Chinese Pond Mussel (*Sinanodonta woodiana*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, March 2020
Revised, April 2020
Web Version, 10/4/2021

Organism Type: Mollusk
Overall Risk Assessment Category: High

Photo: Francisco Welter Schultes. Licensed under Creative Commons CC0 1.0 Universal Public Domain Dedication. Available: https://commons.wikimedia.org/wiki/File:1k_Sinanodonta-woodiana_01.jpg (March 2020).

1 Native Range and Status in the United States

Native Range

From Benson (2019):

"Native Range: Eastern Asia, primarily from the Amur and Yangtze rivers [Russia, China] (Kraszewski and Zdanowski, 2007)"

From Cummings (2011):

"The species is native to temperate and tropical eastern Asia, primarily the Amur and Yangtze basins [Russia, China] (Soroka 2005, Kraszewski and Zdanowski 2007), […]. Its native range is uncertain, but ranges from Indochina and China, north to Korea, Japan, Primorye and the Amur Basin in eastern Russia (Graf 2007). The species native range in Indochina is unclear; it appears to be native to Viet Nam (from 'Cochin' as the synonym *Anodonta jourdyi* Morelet, 1886) and perhaps Cambodia, but Brandt (1974) considers the species to have been introduced to Thailand, Malaysia, Singapore, and other countries in southeast Asia."

Status in the United States

According to Benson (2019), nonindigenous occurrences of *Sinanodonta woodiana* have been reported in New Jersey (2010; Middle Delaware-Musconetcong drainage).

From Benson (2019):

"The mussel did become established locally in several New Jersey fish ponds at a single site. In 2019 these ponds were treated and the mussel is believed to be eradicated. However, the status of a possible mussel population where shells were found in Wickecheoke Creek downstream of the fish ponds is unknown."

From Fassett (2019):

"The Chinese pond mussels were eliminated from nine ponds in the former fish farm, located in the headwaters of the Wickecheoke Creek, from July through to September. Because the Wickecheoke Creek is a Delaware River tributary, eradicating the species dually eradicated the danger of the species spreading to local waterways."

"The mussels were eliminated through a grant provided by the U.S. Fish and Wildlife Service, which funded the use of a copper-based algaecide known as Earth Tec QZ that Mason said causes the mussels to "shrivel up" without impacting other species in their vicinity."

Sinanodonta woodiana is in trade in the United States (e.g., Aquatic Arts 2021).

Means of Introductions in the United States

From Benson (2019):

"Means of Introduction: Most likely the mussels arrived as glochidia (larvae) attached to the gills of imported Asian carp (Beran, 2008). All carp species serve as hosts for the glochidia larval stage."

Remarks

This ERSS was previously published in 2015. Revisions were completed to incorporate new information and conform to updated standards.

Information searches for this ERSS were conducted with the accepted name *Sinanodonta woodiana* and the synonym *Anodonta woodiana*.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

According to MolluscaBase (2021), *Sinanodonta woodiana* (I. Lea, 1834) is the accepted name for this species.

From ITIS (2020):

Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Protostomia
Superphylum Lophozoa
Phylum Mollusca
Class Bivalvia
Subclass Palaeoheterodonta
Order Unionoida
Superfamily Unionoidea
Family Unionidae
Subfamily Unioninae
Tribe Anodontini
Genus *Sinanodonta*
Species *Sinanodonta woodiana* (Lea, 1834)

From Benson (2019):

"Synonyms and Other Names: *Anodonta woodiana*"

Size, Weight, and Age Range

From Benson (2019):

"Size: Reaching 30 cm (Pou-Rovira et al., 2009)."

From Von Proschwitz (2008):

"*S. woodiana* is a large species, and it may reach a length of 12-26 cm and a maximal height of 12 cm."

Environment

From Benson (2019):

"From slowly running rivers to eutrophic ponds (Welter Schultes, 2010). Commonly found in muddy sediment in the Czech Republic (Beran, 2008)."

