Bloody Red Shrimp (*Hemimysis anomala*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, December 2022
Revised, January 2023
Web Version, 7/24/2024

Organism Type: Crustacean
Overall Risk Assessment Category: High

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1 Native Range and Status in the United States

Native Range

From Kipp et al. (2022):

"*Hemimysis anomala* is native to freshwater margins of the Black Sea, the Azov Sea and the eastern Ponto-Caspian Sea. It has historically occurred in the lower reaches of the Don, Danube, Dnieper and Dniester rivers."

Status in the United States

From Kipp et al. (2022):

"*Hemimysis anomala* was reported for the first time in 2006 from two disjunct regions in the Great Lakes: southeastern Lake Ontario at Nine Mile Point near Oswego, New York, in May 2006 (J. Wyda 2007, personal communication); and from a channel connecting Muskegon Lake to Lake Michigan in November 2006 (Pothoven et al. 2007). Specimens resembling *H. anomala* have also been found in the stomach contents of a white perch collected near Port Dover, Lake Erie in August 2006 (T. MacDougall, Ontario Ministry of Natural Resources, pers, comm.). The species is probably present at other locations in the Great Lakes basin, but has escaped detection."

"The presence of juveniles and reproductive females within a dense population suggests that *H. anomala* is well established near Muskegon Lake in southern Lake Michigan (Pothoven et al. 2007) and at Nine Mile Point in Lake Ontario (J. Wyda, pers. comm.)."

From Lake Superior Research Institute (2018):

"Samples were collected weekly May through September of 2018 from the Superior Entry to the Duluth-Superior Harbor (46˚42'26.6"N, 92˚0'45.4"W), Superior, WI. […] [Lake Superior Research Institute taxonomists] Schaefer and Fanberg also confirmed the continued presence of the non-native mysid *Hemimysis anomala*, which was initially discovered nearby in Lake Superior's Allouez Bay in 2017 by U.S. Fish and Wildlife Service."

From Brooking et al. (2010):

"In August 2009, we identified *Hemimysis* [*anomala*] in diets of white perch and yellow perch in Oneida Lake, NY. Night time vertical plankton net tows detected *Hemimysis* at four sites across the lake. […] This is the first documented introduction of *Hemimysis* to an inland lake in North America, outside the Great Lakes."

From Brown et al. (2014):

"Our survey of the New York State canal system (USA) found the species at 10 sites, spanning over 80 km of canal, which confirms the species [*Hemimysis anomala*] continues to colonize human-made canal systems and that canals may catalyze its spread. We report two primary geographic areas where *Hemimysis* is present in the New York State canal system—in the Erie Canal east of Oneida Lake and in the Cayuga-Seneca Canal in the Finger Lakes region."

No records of *Hemimysis anomala* in trade in the United States were found.

Regulations

Hemimysis anomala is listed as a prohibited invasive species in New York and Wisconsin (New York Department of State 2022, Wisconsin State Legislature 2022). While effort was made to find all applicable regulations, this list may not be comprehensive.

Means of Introductions within the United States

From Kipp et al. (2022):

"*Hemimysis anomala* was very likely introduced to the Great Lakes via ballast water release from transoceanic ships."

"The port at Muskegon is not a high-traffic area for shipping; therefore, the population in Lake Michigan probably reflects an introduction from another invaded site in the Great Lakes."

From Brooking et al. (2010):

"No genetic differences were found between *Hemimysis* in Oneida Lake and Lake Ontario, indicating this is likely the source of introduction. Several large rapids, locks, and dams separate the two lakes, and as a result the most likely vector of introduction to Oneida Lake is pleasure boat or light commercial traffic via the canal system or overland transport."

Remarks

From Kipp et al. (2022):

"*H. anomala*'s relatively low fecundity (Ketelaars et al. 1999) suggests that it may have been present in the Great Lakes a few years before being discovered. Monitoring of this species is made difficult by its nocturnal behavior and because of its rapid swimming and response to stimuli. Specialized benthic traps are useful for sampling cryptic populations (Borcherding et al. 2006). It may be detected at night by shining a bright light on calm water, which will cause individuals to rapidly disperse. During daylight hours, swarms may hide in the shade provided by rock crevices, boulders, piers and jetties."

This ERSS was previously published in August 2018. Revisions were completed to incorporate new information and conform to updated standards.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2022):

Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Protostomia
Superphylum Ecdysozoa
Phylum Arthropoda
Subphylum Crustacea
Class Malacostraca
Subclass Eumalacostraca
Superorder Peracarida
Order Mysida

Family Mysidae
Genus *Hemimysis*
Species *Hemimysis anomala* G.O. Sars 1907

According to Mees and Meland (2022), *Hemimysis anomala* is the current valid name for this species.

