kilometres upstream the river Jangtsekiang (Gollasch, 2011). In Europe, crabs are found frequently in the eastern Gulf of Finland, located more than 1500 km from the main area of abundance, the German Bight (Ojaveer et al., 2007). However, being a catadromous species, there are no self-sustaining, land-locked populations of mitten crabs. Electric or physical barriers could be installed to prevent the arrival of the species to new areas or countries. Barriers, bars, K-rails similar to a concrete highway barrier and traveling screens (1.2-1.8 m high, with 2.5 cm openings) have been tested in the USA, especially to prevent impacts in fish salvage facilities (Chinese Mitten Crab Working Group, 2003). Electrical screens can be placed on the river bottom in areas where crabs congregate (Eberhardt et al., 2016). The implementation of barriers involves professionals, but volunteers can be used to check them. Barriers can also be applied for rapid eradication and for management of the species, especially during the migration period from the sea.  |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | Local scale, but it depends on the river.  |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Effectiveness of measures*** | *Effective* |  | *Neutral*  |  | *Ineffective* | *X* | *Unknown* |  |

*Rationale*:Unluckily, adults of the species can disperse overland and climb barriers or banks to overcome the obstacle (Chinese Mitten Crab Working Group, 2003). Chinese mitten crabs are known to be one of the best climbers among crabs (McLaughlin, 1982). Juvenile crabs can climb short distances up vertical concrete walls (Hymanson et al., 1999), and have escaped from 6 m deep concrete holding tanks that were quarter filled or half-filled with water (reported in Cohen & Weinstein, 2001). Adults can live out of water in a dry environment for about a week and are capable of climbing over concrete structures at least 3-4 m high, although it is reported that in China 6 m high vertical and sloped barriers stop most crabs (Cohen & Weinstein, 2001). Mitten crabs can also pass through lock systems and possibly climb fish ladders, or leave the water and walk around barriers where the terrain is suitable (Cohen & Weinstein, 2001). During the 1930s and 1940s, Germany installed electrical screens on the river bottom that would stop or kill crabs using electrical pulses, but they were ineffective (McEnnulty et al., 2001). Barriers cannot be effective in large waterbodies with a high degree of interconnectedness (Eberhardt et al., 2016). Barriers could slow down, but not stop the arrival of the species. Installation of travelling screen and trash racks has been applied in Germany, with the aim of heavily reducing the Chinese mitten crab population during migration events: the method showed to be most effective if done at locations where a river or stream is contained by a regulatory structure (e.g., dam, fish facility) (Peters & Panning, 1933). Rotating “Grizzly” screens to allow water, but not crabs, to pass were 80% effective at removing crabs from the Tracy Fish Collection Facility, California (Eberhardt et al., 2016). |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | The measure should be applied in the long term, in order to limit the spread of the species and avoid its arrival in new countries. |
| **Resources required 1**e.g. cost, staff, equipment etc. | The cost of infrastructure (which is variable depending on the type of barrier; e.g. two physical barriers to stop signal crayfish in the UK cost £ 50,000[[16]](#footnote-16)) of setting and maintenance of the barriers should be considered, together with that of personnel to maintain and frequently check the barriers for animals to be removed. Costs of disposal of caught animals should also be considered.  |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- |
| ***Environmental effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |
| ***Social effects*** | *Positive* |  | *Neutral or mixed* |  | *Negative* | *X* |
| ***Economic effects*** | *Positive* |  | *Neutral or mixed* |  | *Negative* | *X* |

*Rationale*:The impacts to non-target species, including migratory species, could be significant, as the movement of other aquatic species would be affected by the barriers. However, as a positive environmental side effect, other IAS could be stopped by the barriers (e.g. crayfish, fish).There will be a cost for barrier maintenance and barriers can also stop species of fishing interest. |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- |
| ***Acceptability to stakeholders*** | *Acceptable* |  | *Neutral or mixed* | *X* | *Unacceptable* |  |

*Rationale*:Anglers could be against the barriers, which could impact species of fishing interest. Moreover, barriers impeding the movements of other species might not be positively perceived by the public. Finally, the cost of barriers (installation and maintenance) is high, and thus might not be supported by some stakeholders. |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | Cost of its implementation would be high, while its cost-effectiveness is debated. Temporary barriers could be adopted in some cases. |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| *Inconclusive* |  | *Unresolved* |  | *Established but incomplete* |  | *Well established* | *X* |

