GOOD PRACTICE MANAGEMENT

Zebra mussel (*Dreissena polymorpha*)

RAPID

Reducing and Preventing
Invasive Alien Species Dispersal

GOOD PRACTICE MANAGEMENT GUIDE

Zebra mussel (*Dreissena polymorpha*)

ID guides and more information:

https://caseagrant.ucsd.edu/publication/early-detection-monitoring-manual-for-quagga-and-zebra-mussels

https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=365

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Version 1: September 2018

MANAGEMENT SUMMARY

Ecology and impact of zebra mussel

Zebra mussels are freshwater sessile molluscs native to Eastern Europe and are a brownish-yellow colour with characteristic banding. They have spread widely throughout Europe and the Eastern part of North America, transported in ballast water. Eggs and swimming larvae (veligers) have been further spread by water flow, bait buckets, engine cooling water and by other transfer of water from infested waterbodies. Zebra mussels typically live 3-5 years, but can live as long as 15 years. Female zebra mussels may produce over one million eggs per spawning season. Larvae can drift for 3-4 weeks and travel up to 300km before settling and attaching on any hard substrate including pilings, rocks, pipes, piers, boats, aquatic plants, and the shells of other molluscs.

This species of mussel filters water for feeding and respiration, reducing available nutrients and oxygen in their surrounding environment. Particles which are not consumed are discarded as pseudofaeces, and thus are not re-suspended in the water column. This filtering increases clarity of the water resulting in increased productivity of aquatic vegetation and shifting the flow of energy in the aquatic system to the lower (benthic) areas of the waterways. Zebra mussels outcompete native mussels and create large reef-like colonies that can reduce spawning of fish and affect recreational and commercial fisheries. Economic impacts of zebra mussels have been immense due to biofouling of intake pipes, filters and turbines in industrial and public facilities. Some utilities have been shut down due to zebra mussel fouling (Connolly et al., 2007; ENSR, 2005).

Effective management: summary

Regular manual removal of zebra mussels in Lake George, New York reduced the population of zebra mussels to a level considered to be no longer self-sustaining (Nierzwicki-Bauer et al, 2012; Wimbush, et al., 2009). Achieving this level of removal can be difficult if there are hard-to-reach areas where larval or juvenile mussels can escape removal. Zebra mussels were successfully eradicated from Milbrook Quarry, Virginia by infusing the entire quarry with 174000 litres of potassium chloride (KCl) solution over a 3 week period, and there was deemed to be little effect on other aquatic species (Fernald and Watson, 2014). This technique would normally only be used for very dense infestations where more benign options are no longer feasible.

MANAGEMENT METHODS

Chemical

Potassium chloride (KCl)

Potassium chloride (KCl) is the only chemical successfully used to eradicate zebra mussels while not harming other species. A target concentration of KCl must remain present in the water for a certain amount of time depending on water temperature and the life stage of the mussels in the system.

Method: A small watercraft equipped with a diffuser system can be utilised to apply the pre-determined amount of KCl to the water body to reach an effective potassium concentration. In Millbrook Quarry, KCl was dispensed at the surface and at a depth of 10 feet (3 meters) to achieve the target chemical concentration throughout the entire water body. In water bodies with less efficient mixing, it may be necessary to add chemicals at additional depths to ensure the target concentration is achieved throughout the water column. Monitor the chemical levels throughout the infusion process by sampling water to ensure target concentration levels are met and maintained. Re-apply KCl as needed to maintain target potassium concentration, monitoring the status after each application (Sea Grant California, 2013).

Potential equipment requirements (excluding PPE):
Land-based storage tanks and pump system. Work boat outfitted with liquid diffuser system. Floating pipeline. Dive equipment for pre- and post-monitoring. Water quality sampling kit.

Most suitable situation for method:
System-wide application of KCl is typically considered when the mussel infestation is dense and widespread and other more benign tactics are no longer options. Due to the costs and potential environmental impacts of the widespread application of chemicals, including KCl, such application is best used for eradication and not a long-term control measure. Broad application of KCl works best when lakes/reservoirs have no, or very little, flow-through that would increase dissipation of the chemical. KCl can also be added under tarps (see oxygen deprivation) to speed up the process.