From Cummings (2011):

"This species is a habitat generalist found in heavily modified and artificial habitats and is tolerant to high siltation rates (Paunovic et al. 2006). In the Czech Republic it is found in ponds, oxbow lakes and canals (Beran 2008). It prefers substrates of silt and clay, turbid conditions with relatively high water temperatures (30-33° C) and is found in either standing or slow-flowing water (Soroka 2005, Zettler and Jueg 2006)."

Climate

From Cummings (2011):

"The species is native to temperate and tropical eastern Asia, […]."

Distribution Outside the United States

Native

From Benson (2019):

"Native Range: Eastern Asia, primarily from the Amur and Yangtze rivers [Russia, China] (Kraszewski and Zdanowski, 2007)"

From Cummings (2011):

"The species is native to temperate and tropical eastern Asia, primarily the Amur and Yangtze basins (Soroka 2005, Kraszewski and Zdanowski 2007), […]. Its native range is uncertain, but ranges from Indochina and China, north to Korea, Japan, Primorye and the Amur Basin in eastern Russia (Graf 2007). The species native range in Indochina is unclear; it appears to be native to Viet Nam (from 'Cochin' as the synonym *Anodonta jourdyi* Morelet, 1886) and perhaps Cambodia, but Brandt (1974) considers the species to have been introduced to Thailand, Malaysia, Singapore, and other countries in southeast Asia."

Introduced

From Benson (2019):

"This mussel has also been documented in the Dominican Republic and Costa Rica (Watters, 1997). In Europe, it is the most widely introduced unionid mussel (Pou-Rovira et al., 2009). It was found first in Hungary in 1984. Since then, *Sinanodonta woodiana* has been found in at least 13 additional countries (Kraszewski and Zdanowski, 2007; Paunovic et al., 2006; Pou-Rovira et al., 2009), primarily associated with fish farms (Kraszewski and Zdanowski, 2007; Popa and Popa, 2006). In just 20 years, this mussel has spread throughout most of Romania (Popa et al.,

2007) and is rapidly colonizing Italy (Cappelletti et al., 2009) and the Iberian Peninsula (Pou-Rovira et al., 2009)."

CABI (2020) lists *Sinanodonta woodiana* as present in Austria, Belgium, Czechia, Italy, Poland, Romania, Serbia, and Sweden.

From Cummings (2011):

"[…], and has also been very widely introduced within Asia, Europe and the Americas. […], but Brandt (1974) considers the species to have been introduced to Thailand, Malaysia, Singapore, and other countries in southeast Asia.

It is one of the only members of Unionidae that has been introduced around the world (K. Cummings pers. comm. 2011). It was first introduced to Europe in 1963 along with introduced carp, and is currently found in at least fifteen European countries including Romania, Czech Republic, Belgium, Hungary, France, Slovakia, Austria, Poland, Ukraine, Italy, Germany, Serbia, Bulgaria, Moldova, Spain and Sweden as well as in some Indonesian islands (exact location unclear), Dominican Republic, […], and Costa Rica (Paunovic et al. 2006, Bogan et al. 2011, K. Cummings pers. comm. 2011)."

FAO (2020) lists *Sinanodonta woodiana* as introduced to Indonesia, Japan, Romania, Hungary, France, Dominican Republic, and Costa Rica.

From Von Proschwitz (2008):

"From this area the species has, by the help of man, spread to and established itself in large parts of South-East Asia, south of the native distribution area. […] In Europe it established itself in Rumania and Hungary in the late 1970s (Falkner, 1990). Since then it has spread rather rapidly to other countries, especially in the Danube-system, where it locally may occur in high population densities. Occurrences have so far been reported from 15 European countries: Austria, Belgium, Bulgaria, the Czech Republic, France, Germany, Greece, Hungary, Italy, Poland, Romania, Serbia, Slovakia, Sweden and Ukraine. […] With infected carps it has also spread to Costa Rica and the Dominican Republic (Mienis 2003b)."