*Rationale*:Experience and information in the literature on this measure are available and generally agree on its very low effectiveness to prevent secondary spread into new areas. |

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| **Prevention of secondary spread of the species** – measures for preventing the species spreading once they have been introduced (cf. Article 13 of the IAS Regulation). **This table is repeated for each of the prevention measures identified.** |
| **Measure description**Provide a description of the measure, and identify its objective | **Intensive trapping**Intensive trapping can be conducted to prevent spread of the species to neighbouring areas from the area of invasion. Different types of traps/devices are available, e.g. baited traps, fyke nets, ring nets, star traps, snare traps; for a complete review please see Eberhardt et al. (2016). These devices allow the animals to enter, but not to escape. Fyke nets (with or without leaders) seem to be efficient (Garcia-de-Lomas et al., 2010) and can be modified to avoid fish bycatch. Trapping is most effective during migration periods, by placing traps upstream (targeting juvenile migration) or downstream (targeting adult migration) of dams/weirs. Indeed, trapping success is highest in the vicinity of migration barriers, where animals accumulate during upstream migration in spring and downstream migration in autumn (Bouma & Soes, 2010; Eberhardt et al., 2016). It is suggested to set the traps on the bottom for a more efficient action (INBO, 2017); guidance systems could also be used to direct the specimens into the traps/devices or into fall buckets (INBO, 2017). Where possible (e.g. along dams/weirs), the lifting of the traps can be mechanised (INBO, 2017). In Garcia-de-Lomas et al. (2010), lines of fyke nets were set in water depths of 2–5 m on the bottom of the Guadalquivir estuary. Each line was composed of six fyke nets attached to each other. At each fishing station (n=15), four lines (total number of fyke nets = 24) were used. Nets were emptied every 48 h: this is the recommended frequency to allow the release of accidental captures of native species and prevent algae from clogging the nets. Furthermore, if nets are left unchecked for longer, Chinese mitten crabs can destroy the nets and escape. Trapping involves professionals and volunteers.Crayfish traps used for catching different crayfish species of Union concern can also catch Chinese mitten crab. Vice versa, traps used for crabs can also catch alien crayfish, fish, even coypu, sliders and frogs as bycatch (author’s pers. obs.). This measure can also be applied for early detection, rapid eradication (even if rapid eradication of the species has never been reported) and management of established populations.  |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | The scale of application is different, according to the water bodies or estuaries being targeted. Roughly, in Garcia-de-Lomas et al. (2010), each sampling station was 144 m2,and sampling stations were distributed along ca. 108 km. |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Effectiveness of measures*** | *Effective* |  | *Neutral*  | *X* | *Ineffective* |  | *Unknown* |  |

*Rationale*:Contrasting results are reported on trapping effectiveness. Caught crabs, especially during migration, could be mostly males, thus a bias in sex and size of trapped animals can be found (Eberhardt et al., 2016). Moreover, as for other IAS, a “boom and bust” phenomenon can be observed, so sometimes the effect of trapping activity cannot be proved (Garcia-de-Lomas et al., 2010). Traps can be a partly effective tool to keep the population at a low level, but cannot be the only measure to prevent spread, or eradicate, a population (Chinese Mitten Crab Working Group, 2003). |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | Trapping devices can be applied year-round (for example biweekly per month for detection; Abt Associates Inc, 2008), although trapping effort should increase during the spring and autumn migration, depending on the specific locations of the traps (Garcia-de-Lomas et al., 2010).  |
| **Resources required 1**e.g. cost, staff, equipment etc. | Costs include traps (and depend on the type of trap), bait, personnel to be involved to set and check the traps, and disposal of caught animals. The amount of required resources depends on the area of intervention. A cylindrical net trap for crayfish (90x30 cm) which, after modification, could be used for crabs, costs on average € 10 (author’s pers. obs.); a fyke net of around 6x1m (similar to those used by Garcia-de-Lomas et al. (2010)) can cost between € 440 and 800[[17]](#footnote-17). Bait is cheap, e.g. € 0.23 for cat food used in crayfish traps (author’s pers. obs.). Per year, the estimated cost of a dedicated person, plus travel to reach the sampling areas, could be around € 30,000 (author’s pers. obs.). |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- |
| ***Environmental effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |
| ***Social effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |
| ***Economic effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |

*Rationale*:Traps or nets have the potential to bycatch non-target species. However, as they are not lethal traps, non-target animals can be let out again, therefore limiting negative effects. The frequency of emptying the traps is also crucial to minimise this effect. As a positive environmental side effect, other IAS, such as crayfish and fish, could be trapped and removed. No social or economic side effects are reported.  |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- |
| ***Acceptability to stakeholders*** | *Acceptable* | *X* | *Neutral or mixed* |  | *Unacceptable* |  |

*Rationale*:Usually trapping is accepted by most stakeholders, as it is the friendliest capture method. |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | Intensity and cost may need to be increased in areas where the species spread may be expected (e.g. transboundary waters) and in areas of conservation concern. There are not enough data on cost-effectiveness, but for certain selected areas it could be important to use this measure. |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| *Inconclusive* |  | *Unresolved* |  | *Established but incomplete* |  | *Well established* | *X* |

*Rationale*:Trapping has been largely used for containment of various aquatic species, including the Chinese mitten crab. It can slow down the colonisation process and population spread, even if it cannot completely eradicate and manage a population.  |

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| **Surveillance measures to support early detection -** Measures to run an effective surveillance system for achieving an early detection of a new occurrence (cf. Article 16). 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 measure, and identify its objective | **Establish early detection networks**As the species can disperse through interconnected water systems from neighbouring countries or within a country, a network could be established to detect new populations. Networks may consist of watershed groups, volunteers, residents, anglers, commercial freshwater and marine fishermen, farmers, or civil servants (Chinese Mitten Crab Working Group, 2003). People involved in these activities can use traps or nets, permanent or not, left in strategical points (such as fish passages and hydropower facilities, where the animals can congregate during migration periods), or megalopa collectors on boats of marine fishermen (Falkingham et al., 2016). Water abstraction companies could also be involved and water samples could be collected for further eDNA analysis. This measure involves professionals, but mainly volunteers.This measure can also be used to detect other aquatic alien species of Union Concern.  |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | The scale depends on the area to monitor. High risk and high priority areas should be addressed first, designated based on previous sightings of crabs and the presence of vectors, as well as estuarine areas. |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Effectiveness of measures*** | *Effective* | *X* | *Neutral*  |  | *Ineffective* |  | *Unknown* |  |

*Rationale*:This measure has been suggested, but no data are present in the literature on its effectiveness. Nevertheless, it has been useful to detect new alien crayfish and fish species (author’s pers. obs.). In Italy, a network composed by beekeepers has proven effective in monitoring the spread of the Asian hornet, *Vespa velutina* *nigrithorax* (Lioy et al., 2019). Based on these experiences, we could expect this measure to be effective.  |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | Surveillance effort should be high, in order to have a high certainty of locating rare or recently arrived, and established, species. It can be applied year-round and be part of routine activities of the people involved in the network.  |
| **Resources required 1**e.g. cost, staff, equipment etc. | Personnel involved are usually mainly volunteers; sometimes, a sort of incentive could be provided or part of the equipment (e.g. traps, nets) could be paid for, to facilitate their participation. Dedicated professionals could also be employed.  |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Environmental effects*** | *Positive* | *X* | *Neutral or mixed* |  | *Negative* |  |
| ***Social effects*** | *Positive* | *X* | *Neutral or mixed* |  | *Negative* |  |
| ***Economic effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |

*Rationale*:No negative side effects are expected from this measure. On the contrary, as positive side effects, it can increase public awareness on the species and help detect other invasive aquatic species. |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- |
| ***Acceptability to stakeholders*** | *Acceptable* | *X* | *Neutral or mixed* |  | *Unacceptable* |  |

*Rationale*:The measure should not encounter any resistance.  |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | Costs of implementation for Member States vary according to the composition and number of people involved in the network. This measure is extremely helpful, as the extent of EU water bodies is vast, thus it is crucial to involve local people on their surveillance. Early detection is extremely important in eradication and management actions, thus the cost of inaction would be high. |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *Inconclusive* |  | *Unresolved* |  | *Established but incomplete* | *X* | *Well established* |  |

