Assessment of Mystery Snail Technical Memorandum

To:	Ali Forsythe
CC:	John Spranza
Date:	December 19, 2022
From:	Jim Lecky, ICF
Quality Review:	Jason Hassrick, ICF
Subject:	Chinese Mystery Snail *(Cipangopaludina chinensis)*

Based on reports of Chinese mystery snail (*Cipangopaludina* (aka *Bellamya) chinensis*) in the vicinity of the Sites Reservoir Project, the Sites Project Authority (Authority) asked ICF to investigate what ecosystem effects result from the presence of the snails and whether the presence of snails in Funks Reservoir is an issue that needs to be addressed in the Sites Reservoir Project environmental review.

Key points of the literature review include:

- Chinese mystery snails are a widespread introduced species in the United States, including in the three West Coast states (Cohen and Carlton 1995). None of the West Coast states list the Chinese mystery snail as officially invasive.
- There is uncertainty about the ecological risk Chinese mystery snails present to systems they invade (Waltz 2008).
- Chinese mystery snail distribution tends to be associated with boat ramps and urban areas.

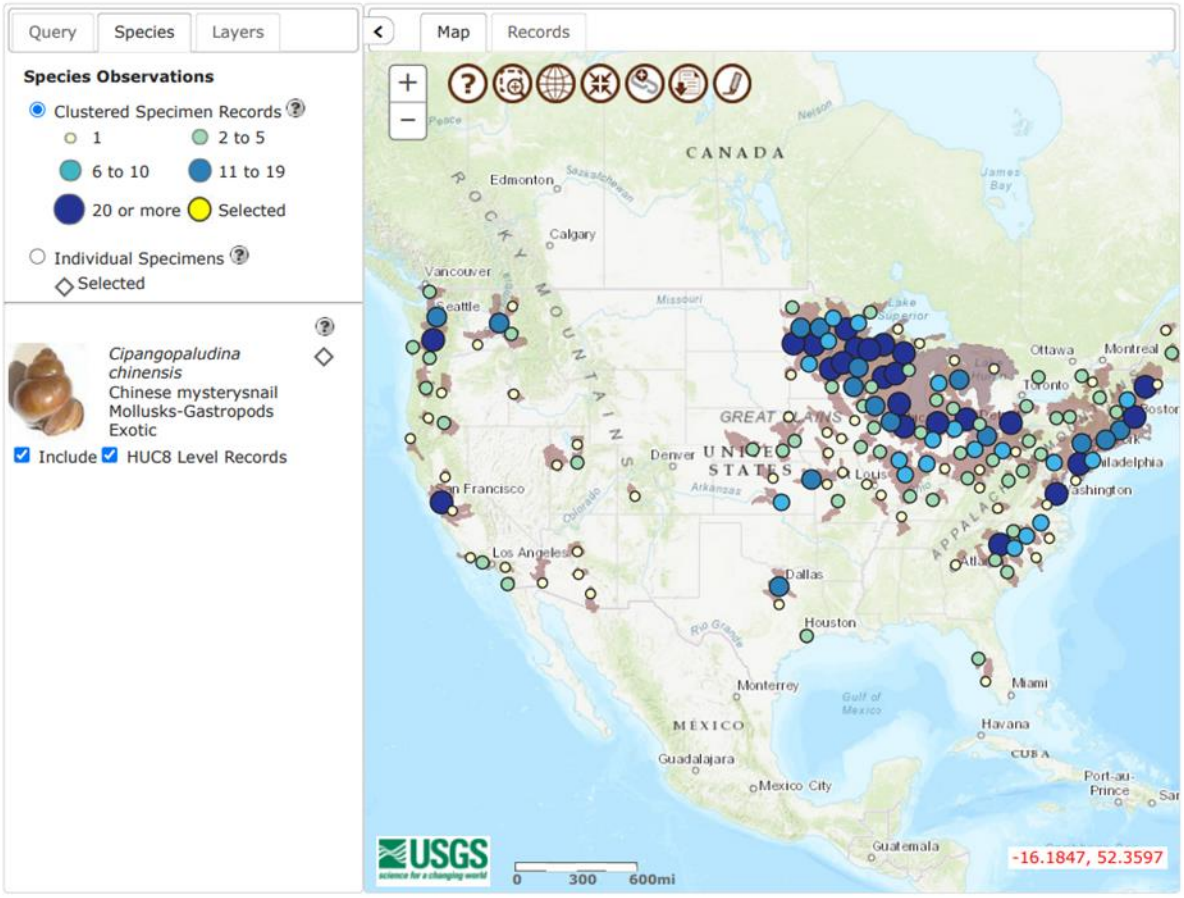
The development of a new reservoir with boating facilities creates another opportunity for expansion of Chinese mystery snail's range in California. ICF recommends that the Authority acknowledge this risk and incorporate information on Chinese mystery snails in the boater education and vessel inspection program described in Appendix 2D, *Best Management Practices, Management Plans, and Technical Studies,* Section 2D.3.6.2, *Invasive Aquatic Invertebrates*, of the *Sites Reservoir Project Final Environmental Impact Report/Environmental Impact Statement*. In addition to boater education, the Authority should incorporate signage at campgrounds and other reservoir access points regarding the environmental risk associated with release of nonnative species (fish and snails) into the waters of California.