Size, Weight, and Age Range

From Kipp et al. (2022):

"Mature individuals range from 6 to 13 mm in length (Borcherding et al. 2006; Janas and Wysocki 2005; Salemaa and Hietalahti 1993). Females are slightly larger than males."

Environment

From Marty et al. (2010):

"Ioffe (1973) reported a preferred [water] temperature range for *Hemimysis* of 9–20°C."

From Kipp et al. (2022):

"*Hemimysis anomala* is a brackish-water mysid able to adapt to freshwater environments (Pienimäki and Leppäkoski 2004; Jazdzewski et al. 2005). It tolerates salinity concentrations of 0–19 ppt (Bij de Vaate et al. 2002; Borcherding et al. 2006) […]. Populations may survive [water] temperatures of 0°C over winter, but not without substantial mortality (Borcherding et al. 2006)."

"This species is normally found in lentic waters, although it has successfully established in European rivers (Bij de Vaate et al. 2002; Holdich et al. 2006). […] The bloody-red mysid has been collected at depths ranging from 0.5 m to 50 m, although it generally inhabits 6 m to 10 m depths (Salemaa and Hietalahti 1993). It favors rocky substrate (Janas and Wysocki 2005), is less abundant on soft sediments, and is usually scarce in areas of dense vegetation or high siltation (Pothoven et al. 2007)."

Climate

From Palomares and Pauly (2022):

"Temperate to subtropical."

From Reid and Orlova (2002):

"The Black Sea (~41–46°N) is located in southeast Europe in a semi-arid climate zone."

"The climate around the [Sea of Azov] basin is continental temperate […]"

“The Caspian Sea spans ~36–47°N and has arid to semiarid continental and Mediterranean climatic zones.”

Distribution Outside the United States

Native

From Kipp et al. (2022):

“*Hemimysis anomala* is native to freshwater margins of the Black Sea, the Azov Sea and the eastern Ponto-Caspian Sea. It has historically occurred in the lower reaches of the Don, Danube, Dnieper and Dniester rivers.”

Introduced

From Ricciardi et al. (2012):

“In 1991, it was discovered in the Baltic Sea within the Gulf of Finland and subsequently spread 200 km along the Scandinavian coast (Lundberg and Svensson, 2004; Salemaa and Hietalahti, 1993). It was also recorded in the Rhine River basin [Switzerland, Liechtenstein, Austria, Germany, France, the Netherlands] in 1997, the River Main [Germany] in 1998, the Danube River [Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania, Moldova, Ukraine] in 1999, the Trent River and surrounding areas of the English Midlands by 2004, and the River Shannon in Ireland by 2009 (bij de Vaate et al., 2002; Borcherding et al., 2006; Dumont, 2006; Minchin and Boelens, 2010; Stubbington et al., 2008).”

From Kestrup and Ricciardi (2008):

“An invasive Ponto-Caspian shrimp, the bloody-red mysid *Hemimysis anomala*, is recorded for the first time in the St. Lawrence River near Montreal [Canada].”

“The mysids were discovered in samples collected from a single site (Chateauguay West) situated on the south shore of the river across from the Island of Montreal; […]”

“Although it is premature to conclude that the species is established in the river, the presence of multiple life stages and gravid females in our samples suggests that *H. anomala* has already formed one or more reproducing populations along the 250 km fluvial corridor between Lake Ontario and the Chateauguay West [St. Lawrence River] site.”

Means of Introduction Outside the United States

From Kipp et al. (2022):

“It was intentionally stocked in reservoirs of the Dnieper and Volga Rivers during the 1950s and '60s (Mordukhai-Boltovskoi 1979; Bubinas 1980; Pligin and Yemel'yanova 1989; Komarova 1991). […] Some of these introductions likely occurred via ballast water release, whereas most dispersal occurred through canals (bij de Vaate et al. 2002; Salemaa and Hietalahti 1993). *H. anomala* is considered to be more invasive than several other Ponto-Caspian mysids currently expanding their ranges in Europe (Wittman 2006).”

From Marty et al. (2010):

“In the middle of the twentieth century, Ponto-Caspian crustaceans were deliberately introduced to lakes and reservoirs in eastern Europe with the intention of increasing fish production. A few decades later, several of the introduced species had extended their distribution to western Europe (Wittmann, 2007; Audzijonyte et al., 2008; Dumont & Muller, 2009) […].”