*Rationale*:This measure is recognised to be helpful for detecting new occurrences of species; published data are, however, scanty. |

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| **Surveillance measures to support early detection -** Measures to run an effective surveillance system for achieving an early detection of a new occurrence (cf. Article 16). 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 measure, and identify its objective | **eDNA monitoring**Traditional surveillance methods for aquatic taxa (e.g., traps, nets) can have low capture probabilities, making them reliable only for species that are moderately to highly abundant, or are sex and size-biased (Jerde et al., 2011). Genetic monitoring continues to grow in importance for a variety of conservation and management applications (Schwartz et al., 2007). Species surveillance using eDNA exploits an advantage of aquatic sampling that can aid in detection: the fact that the aqueous environment often contains microscopic bits of tissue in suspension (e.g., sloughed tissues or cells, larvae or adults that are microscopic, milt, eggs, extracellular DNA from degraded tissues, scales, and invertebrate exoskeletons). As a result, it is possible to sample DNA from even rare taxa that are present, but not detectable by traditional means (Egan et al., 2013). The eDNA method has been successfully developed and applied to Asian carp invasions in the USA (Jerde et al., 2011), alien crustaceans and molluscs in Europe (Blackman et al., 2018), and Chinese mitten crab in the USA (Egan et al., 2013).This method allows to monitor the species by collecting water samples. The content of an eDNA sample is analysed by amplification using polymerase chain reaction (PCR) and DNA sequencing. Professionals must perform the analysis, but water samples could also be collected by volunteers. One or multiple species can be detected using the specific primers (Egan et al., 2013; Blackman et al., 2018). This measure can also be used to detect other aquatic alien species of Union Concern, assuming the necessary primers are available. |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | The scale of application depends on the number of water bodies sampled; in some Member States, this could be large. |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Effectiveness of measures*** | *Effective* |  | *Neutral*  | *X* | *Ineffective* |  | *Unknown* |  |

*Rationale*:In a management context, there are two major advantages of eDNA methods over traditional methods: (i) increased sensitivity, that is, increased probability of detecting a species if it is present; and (ii) potentially lower costs, especially as eDNA methods increase in portability and automation (Egan et al., 2013). However, the detection ability varies among species due to differences in methods, environmental conditions, target species behaviour, population and the minimal threshold of DNA needed to positively confirm the presence of a target taxa (Ficetola et al., 2008; Egan et al., 2013; Furlan et al., 2016). The use of eDNA as a monitoring tool in freshwater systems is becoming increasingly acceptable and widely used for the detection of single species. Techniques are improving, so effectiveness of the measure will increase in the future.  |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | Surveillance effort should be high, in order to have high certainty of locating rare or recently arrived, and established, species. It can be applied year-round (for example monthly) and water samples can be collected also by people involved in the network of surveillance. |
| **Resources required 1**e.g. cost, staff, equipment etc. | Costs include dedicated personnel, laboratory consumables, and dedicated equipment (e.g. PCR). The technique is improving, thus costs are decreasing. According to Zogaris (2017), “setting up the lab (PCR equipment etc) would cost a minimum of € 20,000, while c. €30,000 could be estimated for operational costs (€24,000 personnel and travel + €6,000 lab consumables), referring to six months development, 12 months sampling campaign and six months for 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”. However, the involvement of people from the network mentioned above could lower the cost for travel to collect water samples.  |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| --- | --- | --- | --- | --- | --- | --- |
| ***Environmental effects*** | *Positive* | *X* | *Neutral or mixed* |  | *Negative* |  |
| ***Social effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |
| ***Economic effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |

*Rationale*:No negative side effects on biodiversity or human health are expected. As a positive effect, this method could allow to detect other aquatic invasive species or rare native species. |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Acceptability to stakeholders*** | *Acceptable* | *X* | *Neutral or mixed* |  | *Unacceptable* |  |

*Rationale*:The measure does not encounter any resistance.  |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | The costs depend on the number of samples collected per Member State. Early detection is crucial for aquatic species, and eDNA is becoming more useful in detecting low abundant alien species, usually less detected by traditional methods, thus making the cost of inaction high. |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