1.0 BACKGROUND

The Chinese mystery snail is native to Southeast Asia, Japan, and eastern Russia. It was introduced into the live fish markets in San Francisco in 1892, and by 1911 they were established in freshwater sites between San Jose and San Francisco (Cohen and Carlton 1995). According to the Smithsonian Environmental Research Center's National Estuarine and Marine Exotic Species Information System (Fofonoff et al. 2018), their population in the lower Sacramento River and San Joaquin River systems is

well established. Chinese mystery snails are also popular in the aquarium trade and with garden pond owners because they consume algae and detritus, filter water, and are not harmful to fish or aquatic plants. They also serve as an early indicator of deteriorating water quality (Fox 2005). Consequently, aquariums and garden ponds are another source of introduction of Chinese mystery snails to lakes and streams (Waltz 2008).

The U.S. Geological Survey also monitors and maintains a database of nonindigenous aquatic species (Kipp et al. 2022). According to that database, Chinese mystery snails have been reported in 38 states. There are 14 records in California, from Humboldt County to San Diego County and from the lower Feather River to San Francisco Bay in the Central Valley (Kipp et al. 2022) (see Figure 1).



Source: Map created April 20, 2022, from the Nonindigenous Aquatic Species database (Kipp et al. 2022).

Figure 1. Location of Chinese Mystery Snail Occurrence

In January 2020, the U.S. Fish and Wildlife Service (USFWS) found several Chinese mystery snails in Funks Reservoir, near its confluence with Funks Creek. In a subsequent survey in March 2021, USFWS revisited the site to verify their presence. USFWS collected several shells but no live specimens (Blanco pers. comm.). Thus, whether the population is established in Funks Reservoir remains uncertain.

2.0 BIOLOGY

Chinese mystery snails are viviparous (females give birth to live offspring), gonochoric (male or female), and reproduce sexually, usually between June and October (Waltz 2008). Females are reproductive for 4 years, with an estimated fecundity of 27.2–33.3 young per female per year (Stephen et al. 2013).

However, snail uteri have been documented holding as many as 102 embryos (Waltz 2008). Thus, a single gravid female can establish a population (Kingsbury et al. 2021).

They feed non-selectively on organic and inorganic bottom material, as well as benthic and epiphytic algae, mostly by scraping, but diatoms are probably the most nutritious food Chinese mystery snails ingest at sites in eastern North America (Waltz 2008). They are also capable of filtering the water they breathe, and there may be an ontogenetic shift from grazing to filter feeding as they grow older (Olden et al. 2013).