Short Description

From Kipp et al. (2022):

“This freshwater shrimp can be ivory-yellow in color or translucent, but exhibits pigmented red chromatophores in the carapax and telson (Janas and Wysocki 2005; Salemaa and Hietalahti 1993). The intensity of coloration varies with contraction or expansion of the chromatophores in response to light and temperature conditions; in shaded areas, individuals tend to have a deeper red color (Ketelaars et al. 1999; Pothoven et al. 2007; Salemaa and Hietalahti 1993). Juveniles are more translucent than adults (Ketelaars et al. 1999). Preserved individuals may lose their color. *H. anomala* is distinguishable from other mysid species including the Great Lakes' native opossum shrimp *Mysis relicta* (identified in some recent scientific literature as *Mysis diluviana*) by its truncated telson (tail) with a long spine at both corners; by contrast, *M. diluviana* has a forked telson (Holdich et al. 2006; Ketelaars et al. 1999; Salemaa and Hietalahti 1993).”

Biology

From Kipp et al. (2022):

“Their tendency to aggregate creates locally dense swarms up to several square meters in area (Dumont 2006). *H. anomala* breeds from April to September/October. Sexual maturity occurs in <45 days. Females become ovigerous at 8–9°C and produce 2 to 4 broods per year. Brood size is correlated with female length and ranges from 6 to 70 embryos per individual (Ketelaars et al. 1999; Salemaa and Hietalahti 1993; Borcherding et al. 2006). Extremely high densities of *H. anomala* (up to >6 ind/L) have been recorded in some invaded European reservoirs (Ketelaars et al. 1999).”

“*H. anomala* is an opportunistic omnivore that feeds primarily on zooplankton, particularly cladocerans, but also consumes detritus (plant and animal remains), phytoplankton (particularly green algae and diatoms), and insect larvae, and is occasionally cannibalistic (Ketelaars et al. 1999; Borcherding et al. 2006; Dumont 2006). Younger individuals (< 4mm total length) feed mainly on phytoplankton. The proportion of zooplankton consumed in the mysid's diet increases with its body size (Borcherding et al. 2006). A bloody-red mysid feeds using its thoracic limbs, either by capturing prey with its endopods or by removing food particles from its body that are filtered from incoming currents by its exopods (Borcherding et al. 2006; Ketelaars et al. 1999).”

Human Uses

From Great Lakes Environmental Research Laboratory (2022):

"[…] mysids are also used by aquarists as a high-nutrition food for aquarium fish, although we have not found any records that *Hemimysis* is used this way."

Diseases

No information was found associating *Hemimysis anomala* with any diseases listed by the World Organisation for Animal Health (2022).

No information on diseases of *H. anomala* was found.

Threat to Humans

No information was found on threats to humans from *Hemimysis anomala*.

3 Impacts of Introductions

From Ketelaars et al. (1999):

"A new Ponto–Caspian invader, the mysid *Hemimysis anomala* G.O. Sars, 1907 (Crustacea: Mysidacea) was recorded for the first time in the Netherlands in 1997. In the summer of 1998 extremely high densities (>6 ind. l^{-1}) of this neozoon were recorded in one of the Biesbosch reservoirs (Honderd en Dertig). This high abundance can not be explained by a recent invasion. Either *H. anomala* reached the Netherlands via the River Rhine, probably aided by shipping, or through transport with ballast water from the Baltic or Black Sea. The invasion had dramatic effects on the zooplankton composition and abundance: from the end of August onwards hardly any Anomopoda, Ostracoda, Rotifera and invertebrate predators (*Leptodora kindti* and *Bythotrephes longimanus*) were present. Copepod densities, however, were not influenced. Chlorophyll-a concentrations were significantly lower compared to previous years, possibly the result of mysids feeding on the algae. Laboratory experiments revealed that *H. anomala* is a voracious predator and also an omnivorous feeder."

"Several lines of evidence point toward *H. anomala* as the cause for declines in other zooplankton and phytoplankton biomass. Truly dramatic changes in zooplankton were observed. *Daphnia* spp., *Bosmina* spp., Rotifera and Ostracoda practically disappeared from the zooplankton, a unique phenomenon in the Biesbosch reservoirs. The disappearance of the carnivorous *B. longimanus* and *Leptodora kindti* from the plankton after mid-August could be the result of competition for food or predation by *H. anomala*. The latter is the most likely because *B. longimanus* has been found in the stomachs of *M. relicta* (Fürst et al., 1978, in Langeland, 1981) and both predatory cladocerans were consumed by *H. anomala* in our laboratory feeding experiments […]. In comparison with previous years, however, no significant difference was found. High densities of *B. longimanus* in July 1998 account for not significantly different densities compared to previous years. No significant difference for *L. kindti* can be explained by very variable densities in the three previous years. *Chydorus sphaericus* was also absent from the plankton, but this is known to occur from time to time, mainly depending on

phytoplankton composition. The higher densities of *Dreissena polymorpha* larvae in 1998 are probably not a consequence of the invasion; densities are very variable at this time of year."