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| *Inconclusive* |  | *Unresolved* |  | *Established but incomplete* | *X* | *Well established* |  |

*Rationale*:The use of this measure to detect alien species is becoming more popular and there is a consensus that it should be used much more in the future. However, the technique is still under development, so some thresholds have yet to be agreed and set.  |

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| **Surveillance measures to support early detection -** Measures to run an effective surveillance system for achieving an early detection of a new occurrence (cf. Article 16). 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 measure, and identify its objective | **Develop a citizen science program**Managing biological invasions depends on accurate, detailed and up-to-date information on occurrences, distribution, pathways and impact of invasive alien species at varying spatial scales across Europe. There are several ways in which this information can be gathered, but increasingly citizen science is seen as essential to ensure the spatial and temporal resolution of data capture, allowing for rapid response and the success of prevention and management programs (Roy et al., 2018). Advances in technology, particularly on-line recording and smartphone apps, along with the development of social media, have revolutionised citizen science and increased connectivity, while new and innovative analysis techniques are emerging to ensure appropriate management, visualisation, interpretation, use and sharing of the data (Roy et al., 2018). The Joint Research Centre of the European Commission has developed a dedicated smartphone app for recording species of Union concern; thus, data provided by citizens is sent directly to the competent authority, which can help to detect species at an early stage of invasion. Other species of Union concern can be detected by citizens using that app.  |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | The scale is wide and can cover all the aquatic systems of national territories. |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Effectiveness of measures*** | *Effective* | *X* | *Neutral*  |  | *Ineffective* |  | *Unknown* |  |

*Rationale*:There is much evidence confirming the effectiveness of this measure: through citizen science, different nests of the Asian hornet, *Vespa velutina*, have been detected in the UK (H. Roy, pers. comm., 2019), as well as many first records for freshwater and marine alien species also in Europe (Azzurro et al., 2013; Zenetos et al., 2013; Andaloro et al., 2016; Miyazaki et al., 2016; Giovos et al., 2018).The first confirmed record of Chinese mitten crab along the entire eastern USA, from Florida to Maine, was in Chesapeake Bay near Baltimore, Maryland, in 2005. This initial crab was reported by a commercial crabber[[18]](#footnote-18).  |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | This measure should be applied indefinitely.  |
| **Resources required 1**e.g. cost, staff, equipment etc. | Most citizens have a smartphone, and the apps are already developed. Potential costs are related to maintaining and updating the apps: maintenance can vary between 15 to 20% of app’s development price[[19]](#footnote-19). For example, as reported by Adriaens et al. (2015), an app developed by the RINSE project costed 20,262 €, so a rough estimate of maintenance costs could be between 3000 and 4000 € per year. Costs of people screening, validating and managing the collected data should be included: a part-time position could be sufficient, with personnel managing data collected also on other species targeted by the citizen science initiative (the cost of the position depends on labour costs of Member States[[20]](#footnote-20): in 2018, in the EU, the average hourly labour cost was 27.4 €). |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Environmental effects*** | *Positive* | *X* | *Neutral or mixed* |  | *Negative* |  |
| ***Social effects*** | *Positive* | *X* | *Neutral or mixed* |  | *Negative* |  |
| ***Economic effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |

*Rationale*:There are no negative effects of this measure. As positive consequences, citizen science can play a significant role in public engagement, improved education and public awareness, and is recognised as fundamental to the attainment of the objectives of alien species policies (Roy et al., 2018). Moreover, new alien or native species can be detected. |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Acceptability to stakeholders*** | *Acceptable* | *X* | *Neutral or mixed* |  | *Unacceptable* |  |

*Rationale*:The measure does not encounter any resistance. |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | This measure is very cost effective, the method is very friendly and appreciated by the public, thus the cost of inaction would be high. |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

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| *Inconclusive* |  | *Unresolved* |  | *Established but incomplete* |  | *Well established* | *X* |

*Rationale*:The importance of citizen science programs for invasive alien species management is widely recognised (Roy et al., 2018). New programs and apps are being developed, showing the popularity of this measure.  |

