Golden Mussel (*Limnoperna fortunei*)
Ecological Risk Screening Summary

Web Version—07/24/2014


Photo: © G. Darrigran from Darrigran (2011).

1 Native Range, and Status in the United States

Native Range
From Crosier et al. (2007):

"China and southeastern Asia."

Status in the United States
This species has not been reported in the U.S.

Means of Introductions in the United States
This species has not been reported in the U.S.

Remarks
N/A

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From Darrigran (2008):

"Domain: Eukaryota
Kingdom: Metazoa
Phylum: Mollusca
Class: Bivalvia
Subclass: Pteriomorphia
Order: Mytiloida
Superfamily: Mytiloidea
Family: Mytilidae
Genus: Limnoperna
Species: Limnoperna fortunei (Dunker, 1857)

Taxonomic Status: Valid."

Size, Weight, and Age Range

From Crosier et al. (2007):

"Shell length of 20 mm is common; maximum shell length of about 40 mm and 60 mm, respectively, in some South American and Asian populations."

"Sexual maturity reached by 1 yr."

"Life cycle of South American populations rarely exceeds 2-3 years; 5 and 10 years maximum, respectively, in Korea and China."

Environment

From Crosier et al. (2007):

"Freshwater lakes and rivers and estuaries."

"Euryhaline freshwater species (primarily a freshwater species, capable of tolerating brackish waters and maintaining substantial populations in estuarine habitats). Tolerant of polluted and contaminated water conditions. Capable of inhabiting waters with relatively low calcium and pH levels…, heated waters, and organically enriched waters subject to periodic hypoxia."

"Attaches byssally to hard substrates."

Climate/Range

From Crosier et al. (2007):

"Between 8 and 32 deg C in Asia, confirmed occurrences up to 35°C."

Distribution Outside the United States

Native

From Crosier et al. (2007):

"China and southeastern Asia."

Introduced

From Darrigran (2008):

"[*Limnoperna fortunei*] became established in Hong Kong in 1965 and in Japan and Taiwan in the 1990s."

From Crosier et al. (2007):

"Established in South America."

"Introduced to the Piata River Basin in Argentina in 1991. Moved upstream at a rate of 250 kilometers per year."

Means of Introduction Outside the United States

From Crosier et al. (2007):

"In ship ballast, and as a contaminant of shipments of live Asian clams."

From Darrigran (2008):

"It spreads up stream in the main rivers of the Plata basin (240 km/year), using different vectors (e.g. commercial and tourist ships, fixed to nets, buoys)."

Short description

From Crosier et al. (2007):

"Mussels are considered adults when they become sexually mature at about 1 year of age. Shell appears golden or yellowish in color. Shell length of 20 mm is common; maximum shell length of about 40 mm and 60 mm, respectively, in some South American and Asian populations. Umbones very nearly terminal, dorsal ligament margin is nearly straight. Does not possess hinge teeth or byssal notch. Mantle fusion occurs dorsally. Females typically comprise two-thirds of population."

Biology

From Crosier et al. (2007):

"Ecological tolerances and parameters vary widely by geographical location; populations are capable of adapting to suit various habitats. Attach byssally to available substrates, forming dense aggregations… often establishing colonies with densities > 80,000/m²."

"External fertilization produces clam-shaped free-swimming veligers. Larval stage duration of 30-70 days."

"Spawning occurs at temperatures between 16 and 28 deg C (June-September). Spawning occurs 1-2 times per year. Dioecious, gametes are discharged into the water where external fertilization occurs. Temperature appears to be a major factor in initiating gamete release."

"Filter feed on planktonic algae (phytoplankton) and zooplankton."

From Darrigran (2008):

"*L. fortunei* filters a wide range of particles, such as algae, zooplankton and organic matter. The larval stages feed on bacteria."

Human uses

None reported.

Diseases

From Boltovskoy et al. (2006):

"Another potential threat posed by this invader was reported by Ogawa et al. (2004). The authors identified widespread parasitic infections by bucephalid trematodes in several cyprinid fishes from the Uji river, suggesting that the infections started with the accidental introduction of infested first intermediate hosts – *Limnoperna fortunei*."

Threat to humans

Potential pest.