From Marty et al. (2010):

"The European introductions resulted in mild to severe modifications of existing habitats and food webs, causing extinction of local species in some instances (Ricciardi, 2007). Among these invasive Ponto-Caspian species was *Hemimysis anomala* (hereafter just *Hemimysis*), the bloody red shrimp."

"Impacts of *Hemimysis* on the lower food web have been reported in Europe in relation to size-selective feeding, with smaller individuals (<3 mm) feeding mostly on algal material and larger individuals (>3 mm) relying on zooplankton (Borcherding et al., 2006). Overall, the combined effect of high *Hemimysis* densities and high feeding rates led to a reduction of both algal and zooplankton biomass (Ketelaars et al., 1999). Because of its diurnal activity cycle, dominated by daylight hiding behavior, *Hemimysis* may avoid heavy fish predation, thereby altering patterns of energy flow to higher trophic levels (Kipp & Ricciardi, 2007)."

From Sinclair et al. (2016):

"To investigate the effects of *Hemimysis* on native zooplankton, we conducted two mesocosm experiments that compared composition between communities with and without *Hemimysis* and studied how the effects of this predator on zooplankton species composition varied across a natural gradient of low to high invader densities (0.01-0.1 individuals$\cdot L^{-1}$). Our first experiment found that *Hemimysis* primarily affected cladocerans, and particularly *Daphnia*, shifting communities towards dominance by copepods. Our second experiment showed that *Hemimysis* invasions may do little to suppress *Daphnia* abundances until between 0.067-0.11 individuals$\cdot L^{-1}$ or higher. Cladocerans are important links in freshwater trophic transfer and the nutrient cycle, and disruption of these linkages following *Hemimysis* invasion could result in both bottom-up and top-down impacts in nearshore food webs. However, *Hemimysis* can also fill a similar trophic role as the zooplankton they consume, and longer-term experiments are required to better assess their eventual impacts on native communities."

Hemimysis anomala is listed as a prohibited invasive species in New York and Wisconsin (New York Department of State 2022, Wisconsin State Legislature 2022).

4 History of Invasiveness

The History of Invasiveness for *Hemimysis anomala* is classified as High. This species is not utilized in trade, although it has been introduced deliberately outside of its native range in Europe to increase fishery productivity. Other pathways of its spread include ballast water release and dispersal through manmade waterways. *H. anomala* has a history of negative impacts where introduced: multiple sources report alterations to the food web and zooplankton community in areas where it has been introduced in Europe.

5 Global Distribution

Figure 1. Reported global distribution of *Hemimysis anomala*. Map from GBIF Secretariat (2022). Observations are reported from the Great Lakes Basin in North America, the Don River Delta in Russia, and in Ireland, the United Kingdom, the Netherlands, France, Belgium, Finland, Estonia, Switzerland, Germany, and Sweden.

Georeferenced observations were not available to represent the complete native range for *H. anomala*. In figure 1, only the record in the Don River Delta near the Sea of Azov represents a native occurrence of this species. Additional occurrences provided by Audzijonyte et al. (2008), including some in the species' native range, were included in climate matching analysis.