From Lajtner and Crnčan (2011):

"Field research conducted from 2007 to 2011 indicated that this species [*Sinanodonta woodiana*] has colonised the entire eastern part of Croatia, and that its spread westward is continuing."

Means of Introduction Outside the United States

FAO (2020) lists *Sinanodonta woodiana* as introduced accidently to Dominican Republic, Costa Rica, France, Hungary, Romania, and Indonesia.

From Konieczny et al. (2016):

"Among bivalves, it is known as an invasive species transported with fish shipments and penetrated from Asia not only the American continent but also Europe."

From Urbańska et al. (2012):

"It is believed that the population in Poland was made possible by fish transports of the bighead carp (*Aristichthys nobilis*) and silver carp (*Hypophthalamichthys molitrix*) in the late 80's from Hungary, (Kraszewski, Zdanowski 2001) and its presence was limited to reservoirs with increased thermal trophic dynamics and water supplied by the Konin power plant."

From Von Proschwitz (2008):

"From this area the species has, by the help of man, spread to and established itself in large parts of South-East Asia, south of the native distribution area. Different species of carp fishes function as hosts, especially Silver Carp [*Hypophthalmichthys molitrix* (Valenciennes)] and Grass Carp [*Ctenopharyngodon idella* (Valenciennes)] – and as these species have been imported for biological control of organic debris and freshwater plants, *S. woodiana* has spread also to other parts of the world if the fishes have been infected with its glochidia. According to Mienis (2003d) also Goldfish [*Carassius auratus* (Linnaeus)] and different species of Bitterling [*Rhodeus* spp.] are possible hosts. […] With infected carps it has also spread to Costa Rica and the Dominican Republic (Mienis 2003b)."

"An additional possible direct means of dispersal for *S. woodiana* is its being, unintentionally, marketed and sold by garden centres and aquarium shops as a species for biological control and water purification in several European countries (including Sweden). In many cases it is obvious that the firms are not aware of what species they are offering. Pictures of marketed mussels, shown on the internet pages of such firms, are mostly *Anodonta*-species – but in some cases undoubtedly *S. woodiana*! It is desirable that marketing of mussels as a means of biological control and as water purificators should be restricted to common indigenous species, and that the import of mussels for such purposes will be prohibited in the EU."

Short Description

From Von Proschwitz (2008):

"*S. woodiana* is a large species, and it may reach a length of 12-26 cm and a maximal height of 12 cm. The form of the shell is, contrary to the European species in the subfamily Anodontinae, relatively short and elliptical to almost rounded and very high in the central part. The proportions between length and height are different and very pronounced in adult specimens. Also the marked breadth (up to 6 cm) and the rounding over the umbo and the oldest parts of the shell are marked. The intraspecific variation in the form of the shell is, however, considerable. The umbonal rugae are characteristic, consisting of pronounced, coarse, relatively sparse, transverse ridges (cf. Falkner, 1990: […]), which differ markedly from the finer, thinner and more closely lying ridges, present in the European *Anodonta* and *Pseudanodonta* species. The colour of the shell is dark brown – yellow green – dark green."

Biology

From Liu et al. (2016):

"The worldwide-distributed *Anodonta woodiana* [a synonym, see Remarks page 3] (Douda et al. 2012) is typical of unionid bivalves and has a complex life cycle involving an ecto-parasitic larval glochidial stage and a microscopic juvenile stage (Chen et al. 2015)."

From Bolotov et al. (2016):

"The *S. woodiana* is a broad host generalist, which can complete its development on many host fish species (Watters, 1997; Douda et al., 2012). Many introduced and native fish species were reported as suitable hosts for *S. woodiana* glochidia in Indonesia, including the silver carp (*Hypophthalmichthys molitrix*), the Nile tilapia (*Oreochromis niloticus*), the Snakeskin gourami (*Trichopodus pectoralis*), the Philippine catfish (*Clarias batrachus*), etc. (Djajasasmita, 1982; Hamidah, 2012, 2013)."