3 Impacts of Introductions

From Crosier et al. (2007):

"High filtration rates indicate that suspension feeding may reduce phytoplankton standing stocks and biomass, suppress zooplankton populations, out-compete native species for available food, increase sedimentation rates, and alter contaminant and nutrient cycling. Has the potential to affect the diversity of native molluscan communities (e.g., can overgrow and possibly kill native mollusks; impacts may be similar to *Dreissena*). Adhere byssally to gauges and valves causing them to malfunction. Dead mussels can accumulate on intake screens, strainers, trash racks, and cooling pipes and cause clogging."

"Although strainers and screens may be able to filter out mussels of adequate size, larvae pass through, settle on interior surfaces, detach, and accumulate on intake screens, strainers, trash racks, and cooling pipes causing clogging. Dead mussels have clogged small diameter pipes (e.g., water quality piping, sampling lines, cooling pipes) transmitting raw water which causes, in some situations, a complete shutdown of the plant. Grit chambers and flocculators clog heavily with sediment of broken shell and tissue material. Decaying shell and tissue material give off noxious odor. Increased operational costs (complete shutdown of plant; clogging of mussels, shell material, and sediment may need to be manually removed)."

From GISD (2012):

"The introduction of the golden mussel produces a rapid change in benthic communities and threatens native biodiversity. Golden mussels settle in high numbers on native bivalves (Hyriidae and Mycetopodidae), causing suffocation and starvation, leading to death. Since its invasion of the Plata Basin, dense colonization of hard substrates has modified the presence and abundance of several species of native macroinvertebrates, homogenized the habitat and altered the diet of fish. One fish species (*Leporinus obtusidens* Valenciennes, 1846) has changed its diet to predate entirely on the golden mussel but is not a limiting factor for its dispersion. The golden mussel produces macrofouling in the water systems of facilities."

From: Ricciardi (1998)

"The Asian freshwater mussel *Limnoperna fortunei* was first documented as a major fouling pest when it colonized Hong Kong's water supply system in the late 1960s. It has since fouled municipal waterworks and power plant cooling systems in Korea, Japan, Taiwan, and most recently, in South America. Dense accumulations of byssally-attached mussels obstruct flow in water conduits, causing impacts similar to those of the Eurasian zebra mussel (*Dreissena polymorpha*). *Limnoperna* has demonstrated potential for global range expansion through the oceanic transport of its planktonic larvae in ship ballast tanks. Therefore, unless effective controls are imposed upon ballast-water transport, the mussel will continue to invade and impact aquatic systems on other continents. Given that shipping traffic from both Asia and South America has already resulted in recent introductions of exotic bivalves to the USA, a future North American invasion by *L. fortunei* is highly probable."

From: Boltovskoy et al. (2006)

"Observations of the negative impacts of *L. fortunei* include reports from southern Brazil and Japan. In the area of Guaíba lake (southern Brazil), Mansur et al. (2004) reported that the mussel attaches to at least 6 species of molluscs, including 2 unionids, in numbers of up to ca. 300 *L. fortunei* per host. In several cases this overgrowth may hinder the host's normal displacement and valve mobility. The same authors also suggested that *L. fortunei*'s settlements on the roots of the reed *Scirpus californicus*, an emergent helophyte, may be 'suffocating' the plants and be responsible for the thinning of reed populations. However, this effect is unlikely because the roots of *Scirpus* must be adapted to the very low oxygen environment characteristic of shallow areas with very abundant organic debris. Furthermore, filtering bivalves are known to enhance water oxygenation, rather than the opposite (e.g. Karatayev et al. 1997)."

"Another potential threat posed by this invader was reported by Ogawa et al. (2004). The authors identified widespread parasitic infections by bucephalid trematodes in several cyprinid fishes from the Uji river, suggesting that the infections started with the accidental introduction of infested first intermediate hosts – *Limnoperna fortunei*."

From Boltovskoy et al. (2009):

"The present survey… addresses the question whether *Limnoperna*'s impact on the ecosystem-wide scale is measurable and significant. On the basis of diver collected bottom samples, we estimated the overall density of this mussel in a reservoir (Embalse de Rı´o Tercero, Argentina), where *Limnoperna* is present since 1998 and analyzed changes in several water-column properties before and after the invasion. The 47 km^2 reservoir hosts around 45 billion mussels; at these densities, a volume equivalent to that of this water body can potentially be filtered by the bivalves every 2–3 days. Data collected regularly since 1996 indicate that after the invasion water transparency increased, and suspended matter, chlorophyll *a*, and primary production decreased significantly, with strong changes occurring in the area with highest mussel densities. Our results indicate that the ecosystem-wide impacts of *Limnoperna* are generally comparable to those described in Europe and North America for another invasive mussel—*Dreissena polymorpha*. However, given *Limnoperna*'s wider tolerance limits, its influence on newly invaded water bodies, potentially including Europe and North America, will probably be stronger."