6 Distribution Within the United States

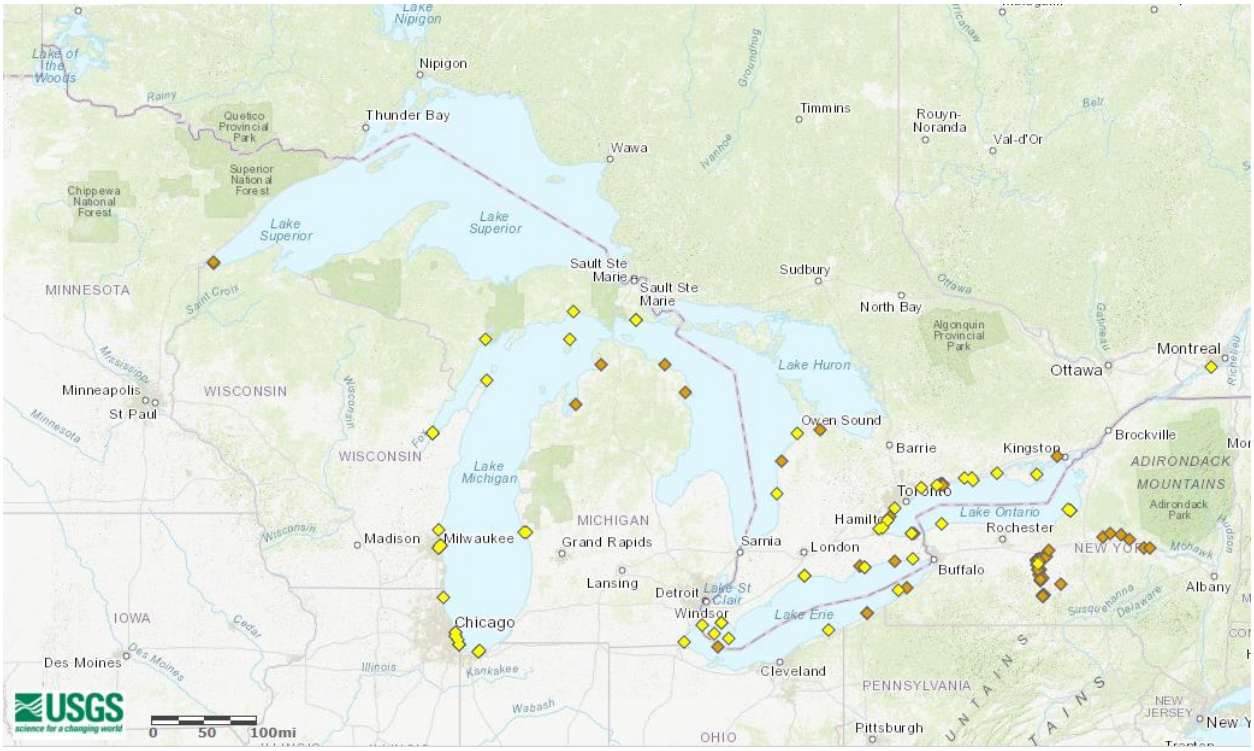

Figure 2. Reported distribution of *Hemimysis anomala* in the United States. Map from Kipp et al. (2022). Observations are reported from Illinois, Indiana, Michigan, New York, Pennsylvania, and Wisconsin. Points highlighted in yellow represent known established populations.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Hemimysis anomala* was highest in the Great Lakes basin, where the species is already present, and surrounding areas of the Northeast and Northern Plains. Smaller, isolated areas of high climate match occurred in the Great Basin and Colorado Plateau. The climate match was low along much of the West Coast and the Gulf Coast, as well as the Desert Southwest. Much of the interior contiguous United States had a medium climate match. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.740, indicating that Yes, there is establishment concern for this species. The Climate 6 score is calculated as: (count of target points with scores ≥ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Hemimysis anomala* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