Human Uses

From Von Proschwitz (2008):

"An additional possible direct means of dispersal for *S. woodiana* is its being, unintentionally, marketed and sold by garden centres and aquarium shops as a species for biological control and water purification in several European countries (including Sweden). In many cases it is obvious that the firms are not aware of what species they are offering. Pictures of marketed mussels, shown on the internet pages of such firms, are mostly *Anodonta*-species – but in some cases undoubtedly *S. woodiana*! It is desirable that marketing of mussels as a means of biological control and as water purificators should be restricted to common indigenous species, and that the import of mussels for such purposes will be prohibited in the EU."

From Bolotov et al. (2016):

"In contradiction to European countries and the USA, the invasive populations of *S. woodiana* in Indonesia are considered as an important protein source to local communities, which has significant economic value (Djajasasmita, 1982; Mujiono, 2011; Hamidah, 2012). The Indonesian populations of this species are actively exploited as a food as well as a feed for cultivated fishes and other animals (Koroh and Lumenta, 2014; Heriyani and Suprapto, 2015)."

Sinanodonta woodiana is in trade in the United States (e.g., Aquatic Arts 2021).

Diseases

No records of OIE-reportable diseases (OIE 2020) were found for *Sinanodonta woodiana*.

Poelen et al. lists *Sinanodonta woodiana* as a host for *Unionicola formosa, Unionicola ischyropalpus, Unionicola ypsilophora, Unionicola agilex,* and *Unionicola arcuata.*

Threat to Humans

No information on *Sinanodonta woodiana* threats to humans.

3 Impacts of Introductions

From Bolotov et al. (2016):

"The abundant invasive *S. woodiana* populations could impact native mussels and other benthic invertebrates as competitors for food, space and hosts, as a source of parasites, as well as 'ecosystem engineers' that are changing the biological and physical characteristics of freshwater systems (Douda et al., 2012; Sousa et al., 2009, 2014; Lopes-Lima et al., [2017]). Generally, invasion by such a large species as *S. woodiana* could affect hydrology, biogeochemical cycling, and biotic interactions through several mechanisms, with impacts ranging from individuals to ecosystems (Sousa et al., 2014)."

From Spyra et al. (2016):

"During an invasion of *S. woodiana* an important role is also played by its non-selective choice of host in its larval stage in comparison with the native Unionidae (Kiss, 1995; Blazek and Gelnar, 2006; Douda et al., 2012; Popa et al., 2015). This reduces the opportunities for survival for native mussels (Lydeard et al., 2004; Corsi et al., 2007; Cappelletti et al., 2009; Hliwa et al., 2015), which are considered to be one of the most threatened groups of organisms in the world (Vaughn et al., 2008; Allen and Vaughn, 2011; Kamburska et al., 2013)."

From Paunovic et al. (2006):

"Observed domination of *A. woodiana* in comparison with native mussel taxa infers that Chinese pond mussel could have an impact on autochthonous bivalves via competition (Essl and Rabitch 2002)."

From Lajtner and Crnčan (2011):

"This species is known to seriously threaten the native population of bivalves from the family Unionidae. Fabbri and Landi (1999) stated that the native species *A. anatina* had been completely replaced by *S. woodiana* in several channels with a soft substrate and high trophic level. The Chinese pond mussel is a direct competitor for food and space with native species, while another important factor is competition for fish hosts (Rashleight 1995; Fabbri and Landi 1999) as the larvae of these species develop on the gills and fins of fish. Dudgeon and Morton (1983) stated that this species reproduces two to three times per year, unlike the native species, which typically reproduce only once per year. The same authors also stated that *S. woodiana* becomes sexually mature in the first year of life at a shell length of 3 to 4 cm, and individuals have an average life span of 12 to 14 years. The parasite phase of the life cycle lasts 5–15 days, depending on the water temperature. Research has shown that this species is not selective with regards to the fish host, which is a significant advantage (Douda et al. [2012]). The species also has a much higher rate of increase and better tolerance of hypoxia and pollution than native

species (Sîrbu et al. 2005). Due to the above mentioned invasive characteristics of *S. woodiana*, it can be expected that all the native bivalve species in Croatia will be threatened."