MANAGEMENT METHODS

Manual

Hand removal

Removal by hand or using another mechanical method is an effective control method and can potentially eradicate mussels under certain conditions.

Method: Divers remove mussels by hand or using tools such as paint scrapers, screwdrivers, chisels and knives. Mussels must be removed from crevices and holes as well as more accessible areas. Mussels must be collected in bags and taken away and not allowed to float away or to the bottom of the waterbody as they are likely to survive. Underwater suction pumps can be used to help with removal of detached mussels. Removed mussels must then be killed by freezing in bags for 24 hrs, exposing to temperatures above 40°C, or desiccation in a biosecure unit.

Potential equipment requirements (excluding PPE):
Scuba gear including gloves and head torch. Dive bags to hold tools. Mussel collection bags such as sealable plastic bags or fine mesh bags. Tools such as paint scrapers, screwdrivers, chisels, dull knives. If using underwater suction pump, then underwater suction pump and fuel.

Most suitable situation for method:
The structure to which the mussels are attached must lend itself to this method as possibly damage can be done by scraping. Manual/mechanical removal can potentially eradicate zebra mussels if the mussels are concentrated in a particular area, no additional larval or juvenile mussels are entering the system, and enough mussels are removed to reduce the population to a level at which it is no longer self-sustaining. Where there are inaccessible areas, a combination of different methods may be required.

MANAGEMENT METHODS

Mechanical

High-pressure water guns

There are a number of different commercial high-pressure waterjet systems with different cleaning rates.

Most suitable situation for method:
These systems are most effective in deep waterbodies where the detached mussels will sink into depths where there is extremely low oxygen content (dissolved oxygen <2mg/l) and only when these low oxygen conditions will persist as zebra mussels can survive for over a month without oxygen. Repeatedly using this method could affect water quality if there are large amounts of decomposing mussels. If mussels are removed, they should either be frozen in bags for at least 24 hours or exposed to hot water over 40^{o}C (Sea Grant California, 2013).

Constraints: The high pressure water jetting gun is a potentially dangerous tool that can cut through skin and bone. All divers using such equipment must be properly trained in its use (Scuba Diving Chicago, 2018).

Environmental

Oxygen deprivation

Method: Oxygen deprivation by covering with tarpaulins or benthic mats. Tarps can be installed over mussels by divers and weighed down on lake bottoms or wrapped around rocks or structures such as pylons. Covers should be left for at least a month. Potassium chloride can be applied under the tarp to or wood shavings have been used to absorb oxygen. Both these treatments will decrease the amount of time the covers must remain in place. It may be necessary to limit the use of the waterbody while the tarps are in use to prevent damage or movement. Covers should be checked regularly during this time. After a suitable amount of time, the tarps can be removed and the areas checked for surviving mussels. If mussels remain alive, replace the tarp and continue treatment (Sea Grant California, 2013).

MANAGEMENT METHODS

Environmental (cont)

Potential equipment requirements (excluding PPE):
Sheets of non-gas-permeable PVC or plastic tarps, or black pond liners at least 20 mm thick. Sandbags, bags of gravel, rocks, or rebar to weigh down tarp. Boat to aid with deploying tarp. Dissolved oxygen loggers to measure oxygen levels under tarp could be useful.

Most suitable situation for method:
Low to moderate site-specific infestations. This method targets juvenile and adult mussels, not larval stages.

Ineffective, unavailable or untested methods

Biological

Zequanox© is a biological product developed specifically to control invasive zebra and quagga mussels, derived from a microbe *Pseudomonas fluorescens*. It has been shown to be highly lethal to zebra and quagga mussels without harming humans, infrastructure, non-target species, or the environment (Molloy et al., 2013). It is registered in parts of the US for site-specific applications. However, the active substance has not been supported for review as a biocide under the EU Biocidal Products Regulation, and as such cannot be marketed or used in the UK at the current time. For more information on the product, see Marrone Bio Innovations.