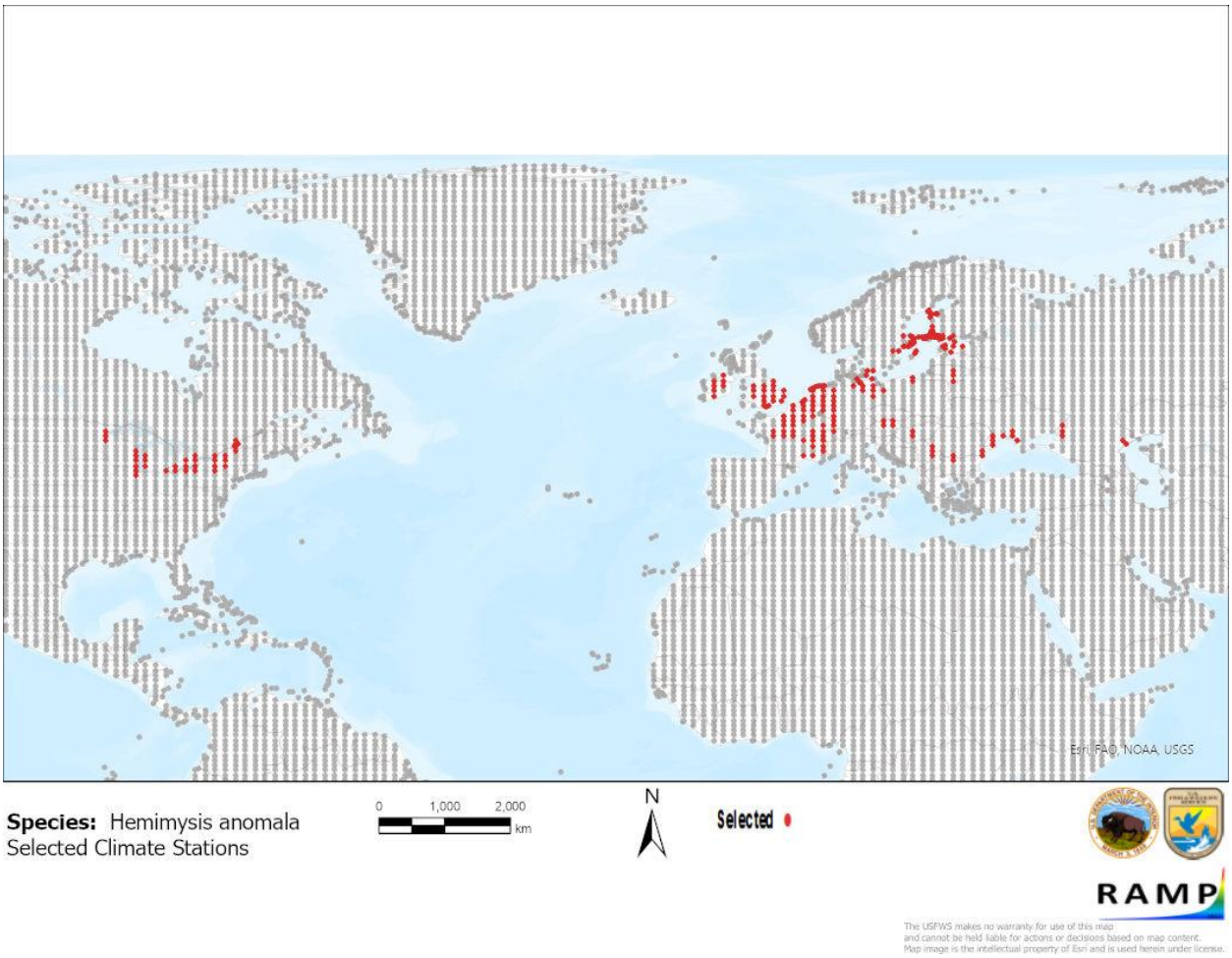

Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations in Europe and North America selected as source locations (red; United States, Canada, Ukraine, Russia, Bulgaria, Serbia, Romania, Hungary, Poland, Ireland, the United Kingdom, the Netherlands, France, Belgium, Finland, Estonia, Lithuania, Switzerland, Germany, Austria, and Sweden) and non-source locations (gray) for *Hemimysis anomala* climate matching. Source locations from GBIF Secretariat (2022) and Audzijonyte et al. (2008). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