From Darrigran (2008):

"Impact: Economic

Freshwater macrofouling is a new economic/environmental problem for South America. Until the beginning of the 1990s, macrofouling in the neotropical region occurred only in marine and mixohaline waters. Since the introduction of *L. fortunei*, macrofouling also extended to freshwaters in Argentina, Brazil, Paraguay and Uruguay (Darrigran and Damborenea 2005). This kind of problem (freshwater macrofouling) is caused by the appearance of larvae or juveniles of *L. fortunei*. It impacts the sources of water supply of many water-treatment plants, industrial refrigeration systems, and power stations. Among the usual problems involved, the following are the most significant: pipe obstruction; reduction in flow velocity in pipes due to friction loss (turbulent flows); accumulation of empty valves and pollution of water ways by massive mortality; filter occlusion; and increase in the corrosion of surfaces due to mussel infestation. This new economical and environmental problem for the neotropical regions produces unexpected expenses, for example, due to system shutdowns, the need for chemical or mechanical cleaning, and pipe and filter replacement."

“Impact: Environmental

Impact on Habitats
The large biomass associated with high densities of *L. fortunei* impacts on aquatic food chains. Several species of native fish consume *L. fortunei* (López Armengol and Casciotta, 1998; Montalto et al. 1999) and it has become the main food source for *Leporinus obtusidens* (Anostomidea) in the Río de la Plata (Penchaszadeh et al. 2000).”

“However, many other aspects of the biology of *L. fortunei* are poorly understood (Sylvester et al. 2005), including its filtering capacity. Because of its high density in the Plata basin, *L. fortunei* could increase water clarity in a manner similar to that caused by *Dreissena polymorpha* in North America (Darrigran and Damborenea 2005).”

“Impact on Biodiversity
The impact caused by *L. fortunei* it is not restricted to the economic aspect. Darrigran et al. (1998) showed that since the introduction of *L. fortunei* at Bagliardi Beach, two gastropods commonly found have been displaced: one of them, *Chilina fluminea*, is no longer found; whereas the other, *Gundlachia concentrica*, is becoming rare. In contrast, several benthic species, uncommon or absent before the occurrence of *L. fortunei* in this microenvironment, are now present, including the Annelids: Oligochaeta (eight species), Aphanoneura (one species) and Hirudinea (eight species). In addition, several species of crustaceans and insects never cited at the invaded areas are now present (Darrigran et al. 1998).”

“The most direct and severe ecological impact has been the epizoic colonization of native naiads (Hyriidae and Mycetopodidae) by *L. fortunei*, similar to the impact of *D. polymorpha* on native bivalves in North America (Ricciardi et al. 1997).The displacement of the native naiads resulted from their inability to open and shut their valves because of the byssally-attached mussels on their shells. The quantitative impact of *L. fortunei* on native naiads in South America is unknown. *L. fortunei* also settles on other native fauna, such as *Pomacea canaliculata* (Gastropoda, Ampullariidae) and *Aegla platensi*s (Anomura, Aeglidae), as well as on the introduced *Corbicula fluminea* (Bivalvia, Corbiculidae) (Darrigran et al. 2000; Darrigran, 2002).”

“Risk and Impact Factors

Invasiveness
Benefits from human association (i.e. it is a human commensal)
Fast growing
Gregarious
Has high reproductive potential
Highly adaptable to different environments
Is a habitat generalist
Pioneering in disturbed areas
Proved invasive outside its native range”

"Impact outcomes
Altered trophic level
Damaged ecosystem services
Ecosystem change/ habitat alteration
Infrastructure damage
Modification of natural benthic communities
Modification of nutrient regime
Negatively impacts aquaculture/fisheries
Reduced native biodiversity
Threat to/ loss of native species"

"Impact mechanisms
Competition - other
Competition - smothering
Filtration
Fouling
Interaction with other invasive species
Rapid growth"

"Likelihood of entry/control
Difficult to identify/detect as a commodity contaminant
Difficult/costly to control
Highly likely to be transported internationally accidentally"