From Benkö-Kiss et al. (2013):

"In this basin, comparing these data to the distribution of unionids measured in 1992/93, the impact of *S. woodiana* seems high, as *A. cygnea* has been replaced by *S. woodiana* and the ratio of *A. anatina* reduced from 17.8% to 8.6%. Taking into consideration that *S. woodiana* has so rapidly developed high relative abundance and biomass close to the supposed source of introduction and it has a high spread potential in the lake, future increase in population size (and dominance) can be expected."

From Donrovich et al. (2017):

"The metamorphosis success rate of the native *A. anatina* glochidia was strongly reduced (Wilcoxon Signed-Rank Test, $P < 0.001$) and declined by 42.1 and 45.4% on fish hosts that were previously exposed to *S. woodiana* by single and multiple priming infestations, respectively, in comparison with the control group. Such cross-resistance is expected to decrease significantly the quality of the host resources available to native mussels."

"This study provides the first evidence of the host-mediated adverse impact of invasive *S. woodiana* on native mussel species. These results also highlight the importance of potential competition for hosts between threatened groups of affiliate species and their invasive counterparts, which should be reflected in conservation strategies."

4 History of Invasiveness

Sinanodonta woodiana has been introduced to numerous countries outside of its native range, many of which it has become established. *S. woodiana* most likely arrived as glochidia (larvae) attached to the gills of imported Asian carp. *S. woodiana* can impact native mussels and other benthic invertebrates as competitors for food, space and hosts. Donrovich et al. (2017) found that *S. woodiana* can decrease metamorphosis of native mussels due to cross-resistance. Competition with native species is another potential impact listed in the literature. The history of invasiveness for *S. woodiana* is classified as High.