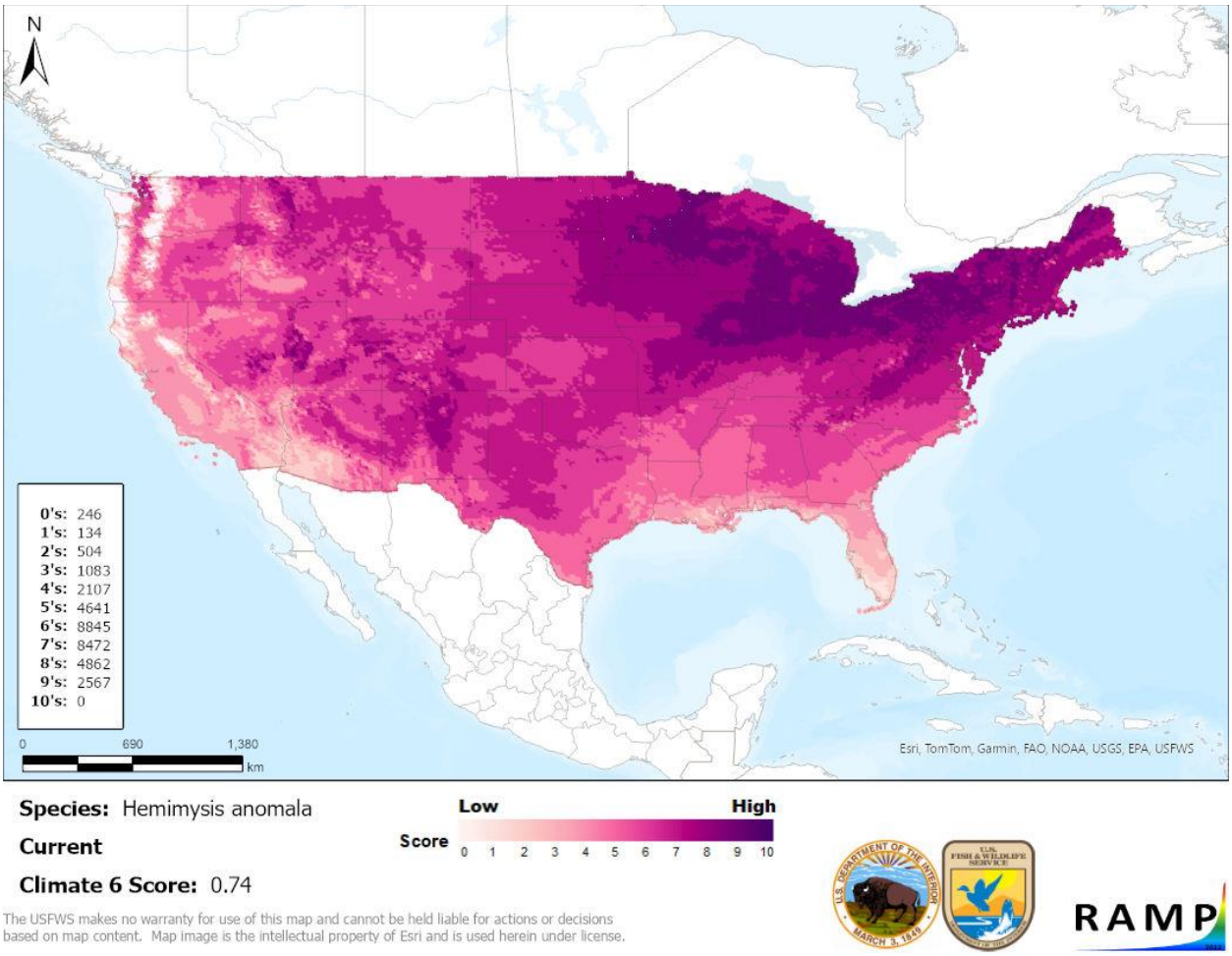

Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Hemimysis anomala* in the contiguous United States based on source locations reported by GBIF Secretariat (2022) and Audzijonyte et al. (2008). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Hemimysis anomala* is classified as High. Information on the biology, distribution, and spread of *H. anomala* is widely available for populations of this species in Europe. Negative impacts from introductions of this species throughout Europe are adequately documented in the scientific literature. Some of the native range of the species may not be represented in the source points of the climate match but it is not thought to be enough to affect the interpretation of the climate match results.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Hemimysis anomala, the Bloody Red Shrimp, is a crustacean that is native to the nearshore habitats in the Ponto-Caspian region. It has spread widely throughout Europe through deliberate introductions to support fisheries, accidental transport in ship ballast, and dispersal through canal

systems. This species has been introduced to the Great Lakes via ballast water. The states of New York and Wisconsin have prohibited possession of this species. The History of Invasiveness for *Hemimysis anomala* is classified as High due to multiple negative impacts of its introduction documented in Europe including changes in zooplankton communities and changes in food webs. The climate matching analysis for the contiguous United States indicates establishment concern for this species. The climate match was highest in the area surrounding the Great Lakes basins, where the species has already been documented. The Certainty of Assessment for this ERSS is classified as High. The Overall Risk Assessment Category for *Hemimysis anomala* in the contiguous United States is High.

Assessment Elements

- **History of Invasiveness (see section 4): High**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): High**
- **Remarks, Important additional information: Species is cryptic and may be difficult to detect.**
- **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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Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2022) and Audzijonyte et al. (2008).

Under the future climate scenarios (figure A1), on average, high climate match for *Hemimysis anomala* was projected to occur in the Great Lakes region of the contiguous United States. Under all scenarios there were patches of high match through the Western Mountains. Areas of low climate match were projected to occur in the Gulf Coast, Northern Pacific Coast, and Southern Florida regions. In the 2085 time steps, additional areas of low match occurred in California and the Desert Southwest. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.159 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.627 (model: MPI-ESM1-2-HR, SSP3, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.740, figure 4) falls above the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under one or more time step and climate scenarios, areas within the Colorado Plateau saw a moderate increase in the climate match relative to current conditions. Under the 2055 time steps, there were small areas of moderate increase in the northern Great Lakes. No large increases were observed regardless of time step and climate scenarios. Under one or more time step and climate scenarios, areas within the Appalachian Range, Colorado Plateau, Great Lakes, Gulf Coast, Mid-Atlantic, Northeast, Northern Plains, Southeast, Southern Atlantic Coast, Southern Plains, and Southwest saw a large decrease in the climate match relative to current conditions. Additionally, areas within California, the Great Basin, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. The degree of decrease was greater at the 2085 time step relative to the 2055 time step. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).