Chinese mystery snails prefer lentic waterbodies with silt, sand, and mud substrate, but they can survive in slower regions of streams as well (Waltz 2008). They are a truly aquatic species and do not have a lung (Fox 2005), although they can survive for extended periods of time (more than 9 weeks) out of water by burrowing into the sediment and/or closing their opercula (Unstad et al. 2013). Habitat characteristics are reviewed in detail by Kingsbury et al. (2021). Generally, Chinese mystery snails can tolerate a wide range of temperatures (0 degrees Celsius [°C] to 45°C), pH between 4 and 10, dissolved oxygen between 7 and 10 parts per million (ppm) (levels reported at collection sites), salinity between 0 and 5 parts per thousand, and calcium ion concentrations between 5 and 97 ppm. Snails found in lower pH and lower concentrations of calcium have shown signs of shell erosion (Chiu et al. 2002).

3.0 ECOLOGICAL RISK

In locations where Chinese mystery snails are present, they may be among the most ubiquitous of nonnative aquatic species (Solomon et al. 2010). Opinion on the snail's ecological impact is divided (Waltz 2008). Solomon et al. (2010) and Mackie (1999) considered them to have few impacts where introduced. At the low density observed by Mackie (1999) in the Saint John River, they are not likely to cause significant ecosystem effects. In contrast, Bury et al. (2007) caution they may present a threat to native mollusks and could reduce native snail populations through competitive exclusion, and Olden et al. (2013) suggest they may alter nutrient cycling and algal biomass, which may cascade into ecosystem effects.

Johnson et al. (2009) conducted an outdoor mesocosm experiment to evaluate the individual and combined effects of rusty crayfish (*Orconectes rusticus*) and Chinese mystery snails on native snail communities (*Physa*, *Helisoma*, and *Lymnaea* sp.). They found that while the two invaders had only weakly negative effects upon one another, both negatively affected the abundance and biomass of native snails, and their combined presence drove one native species to extinction and reduced a second by more than 95%. Chinese mystery snails were protected from crayfish attack relative to native species by their larger size and thicker shell, suggesting the co-occurrence of the two invaders could have elevated consequences for native communities.

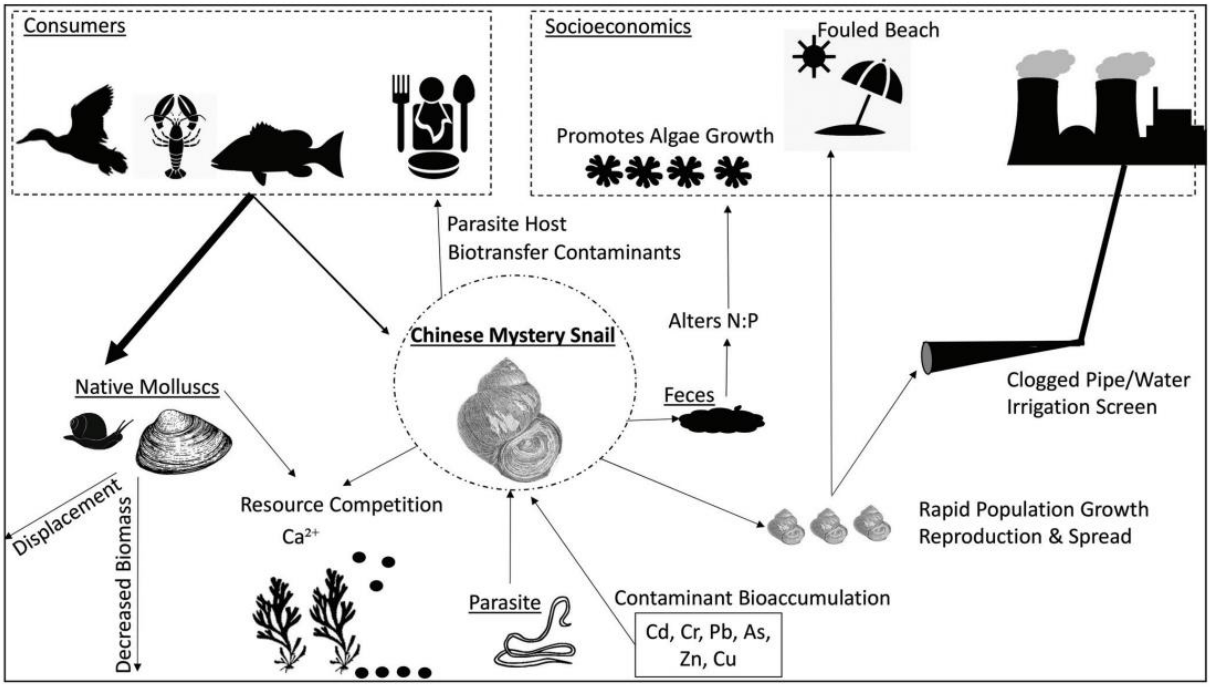
Oden et al. (2009) evaluated how native signal crayfish (*Pacifastacus leniusculus*), nonnative red swamp crayfish (*Procambarus clarkii*), and northern crayfish (*Orconectes virilis*) use the nonnative Chinese mystery snail as a novel prey resource. They concluded that Chinese mystery snails are a suitable food source for crayfish and that native signal crayfish may out-consume invasive crayfishes for the new prey resource. They are also a likely food source for largemouth bass and other sport fish species (Kingsbury et al. 2021).