5 Global Distribution

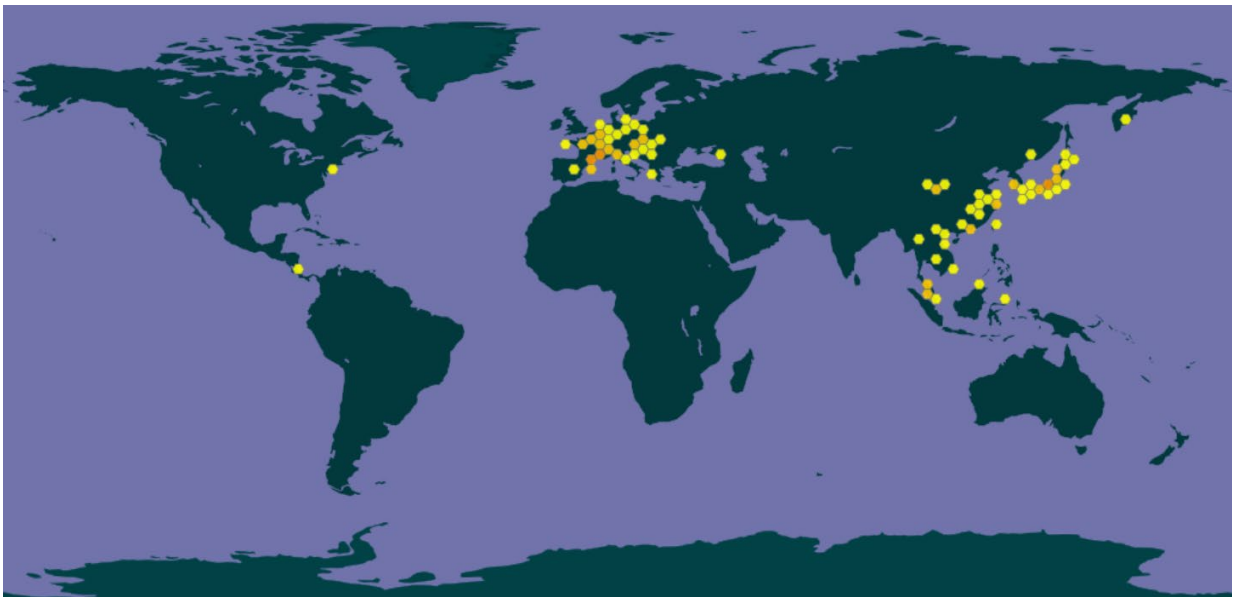

Figure 1. Known global distribution of *Sinanodonta woodiana*. Observations are reported from Europe, Eastern Asia, United States and Costa Rica**.** Map from GBIF Secretariat (2020). Although Fassett (2019) states that the *Sinanodonta woodiana* population in New Jersey has been eradicated, it was able to survive in the wild suggesting that New Jersey has suitable climate conditions for that population, therefore, the location was used for climate matching.

6 Distribution Within the United States

Figure 2. Historical known distribution of *Sinanodonta woodiana* in the United States. Map from Benson (2019). Although Fassett (2019) states that the *Sinanodonta woodiana* population in New Jersey has been eradicated through human activities, it was able to survive in the wild suggesting that New Jersey has suitable climate conditions for that population, therefore, the location was used for climate matching.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match was medium to high throughout the majority of the contiguous United States, except for a small area in the Pacific Northwest and southern California and Arizona where low match was found. The overall Climate 6 score (Sanders et al. 2018, 16 climate variables, Euclidean distance) for the contiguous United States was 0.598, high (scores greater than or equal to 0.103 are classified as high). The following States had low individual Climate 6 scores: Louisiana and Mississippi. Alabama and Rhode Island had medium individual scores, while all other States received high individual scores.

