



The management of golden mussel (*Limnoperna fortunei*)




Measures and associated costs

Limnoperna fortunei is native to China but has been accidentally introduced to South America and several countries in Asia.

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Scientific name(s)	<i>Limnoperna fortunei</i> Dunker (1857)
Common names (in English)	Golden mussel
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Date of completion	30/09/17
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Measures for preventing the species being introduced, intentionally and unintentionally.

This section assumes that the species is not currently present in a Member State, or part of a Member State's territory.



Managing the Pathway 1.

MEASURE DESCRIPTION

Ships originating in South-east Asia and South America, with ballast water tanks, should ideally discharge treated ballast water in open sea before entering European ports. The international Maritime Organisation's ballast water convention entered into force on September 8th, 2017 and will minimize the risk of invasions by alien species via ballast water (IMO.org). Under the Convention, all ships in international traffic are required to manage their ballast water and sediments to a certain standard, according to a ship-specific ballast water management plan. All ships will also have to carry a ballast water record book and an international ballast water management certificate. The ballast water management standards will be phased in over a period of time. As an intermediate solution, ships should exchange ballast water mid-ocean. However, eventually most ships will need to install an on-board ballast water treatment system. Article 6 Scientific and Technical Research and Monitoring calls for Parties individually or jointly to promote and facilitate scientific and technical research on ballast water management; and monitor the effects of ballast water management in waters under their jurisdiction (www.imo.org).

This is a broad issue which involves not just *Limnoperna* but prevention of the introduction of all IAS in ballast water discharges.

ADDITIONAL COST INFORMATION

The cost will be borne by the shipping companies. Ballast water management systems can cost up to US \$5 million/ship with running costs of up to 2–3% of total operational costs for maintenance and management of chemical, filtration units or UV ballast water treatment systems (<http://www.ballastwatermanagement.co.uk>). Discharge in open seas may not always be possible due to geography or Health and Safety (ship instability). Compliance with the biological standard of the Convention, realized through application of chemical oxidants favour the formation of potentially toxic disinfection by-products, which has so far been insufficiently investigated in marine waters and could impact environmental and public health protection (Werschkun *et al.*, 2014). Potential conflict with EU Directives (for example, Marine SFD) or challenges by stakeholders.

Efficiencies of various technologies utilised for ballast water treatment are reviewed in Tsolaki and Diamadopoulos (2009) with >70% effectiveness for filtration of zebra mussel (proxy for *Limnoperna*) and >90% effectiveness for chemical treatments of zooplankton (proxy). Use of saline water in ballast tanks could be a very simple way to prevent further expansion of *Limnoperna* (Claudi and Oliveira, 2015).

LEVEL OF CONFIDENCE¹

Medium.



Managing the Pathway 2.

MEASURE DESCRIPTION

Increasing public awareness. Education and outreach programmes could be effective in prevention of introduction of *Limnoperna* as contaminants with freshwater bivalves and aquatic plants (see Risk Assessment - RA) to waterways.

ADDITIONAL COST INFORMATION

Education and outreach on IAS to broad audiences (school children to elderly) has been implemented in Member States

via various agencies (such as Inland Fisheries Ireland) and projects, for example, EU LIFE (Mulkearlife.com) to prevent introduction of IAS. It is difficult to measure the long-term effectiveness of these programmes. These are broadscale and not specific to *Limnoperna fortunei*.

LEVEL OF CONFIDENCE¹

Medium.

¹ See Appendix

Measures to achieve rapid eradication after an early detection of a new occurrence.



Effective surveillance and reporting.

MEASURE DESCRIPTION

Freshwater monitoring programmes and other sampling by researchers for plankton and macroinvertebrates can provide early warning of the arrival of *Limnoperna*. Larval densities are often 6,000 ind./m³ during the reproductive season (Boltovskoy *et al.*, 2015), which would be during summer in Europe. Adults occurring in densely packed clusters would also be easily identifiable, once distinguished from Dreissenids and might also be reported by the public in areas where water levels may lower. Encouraging rapid reporting of new incursions increases the likely success of rapid response before the species can become established.

ADDITIONAL COST INFORMATION

The following methods may be suitable for surveillance and monitoring in the EU. Vertical, horizontal and oblique

tows using plankton nets (64 µm) are effective for larval sampling. Adults may be collected by vertical scrapers (Minchin *et al.*, 2002) or collected using pond nets or by snorkel/dive surveys. Also citizen-science species occurrence datasets are increasingly recognized as a valid tool for monitoring the occurrence and spread of invasive species across large spatial and temporal scales (Roy *et al.*, 2015).

Costs are covered by existing sampling programmes and by voluntary academic or citizen-science programmes.

LEVEL OF CONFIDENCE¹

Medium.



Biological control.

MEASURE DESCRIPTION

Biological control methods have been used in a water transfer pipeline in Guangdong Province, China using cultured fishes (Boltovskoy *et al.*, 2015). Introducing cyprinid fish stocks to infested waters within the same MS could affect predation on *Limnoperna*.

ADDITIONAL COST INFORMATION

Cyprinidae have pharyngeal teeth and are known predators of freshwater molluscs including Dreissenids in native and invaded waters (Molloy *et al.*, 1997). However, despite the presence of high stocks, they have not been effective at eradicating *Dreissena* from invaded Irish lakes (Millane *et al.*, 2012). Bivalve shellfish, while consumed by generalist fish feeders are not preferentially selected (Millane *et al.*, 2012). It is considered that this method would be ineffective for eradication of *Limnoperna*, even if fish stocks were increased.