Olden et al. (2013) investigated filtration rates of Chinese mystery snails on natural seston and found they are comparable to reported values for invasive bivalves, including zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena bugensis*), and Asian clam (*Corbicula fluminea*). Consequently, in certain environments and population densities, Chinese mystery snails may shift primary production from pelagic to benthic zones. On the other hand, Twardochleb and Olden (2016) investigated whether

Chinese mystery snails create a “resource cul-de-sac” by trapping resources in the benthic community or integrate benthic pathways in the lake food webs. They used stable isotopes of ^{13}C, ^{15}N, and ^{2}H to assess whether Chinese mystery snails provide a prey resource to consumers and maintain the integration of benthic resources into food webs of lakes subjected to lakeshore development. They noted that consumers in undeveloped lakes were supported primarily by benthic resources irrespective of the presence of Chinese mystery snails and that lakeshore development substantially reduced availability of those resources. This was, at least partly, due to a reduction in the availability of native snails, a high-quality prey item. They found Chinese mystery snails provided a prey substitute in developed lakes where native snail populations were depressed; the snail’s influence extended to higher trophic-level consumers. Thus, the Twardochleb and Olden (2016) study suggests that nonnative species can ameliorate some effects of environmental degradation.

Harried et al. (2015) investigated Chinese mystery snail’s capacity to serve as a host for parasites within local habitats, including parasites with conservation implications. Of 147 necropsied Chinese mystery snails from lakes in Wisconsin, only two contained trematode parasites, suggesting parasite prevalence in Chinese mystery snails in invaded habitats is lower than among indigenous populations. They also conducted experimental exposures using a trematode (*Sphaeridiotrema pseudoglobulus*) implicated in waterfowl die-offs and found that Chinese mystery snail infection levels were significantly lower than those in co-occurring snail species. They found that parasites that did successfully infect Chinese mystery snails were often found encased in the shells of the snails in a nonviable state. Although infection rates appear much lower in snail-invaded range than in its indigenous range, the infection rate was not zero, and Chinese mystery snail may therefore still play a role in transmission of disease.

Kingsbury et al. (2021) constructed a conceptual diagram based on a literature review to demonstrate how Chinese mystery snails may fit into the foreign environments in North America and Europe, to assist in their evaluation of whether the snails met the definition of Canadian federal government criteria for a nonindigenous invasive species, and to identify ecosystem interactions (either positive or negative) that may occur in North America should Chinese mystery snail populations become widely distributed (Figure 2).