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| **Rapid eradication for new introductions** - Measures to achieve eradication at an early stage of invasion, 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, and identify its objective | **Integrated Pest Management (IPM)**Aquatic IAS are very difficult to manage, and usually the combination of different techniques is recommended to achieve good results (Gherardi et al., 2011). Eradication is even more challenging, and could be contemplated only in a closed system. A combination of intensive trapping with temporary fences/barriers along the area of intervention to delimit it could be designed to eradicate the species at an early stage of invasion. Use of diversion and pitfall traps can also be considered (Chinese Mitten Crab Working Group, 2003). Drainage of water bodies cannot be considered, as this species can walk overland, and considerable negative side effects on non-target species can result from this. Chemical methods have never been tested. Similarly, no biological control specific to Chinese mitten crab is known. Thus, only the combination of mechanical (traps) and physical (barriers, diversion) methods can be considered. This measure can also be applied for management of established populations. |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | The scale of application depends on the size of the selected water body for eradication. However, no data on eradication of the species are available. |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Effectiveness of measures*** | *Effective* |  | *Neutral*  |  | *Ineffective* | *X* | *Unknown* |  |

*Rationale*:Up to now, eradication of the species has never been achieved. In the USA, a pilot project to evaluate the feasibility of capturing adult crabs via a diversion and pitfall trap during fall downstream migration was conducted. Success of this method was very high, with an estimated 11,000 crabs captured on one small creek during a 6-week period, with 85% of the crabs caught in less than 3 weeks (Chinese Mitten Crab Working Group, 2003); however, eradication of the species was not achieved. Hence, for now, this method is considered as ineffective for eradication (with the possible exception of very intense IPM at a very early stage of introduction), but it can give good results for the control of Chinese mitten crab’s populations. |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | A long time is required to achieve an eradication; moreover, a post-intervention verification is needed to confirm it (the use of eDNA can be considered) and a monitoring system should be set to avoid a reintroduction. When using IPM for the control of an established population, the measure should be applied indefinitely. |
| **Resources required 1**e.g. cost, staff, equipment etc. | Costs are related to the different techniques applied (traps with bait/barriers/diversion), the personnel involved in the eradication, the disposal of caught animals, and eventually the use of eDNA to confirm eradication. A cost of more than € 120,000 during the first year, decreasing the subsequent years, has been estimated (Kelly & Maguire, 2009). |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Environmental effects*** | *Positive* |  | *Neutral or mixed* |  | *Negative* | *X* |
| ***Social effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |
| ***Economic effects*** | *Positive* |  | *Neutral or mixed* |  | *Negative* | *X* |

*Rationale*:Traps and barriers can impact native non-target species, thus frequent checks are required to avoid this. An impact on species of fisheries interest might occur. |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Acceptability to stakeholders*** | *Acceptable* |  | *Neutral or mixed* | *X* | *Unacceptable* |  |

*Rationale*:The possible impacts on native species (especially on species of fisheries interest) can elicit concern to some stakeholders.  |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | Cost-effectiveness of this measure for eradicating the species seems to be low due to high costs. However, it can be applied to manage the species, limiting its spread. The cost of inaction would be high, because the species would then spread, causing increased impacts. |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

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| *Inconclusive* | *X* | *Unresolved* |  | *Established but incomplete* |  | *Well established* |  |

*Rationale*:Eradication of this species has never been reported, so there is no agreement on this measure as an eradication technique. It can, however, be used for managing the species. |

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| **Management**- Measures to achieve management of the species once it has become widely spread within a Member State, or part of a Member State’s territory. (cf. Article 19), i.e. **not** at an early stage of invasion (see Rapid eradication table above). These measures can be aimed at eradication, population control or containment of a population of the species. **This table is repeated for each of the management measures identified.** |
| **Measure description**Provide a description of the measure, and identify its objective | **Commercial use**As adult crabs are highly valued food, Chinese mitten crabs can be introduced through illegal importation or intentional release to establish a commercial fishery for human consumption (Chinese Mitten Crab Working Group, 2003). An economic incentive, or even selling the specimens caught with traps, has been evaluated as a management option. For example, in 1998, live mitten crabs were available for sale in seafood markets of New York City’s Chinatown, fetching up to $ 40/pound (Chinese Mitten Crab Working Group, 2003). Illegal individuals sold in Italy can attain a price of € 50-80/kg (author’s pers. obs.). This measure involves mainly fishermen.While catching crabs for selling, other IAS can also be trapped, such as crayfish and fish. |
| **Scale of application**At what scale is the measure applied? What is the largest scale at which it has been successfully used? Please provide examples, with areas (km2 or ha) if possible. | The main invaded areas can be the target area of intensive fishing, in order to decrease species abundance. |
| **Effectiveness of the measure**Is it effective in relation to its objective? Has the measure previously worked, failed?Please select one of the categories of effectiveness (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Effectiveness of measures*** | *Effective* |  | *Neutral*  | *X* | *Ineffective* |  | *Unknown* |  |