4 Global Distribution

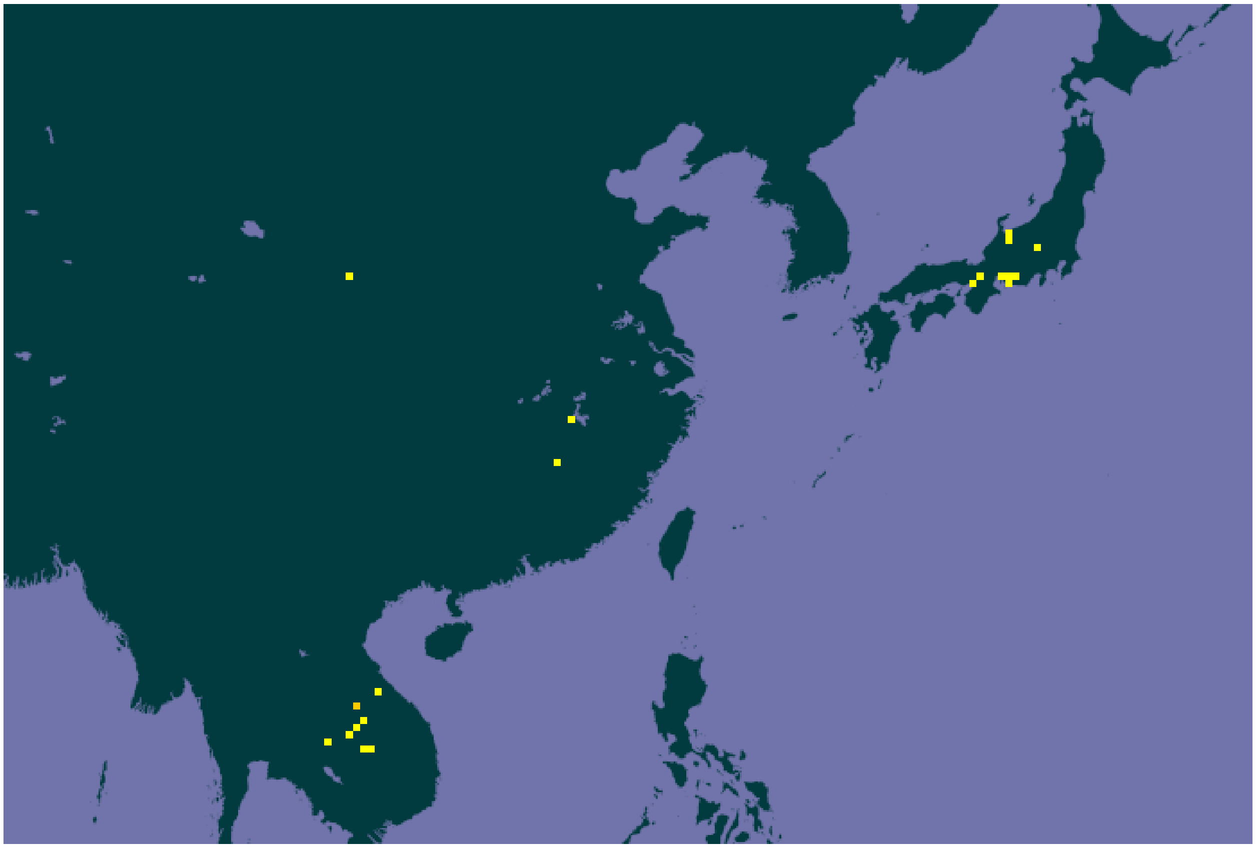

Figure 1. Distribution of *Limnoperna fortunei* in Asia. Map from GBIF (2014).

Figure 2. Distribution of *Limnoperna fortunei* in South America. Map from Crosier et al. (2007).

5 Distribution within the United States

This species has not been reported in the U.S.

6 CLIMATCH

Summary of Climate Matching Analysis

The climate match (Australian Bureau of Rural Sciences 2008; 16 climate variables; Euclidean Distance) in the U.S. was high throughout the East, Southeast, and Central Plains. Low matches covered most of the North and West. The Climate 6 proportion indicated that the contiguous U.S. has a high climate match. The range for a high climate match is 0.103 and greater; climate match of *Limnoperna fortunei* is 0.314.