Fish predation

Several fish species feed on various life stages of mussels, but most of the fish, such as redear sunfish (*Lepomis microlophus*), common carp (*Cyprinus carpio*) and pumpkinseed (*Lepomis gibbosus*) are non-native to the UK, though the redear is not considered a nuisance species (CABI, n.d.). The redear has been effectively deployed for quagga mussel, but it appears that as a biocontrol agent for zebra mussels it has been considered likely to be unsuccessful due to the zebra mussels' prolific reproduction rates (Magoulick and Lewis, 2002).

MANAGEMENT METHODS

Ineffective, unavailable or untested methods (cont)

Biological (cont)

Roach (*Rutilus rutilus*) are UK natives and will feed on both juvenile and adult mussels, but the fish must be relatively large (>220mm) to be effective (Prejs, et al., 1990). Fish could be used for site-specific control by using cages to achieve higher fish densities, but are unlikely to eliminate mussels, only reduce numbers (US Department of the Interior, 2014). For example, mussel infestations on docks, water towers, or irrigation canals may potentially be controlled by caging fish around structures or in canals (Sea Grant California, 2013). However, these methods are still being researched and have not been tested in the UK. In addition to this, increased fish densities could also cause negative environmental impacts of their own, such as eutrophication.

Mechanical

Pulse pressure technology introduces electrical energy between two submerged electrodes which produces an intense shockwave, a steam bubble, and ultraviolet light. The technology is in use in Canada and the United States in pipelines in industrial settings. While the technology has been used since the 1990s, production of efficient and effective technology is still undergoing development and testing (Louma et al, 2017; Mackie et al., 2000). Results indicate that pressure pulses can eradicate adult zebra mussels and prevent the settlement of veligers (Schaefer, et al., 2010). Because of the nature of the equipment, this technology is most cost-effective in smaller scale or industrial settings, especially where chemical discharge would not be acceptable. There is no literature or guidance on the use of this technology in the UK at this time.

Environmental

Mussels have a relatively narrow range of pH tolerance, with the optimum from 7.5 to 9.3. Research is ongoing to determine if manipulating the pH could prove to be an effective control strategy or a preventative measure in small cooling water systems or aqueducts (Claudi, et al., 2012).

Preventing spread

Divers and boat operators must decontaminate themselves and all gear after being in contact with zebra mussel-infested waters, to prevent the spread of mussel larva or juveniles to other waterbodies. Boats should be cleaned thoroughly and gear should be washed and then dried according to the Clean, Check Dry procedure, treated with hot water (>40°C), or placed in a freezer to ensure no larvae are present. See California Department of Fish and Wildlife decontamination protocol.

Use of anti-fouling coatings on boats can help minimise spread, but boats will still require cleaning. In a test of 100 materials, the U.S. Department of the Interior found that Jotun SeaLion Resilient silicone epoxy coating was the most effective. Mussels did attach weakly, but were easily removed with washing at low water pressure (U.S. Dept of Interior, 2015).

Legislation

The 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediment came into force in September 2017 and aims to address the issue of transport of INNS in ballast water. The European Marine Strategy Framework Directive (MSFD) requires Member States to work towards 'good environmental status' (GES) of their marine waters by 2020, including reduction in the risk of introduction and spread of non-native species through improved management and species specific management plans for high risk invasive species. The EU Invasive Alien Species regulation (2015) requires that pathway action plans be put in place to control the introduction and spread of listed species (as of 2018, the only marine species listed is the Chinese Mitten Crab).

Health and Safety

The link below is to a useful webpage on the GBNNSS website which provides resources and guidance on health and safety when planning a project working with invasive species:

http://www.nonnativespecies.org/index.cfm?pageid=266

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Reducing and Preventing Invasive Alien Species Dispersal

Where To Go For More Information

http://www.europe-aliens.org/
http://www.nonnativespecies.org/home
http://www.nonnativespecies.org/rapid
http://www.nonnativespecies.org/factsheet/factsheet.cfm?speciesId=1250

RAPID

RAPID is a three year EU funded LIFE project led by the Animal and Plant Health Agency (APHA), with Natural England and Bristol Zoological Society as key partners that piloting innovative approaches to Invasive Alien Species (IAS) management in freshwater aquatic, riparian and coastal environments across England. The project is supported by a number of further Technical Partners.

http://www.nonnativespecies.org/rapid

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