*Rationale*:Commercialisation can reduce species abundance with minimal cost (Eberhardt et al., 2016). However, an experimental trial in Belgium, in Beneden-Zeeschelde area, from winter 2013-2014 to winter 2015-2016, showed that catch rates were highly variable and did not lead to a decrease in species population numbers or to an economic yield (INBO, 2017). |
| **Effort required**e.g. period of time over which measure needs to be applied to have results | This measure should be implemented indefinitely. However, the effort for promoting the commercial use of the species will need to be done for a limited period of time (ca. a couple of years) and, when its commercial use is established to both fishers and consumers, no more such effort will be needed. |
| **Resources required 1**e.g. cost, staff, equipment etc. | This measure would require minimal, or no, costs, which would be essentially for promoting the commercial use of the species (through advertisements, training fishers, informing consumers etc). |
| **Side effects (incl. potential) – both positive and negative**i.e. positive or negative side effects of the measure on public health, environment including non-targeted species, etc.For each of the side effect types please select one of the impact categories (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Environmental effects*** | *Positive* |  | *Neutral or mixed* |  | *Negative* | *X* |
| ***Social effects*** | *Positive* |  | *Neutral or mixed* | *X* | *Negative* |  |
| ***Economic effects*** | *Positive* | *X* | *Neutral or mixed* |  | *Negative* |  |

*Rationale*:There are many negative side effects of this measure. Smaller crabs are less marketable, so may not be effectively controlled (Eberhardt et al., 2016). In addition, it may increase the risk of spread (both intentionally and unintentionally). Promoting the species for its economic value may decrease understanding of the need for their control (Eberhardt et al., 2016). Finally, public health implications are unclear, e.g., bioaccumulation of contaminants or pathogens present in the species: Chinese mitten crab is the second intermediate host for human lung fluke parasite, *Paragonimus westermanii* in Asia (Gollasch, 2011).There would be a positive economic side effect related to an economic incentive or to selling caught specimens.According to EU Regulation 1143/2014, art. 19 “The commercial use of already established invasive alien species may be temporarily allowed as part of the management measures aimed at their eradication, population control or containment, under strict justification and provided that all appropriate controls are in place to avoid any further spread”. As such, the use of this measure should be carefully evaluated, case by case. |
| **Acceptability to stakeholders**e.g. impacted economic activities, animal welfare considerations, public perception, etc.Please select one of the categories of acceptability (with an ‘X’), and provide a rationale, with supporting evidence and examples if possible. |

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| ***Acceptability to stakeholders*** | *Acceptable* | *X* | *Neutral or mixed* |  | *Unacceptable* |  |

*Rationale*:The measure should not encounter any resistance from stakeholders; they may promote it as an increased economic resource. |
| **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 aspectsInclude quantitative &/or qualitative data, and case studies (incl. from countries outside the EU). | In some cases, this measure could be the only technique for controlling the species, thus cost of inaction would be high.  |
| **Level of confidence on the information provided 2**Please select one of the confidence categories along with a statement to support the category chosen. See *Notes* section at the bottom of this document.**NOTE – this is not related to the effectiveness of the measure** |

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| *Inconclusive* |  | *Unresolved* | *X* | *Established but incomplete* |  | *Well established* |  |

*Rationale*:There is a strong debate about the use of invasive species for human consumption due to the possible negative side effects[[21]](#footnote-21),[[22]](#footnote-22); however, in some cases, it could be the only solution to reduce populations (when no other measures are successful, or possible, and populations should be controlled). |

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| **Bibliography** **3**See guidance section |
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**Notes**

**1. Costs information.** The assessment of the potential costs shall describe those costs quantitatively and/or qualitatively depending on what information is available. This can include case studies from across the Union or third countries.