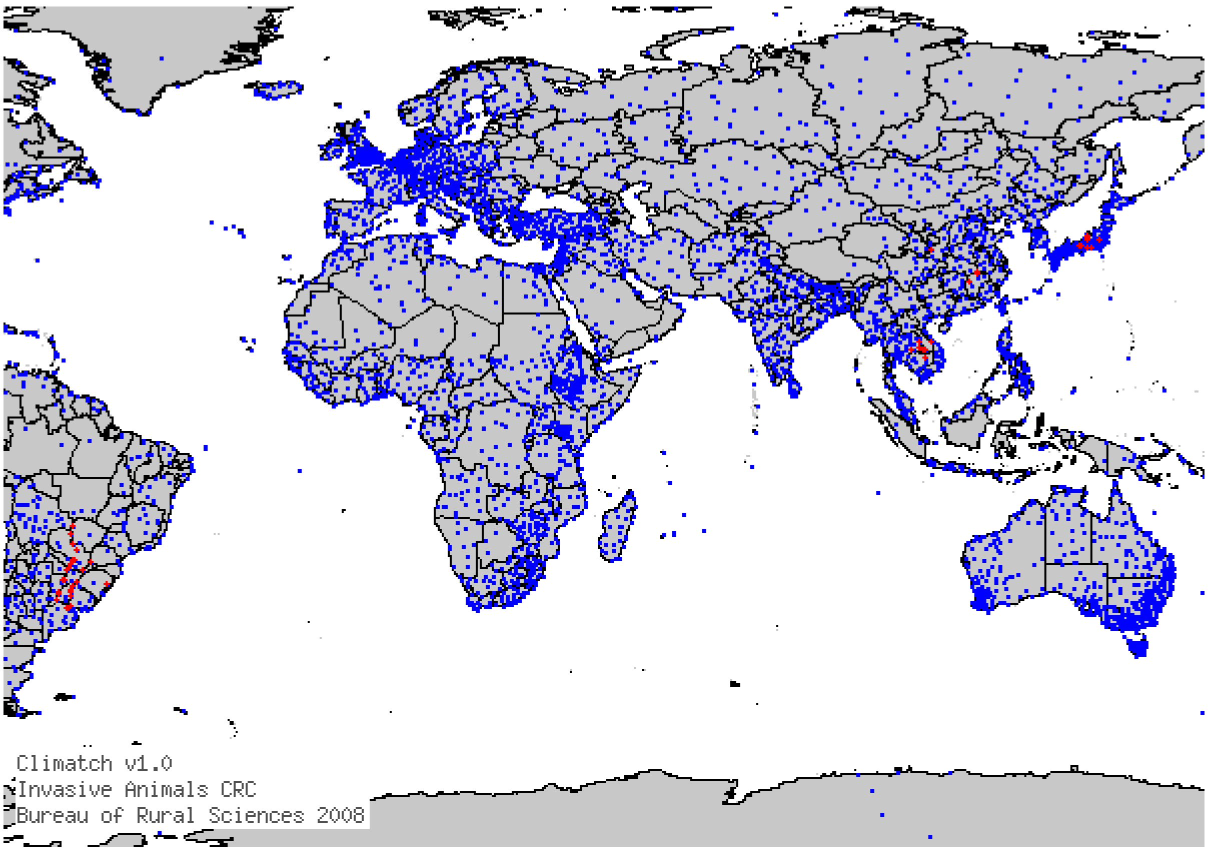

Figure 3. CLIMATCH (Australian Bureau of Rural Sciences 2008) source map showing weather stations selected as source locations (red) and non-source locations (blue) for *Limnoperna fortunei* climate matching. Source locations from GBIF (2014) and Crosier et al. (2007).