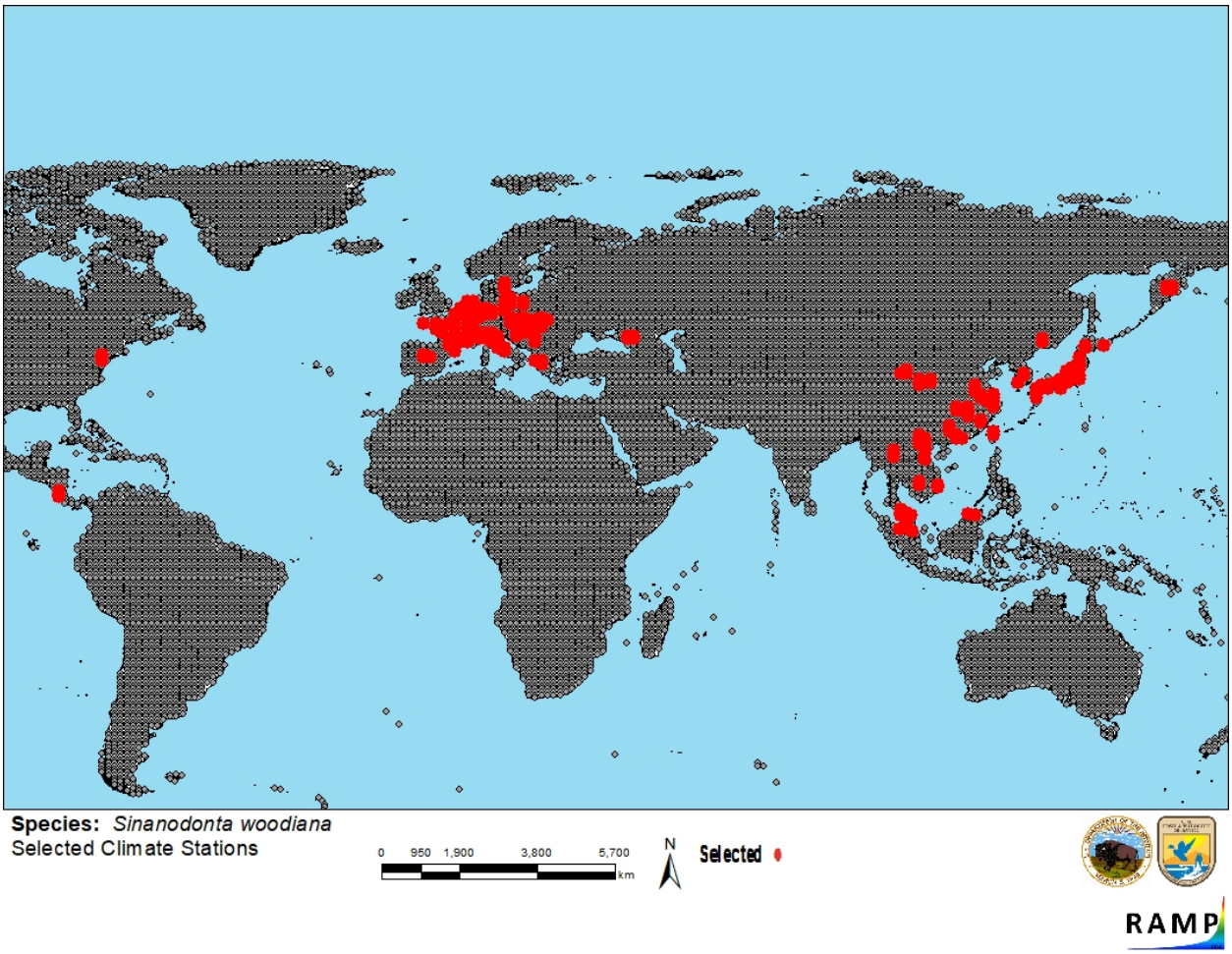

Figure 3. RAMP (Sanders et al. 2018) source map showing weather stations in Europe, Eastern Asia, United States and Costa Rica selected as source locations (red) and non-source locations (gray) for *Sinanodonta woodiana* climate matching. Source locations from GBIF Secretariat (2020) and Benson (2019). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