Source: Kingsbury et al. 2021.
Note: As = arsenic; Ca = calcium; Cd = cadmium; Cr = chromium; Cu = copper; N = nitrogen; P = phosphorous; Pb = lead; Zn = zinc.

Figure 2. Conceptual Diagram Summarizing Cipangopaludina chinensis Ecosystem Impacts within the Nonindigenous Range in North America and Europe

Based on this analysis, Kingsbury et al. (2021) concluded the Chinese mystery snail should be considered invasive because of their wide distribution and likely underreported presence, their potential for negative effects on native species via displacement and competition for resources, and the potential for transmission of disease. However, to date, none of the three West Coast states lists Chinese mystery snail as invasive.

4.0 MODES OF INTRODUCTION

As discussed above, early introductions of Chinese mystery snails originated from imports to live fish markets for human consumption. These snails were likely cultivated in irrigation canals and stock ponds from which they escaped (Cohen and Carlton 1995). Their continued popularity with aquarists and garden pond owners is also a source of snails released to the environment. McAlpine et al. (2016) noted a frequent association between Chinese mystery snail distribution and the presence of boat ramps and urbanized shorelines, and Solomon et al. (2010) correlated their presence with boat ramps, distance from population centers, and shoreline housing density.

Chinese mystery snails attach to macrophytes that can get tangled on boat trailers. Solomon et al. (2010) observed individuals brought into boats inadvertently with sediments on anchors. The ability of Chinese mystery snails to close their opercula makes them resistant to desiccation (Unstad et al. 2013). Once on a boat or trailer, that trait and the fact that Chinese mystery snails bear live young that may be stored for long periods inside the adult could facilitate invasions even when boaters do not visit new lakes on the same day or within several days.

On the East Coast, Chinese mystery snails were initially discovered in Massachusetts in September 1917. Waltz (2008) hypothesized that this introduction may be attributed to biocontamination; Chinese mystery snails were introduced indirectly when goldfish were added to a stream for mosquito larvae control (Waltz 2008).

Currently, boating is allowed in many upper Sacramento Basin reservoirs that drain to the Sacramento River (e.g., Black Butte Lake and Stony Gorge Reservoir on Stony Creek), which creates the potential for dispersal. The California Division of Boating and Waterways has a boater education program designed to educate boaters of the importance of cleaning boats and trailers before and after use (California Division of Boating and Waterways 2022), and the state conducts boat inspections at boat ramps on many of those reservoirs. However, those programs are currently focused on quagga and zebra mussels and do not address other invading invertebrates.

5.0 CONCLUSION AND RECOMMENDATION

Chinese mystery snails have been established in California for over a century. They are not currently listed as an invasive species by the California Department of Fish and Wildlife (2022). While they are widespread, particularly in the Midwest and the Northeast, their effect on the ecosystems they have invaded is poorly understood, and the degree to which they are considered harmful is unresolved The literature review presented above suggests the scale is beginning to tilt toward considering them invasive.

Their population in the lower Sacramento River and San Joaquin River systems is well established (Fofonoff et al. 2018); whether the USFWS observation in Funks Reservoir is a unique occurrence of evidence of a new established location remains to be determined. The current range and distribution of the Chinese mystery snail is a baseline condition, and extension of that baseline into the future could include the expansion of Chinese mystery snails into the upper watershed given the broad access boaters have to reservoirs in the northern Sacramento Valley.

Nevertheless, the development of a new reservoir with boating facilities creates another opportunity for expansion of Chinese mystery snail's range in California. ICF recommends that the Authority acknowledge this risk and incorporate information on Chinese mystery snails in the boater education and vessel inspection program described in Appendix 2D, Section 2D.3.6.2 of the *Sites Reservoir Project Final Environmental Impact Report/Environmental Impact Statement*. In addition to boater education, the Authority should incorporate signage at campgrounds and other reservoir access points regarding the environmental risk associated with release of nonnative species (fish and snails) into the waters of California.

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6.2 Personal Communications

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