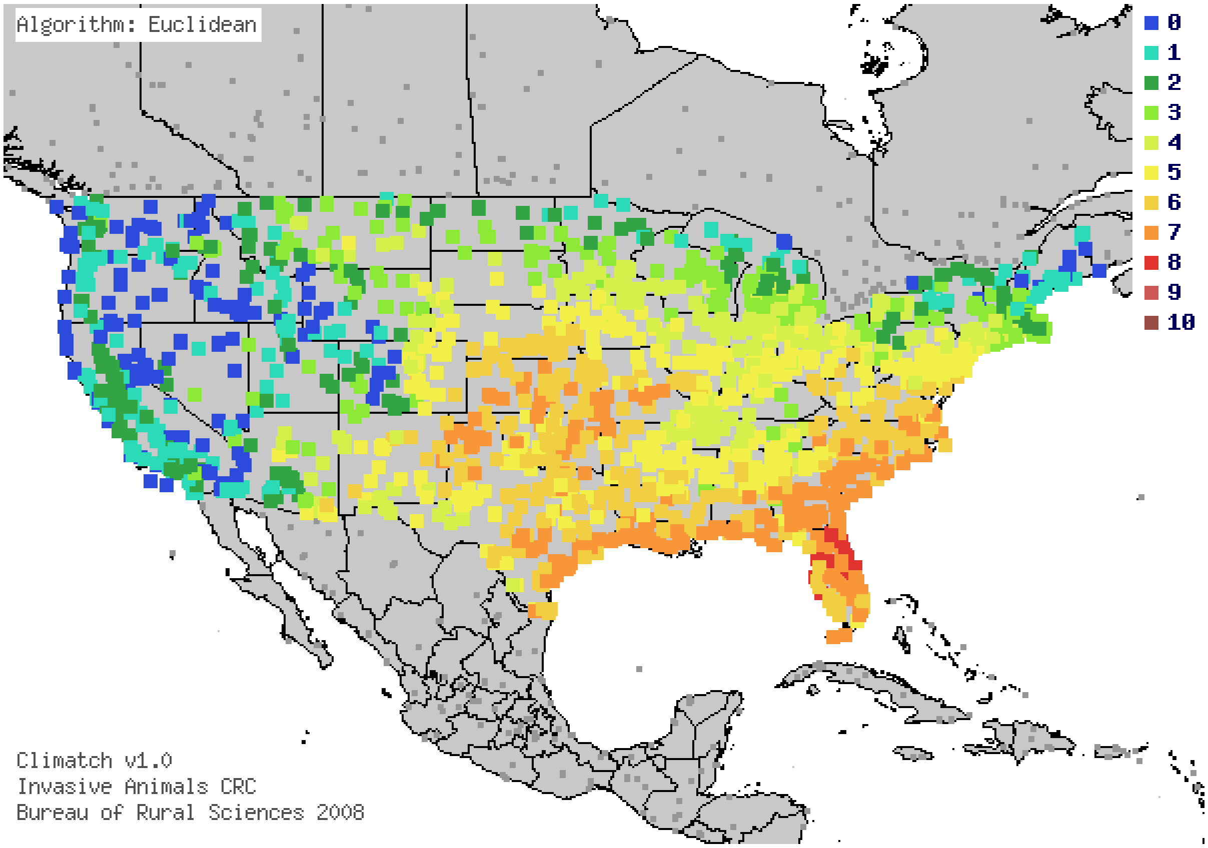

Figure 4. Map of CLIMATCH (Australian Bureau of Rural Sciences 2008) climate matches for *Limnoperna fortunei* in the contiguous United States based on source locations reported by GBIF (2012) and Crosier et al. (2007) . 0= Lowest match, 10=Highest match.

Table 1. CLIMATCH (Australian Bureau of Rural Sciences 2008) climate match scores.

CLIMATCH Score	0	1	2	3	4	5	6	7	8	9	10
Count	144	191	206	189	270	354	349	249	22	0	0
Climate 6 Proportion =		0.314									

7 Certainty of Assessment

Information on this species is abundant, both on its biology and on the impacts caused by introduction of this species. Certainty of this assessment is high.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Limnoperna fortunei is a euryhaline bivalve mussel native to China and southeast Asia. This species has not yet been reported in U.S. waters. However, it has caused significant environmental problems in South America, where it became established in 1991. This species was likely introduced through ballast water releases, and has spread rapidly through a large portion of South America. *Limnoperna fortunei* alters food webs and increases water clarity by filtering large quantities of plankton. This species clogs pipes and intake screens and fouls boats, nets, and other equipment. Impacts of *Limnoperna fortunei* are often compared to impacts of *Dreissena polymorpha*, the zebra mussel. The climate match with the U.S. is high for this highly invasive species, leading to an overall risk rating of high.

Assessment Elements

- **History of Invasiveness (Sec. 3):** High
- **Climate Match (Sec.6):** High
- **Certainty of Assessment (Sec. 7):** High
- **Remarks/Important additional information** Reported as a potential pest
- **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

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10 References Quoted But Not Accessed

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