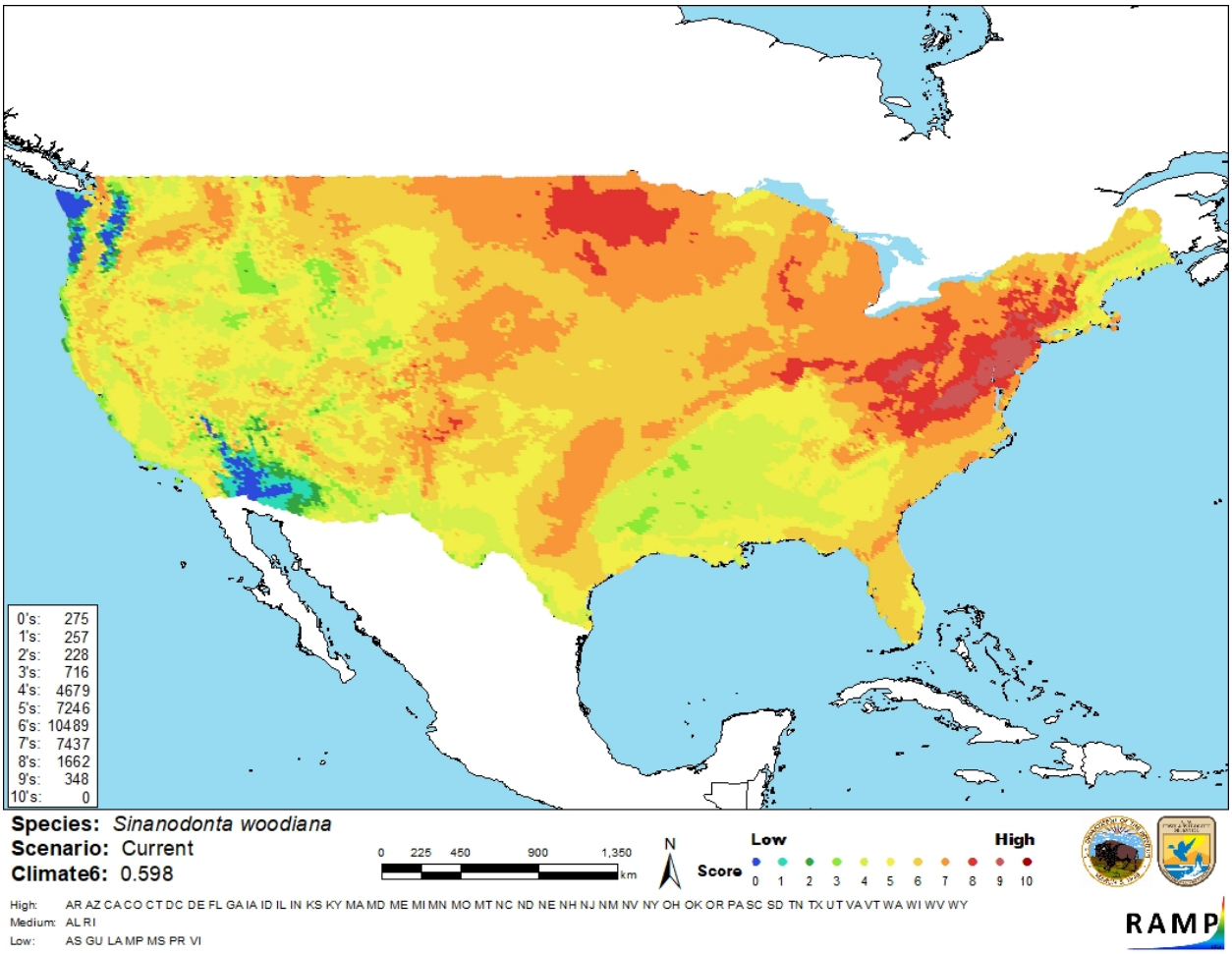

Figure 4. Map of RAMP (Sanders et al. 2018) climate matches for *Sinanodonta woodiana* in the contiguous United States based on source locations reported by GBIF Secretariat (2020) and Benson (2019). Counts of climate match scores are tabulated on the left. 0/Blue = Lowest match, 10/Red = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: (Count of target points with climate scores 6-10)/ (Count of all target points)	Overall Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

8 Certainty of Assessment

The biology and ecology of *Sinanodonta woodiana* is well documented. There are many reports of introductions, with most resulting in establishment. Negative impacts from introductions of this species are documented in the scientific literature. The certainty of this assessment is High.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Sinanodonta woodiana, the Chinese Pond Mussel, is a large freshwater mussel native to Eastern Asia, primarily from Amur and Yangtze rivers in Russia and China. This species has been introduced and become established in many countries around the world, in southern Asia, Europe, and North America. *S. woodiana* most likely arrived as glochidia (larvae) attached to the gills of imported Asian carp. *S. woodiana* can impact native mussels and other benthic invertebrates as competitors for food, space and hosts. Donrovich et al. (2017) found that *S. woodiana* can decrease metamorphosis of native mussels due to cross-resistance. The history of invasiveness of this species is classified as High. The overall climate match for the contiguous United States is High, with nearly all States having high individual Climate 6 scores. The certainty of assessment is High. Therefore, the overall risk assessment category for *S. woodiana* is High.

Assessment Elements

- **History of Invasiveness (Sec. 4): High**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): High**
- **Remarks/Important additional information:** No additional remarks.
- **Overall Risk Assessment Category: High**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 11.

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11 Literature Cited in Quoted Material

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

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