**2. Level of confidence[[23]](#footnote-23):** based on the quantity, quality and level of agreement in the evidence.

|  |  |  |
| --- | --- | --- |
|  |  | * **Well established**: comprehensive meta-analysis[[24]](#footnote-24) or other synthesis or multiple independent studies that agree.
* **Established but incomplete**: general agreement although only a limited number of studies exist but no comprehensive synthesis and/or the studies that exist imprecisely address the question.
* **Unresolved**: multiple independent studies exist but conclusions do not agree.
* **Inconclusive**: limited evidence, recognising major knowledge gaps
 |

**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)

1. <http://www.imo.org/en/OurWork/Environment/BallastWaterManagement/Pages/BWMTechnologies.aspx> [↑](#footnote-ref-1)
2. <http://www.imo.org/en/About/Conventions/StatusOfConventions/Pages/Default.aspx> [↑](#footnote-ref-2)
3. [https://www.ballastwatermanagement.co.uk/news/view,counting-the-cost-of-ballast-treatment\_42146.htm](https://www.ballastwatermanagement.co.uk/news/view%2Ccounting-the-cost-of-ballast-treatment_42146.htm) [↑](#footnote-ref-3)
4. [http://www.imo.org/en/OurWork/Environment/Biofouling/Documents/RESOLUTION%20MEPC.207[62].pdf](http://www.imo.org/en/OurWork/Environment/Biofouling/Documents/RESOLUTION%20MEPC.207%5B62%5D.pdf) [↑](#footnote-ref-4)
5. http://www.imo.org/en/OurWork/Environment/Anti-foulingSystems/Pages/Default.aspx [↑](#footnote-ref-5)
6. http://www.imo.org/en/OurWork/Environment/MajorProjects/Pages/GloFouling-Project.aspx [↑](#footnote-ref-6)
7. http://www.imo.org/en/OurWork/Environment/Biofouling/Documents/MEPC.1-Circ.792.pdf [↑](#footnote-ref-7)
8. https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/vp.2019.01.pdf [↑](#footnote-ref-8)
9. <https://rm.coe.int/1680746815> [↑](#footnote-ref-9)
10. http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=ECOTEC\_Clean\_Ship\_Hulls\_and\_Ports.pdf [↑](#footnote-ref-10)
11. <http://www.nonnativespecies.org/checkcleandry/> [↑](#footnote-ref-11)
12. https://www.cbsm.com/cases/22699-the-check-clean-dry-campaign [↑](#footnote-ref-12)
13. https://www.cbsm.com/cases/22699-the-check-clean-dry-campaign [↑](#footnote-ref-13)
14. http://www.nonnativespecies.org/index.cfm?sectionid=140 [↑](#footnote-ref-14)
15. https://www.cbsm.com/cases/22699-the-check-clean-dry-campaign [↑](#footnote-ref-15)
16. https://www.bbc.com/news/uk-scotland-south-scotland-13964184 [↑](#footnote-ref-16)
17. <https://collinsnets.co.uk/product/1-mtr-high-large-fyke-nets> [↑](#footnote-ref-17)
18. https://www.scientificamerican.com/citizen-science/mitten-crab-watch/ [↑](#footnote-ref-18)
19. https://gbksoft.com/blog/how-much-does-it-cost-to-maintain-an-app/ [↑](#footnote-ref-19)
20. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Wages\_and\_labour\_costs [↑](#footnote-ref-20)
21. https://www.scientificamerican.com/article/can-we-really-eat-invasive-species-into-submission/ [↑](#footnote-ref-21)
22. https://ensia.com/voices/why-eating-invasive-species-is-a-bad-idea/ [↑](#footnote-ref-22)
23. Assessment of confidence methodology is taken from IPBES. 2016. Guide on the production and integration of assessments from and across all scales (IPBES-4-INF-9), which is adapted from Moss and Schneider (2000). [↑](#footnote-ref-23)
24. A statistical method for combining results from different studies which aims to identify patterns among study results, sources of disagreement among those results, or other relationships that may come to light in the context of multiple studies. [↑](#footnote-ref-24)