LEVEL OF CONFIDENCE¹

High.



Golden mussel colony on a tree trunk. © Boltovskoy. CC BY-SA 4.0.

¹ See Appendix



Mechanical removal.

MEASURE DESCRIPTION

Mechanical removal could be used to remove *Limnoperna* in a very localised population, for example, a boat jetty. This could be by scraping (Minchin *et al.*, 2002) or by hand removal.

ADDITIONAL COST INFORMATION

It is unlikely that a discovered population in a waterbody, is existing in isolation. It is more likely to be a metapopulation of a more wide-ranging spread of establishment (Boltovskoy

et al., 2015; Ito, 2015). Therefore, this method is unlikely to affect eradication.

Cost for dive operation/day = 1,200 euro (3 divers – Irish costs)

LEVEL OF CONFIDENCE¹

High.



Physical and chemical methods.

MEASURE DESCRIPTION

Physical and chemical methods have been designed to control *Limnoperna* on man-made structures in industrial facilities. These include dessication, oxygen deprivation, ozonation, and thermal treatment (Boltovskoy *et al.*, 2015) and various chemical methods (Claudi and Oliveira, 2015)

The physical and chemical methods have been designed to control *Limnoperna* on man-made structures in industrial facilities and cannot be used for eradication of the species

in open waters in the wild. It is possible that one of the methods could be used for rapid response if a population was isolated in a very small part of a waterbody, that could be surrounded by watertight booms, such as a docking area, or if a population was found in a very small water body, for example, a pond.

LEVEL OF CONFIDENCE¹

Low.

¹ See Appendix

Measures for the species' management.



Control strategies in industrial settings.

MEASURE DESCRIPTION

Chemical Controls (Claudi and Oliveira, 2015)

All the management methods described here are for use to remove fouling and manage *Limnoperna* populations in localised industrial settings (Boltovskoy *et al.*, 2015)

- pH adjustment
- MXD-100
- Ozone
- Chlorine dioxide
- Chlorine
- Potassium chloride
- Clam-Trol CT-2/Spectrus CT1300
- Bulab 6002
- Didecyl Dimethyl Ammonium chloride
- Bayluscide
- Veligon
- Copper sulfate
- Salinity
- Ammonium chloride
- Biobullets

ADDITIONAL COST INFORMATION

Fouling problems involve an increase in the number of personnel-hours devoted to cleaning and other maintenance procedures. At Salto Grande (Argentina / Uruguay), hydroelectric power plant each turbine must be cleaned every 7 years. Cleaning of penstock walls now requires 10 days instead of 2 days at this plant (Boltovskoy *et al.*, 2015). Treatments to achieve management include the cost of the control product and the manpower to carry out the eradication and subsequent clean-up and remediation of the habitat.

Many chemicals will cause mortality in golden mussels. However, worker safety, cost, protection of the environment and water quality all have to be evaluated before carrying out chemical control (Claudi and Oliveira, 2015). An example is pH control (high pH 10–12), which though effective in terms of mortality and prevention cost a Brazilian hydroelectric plant \$200/day and had associated Health and Safety implications. In addition, due to EU legislation, for example, Biocide Regulation, many of these chemicals would not be permitted for use in the EU and would require

special licenses for use. They could be used for rapid response only if the area to be eradicated was very localised (for example, a jetty) and could be cordoned off with booms or similar barriers.

Biobullets may be a more environmentally friendly alternative to deliver chemical treatment to adult mussels as the amount of KCl required to cause 50% mortality was ten times lower than that for the dissolved form of the chemical (Calazans *et al.*, 2013). Timing of treatment is also important – more effective, with lower concentrations when water is warm (>15°C).

Not possible to assess the cost of treatments in open water as they would be on a case-by-case basis. Expense would include cost of chemicals and round-the-clock labour and expertise during treatments.

Other treatments used in biofouled industrial settings include dessication, oxygen deprivation, ozonation, and thermal treatment (Boltovskoy *et al.*, 2015), but these are considered impractical for use in open waters.

LEVEL OF CONFIDENCE¹

Medium.

All the methods described for management in industrial settings could be used also for long-term management of *Limnoperna fortunei* in isolated populations.

The chemical methods designed to control *Limnoperna* on man-made structures in industrial facilities cannot be used for long-term management of the species in open waters in the wild. It is possible that one of the methods could be used in management if a population was isolated in a very small part of a waterbody, that could be surrounded by watertight booms, such as a docking area, or if a population was found in a very small water body, for example, a pond. Most likely they will not be effective for management in open water unless the infested area is very localised, can be exclusively cordoned off and treated.

LEVEL OF CONFIDENCE¹

Low.

¹ See Appendix

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Appendix

High. Information comes from published material, or current practices based on expert experience applied in one of the EU countries or third country with similar environmental, economic and social conditions.

Medium. Information comes from published data or expert opinion, but it is not commonly applied, or it is applied in regions that may be too different from Europe (for example tropical regions) to guarantee that the results will be transposable.

Low. Data are not published in reliable information sources and methods are not commonly practiced or are based solely on opinion; this is for example the case of a novel situation where there is little evidence on which to base an assessment.

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