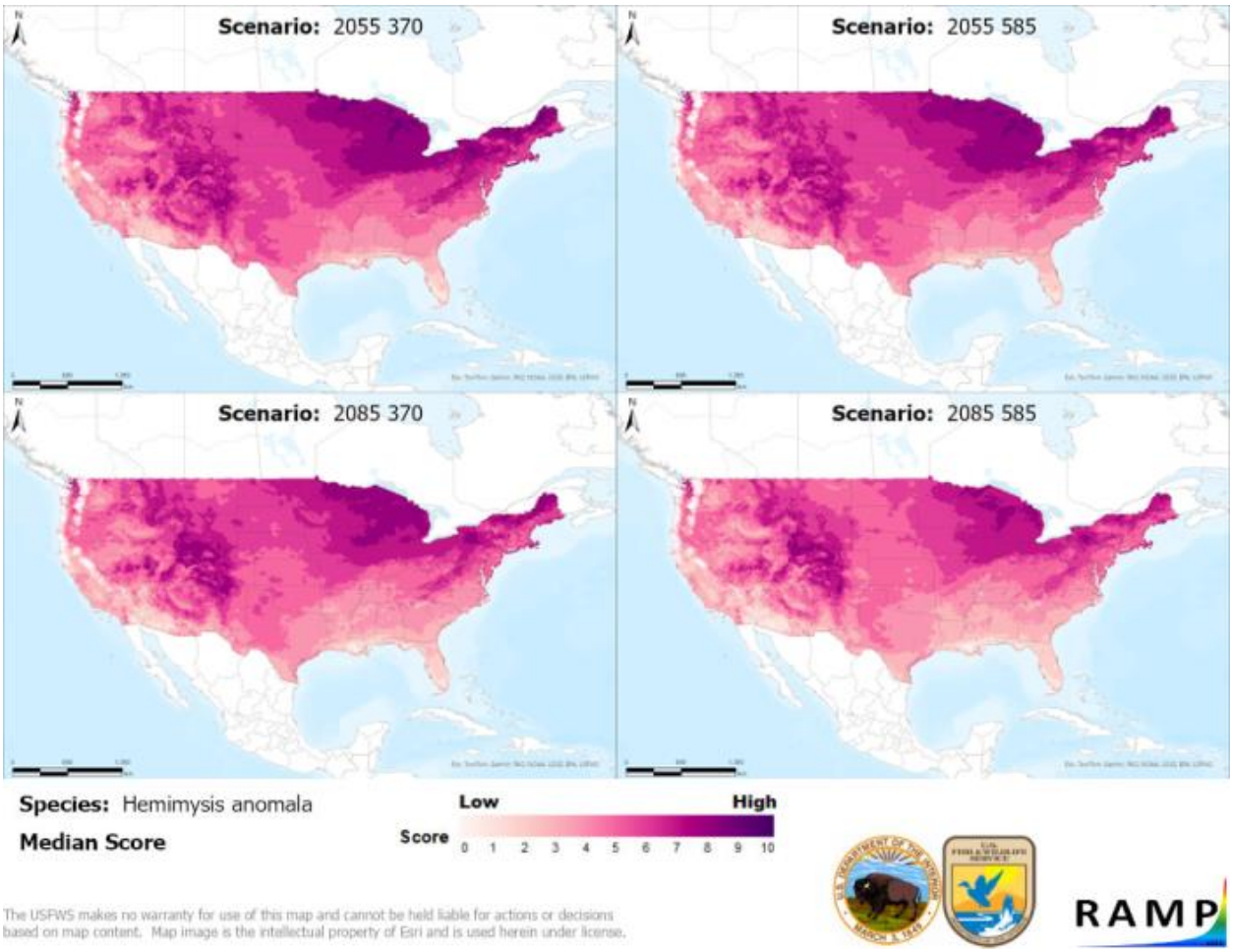

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Hemimysis anomala* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2022) and Audzijonyte et al. (2008). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

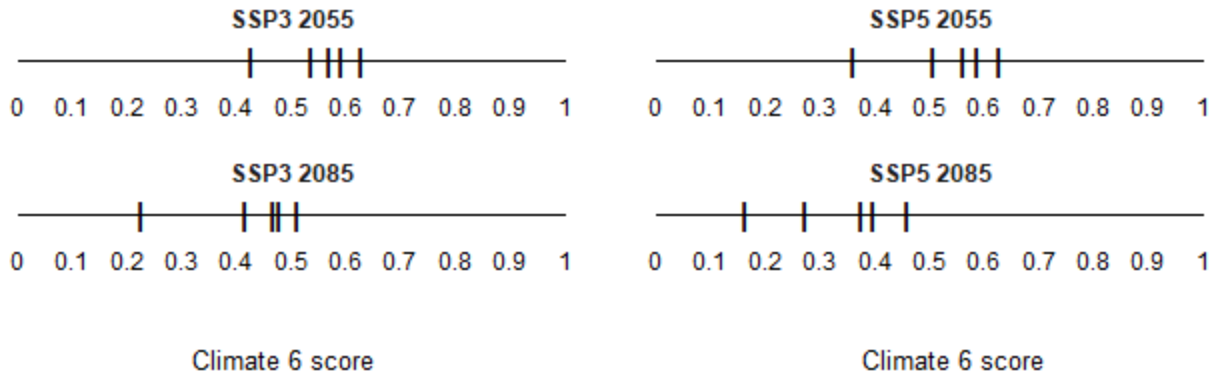

Figure A2. Comparison of projected future Climate 6 scores for *Hemimysis anomala* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

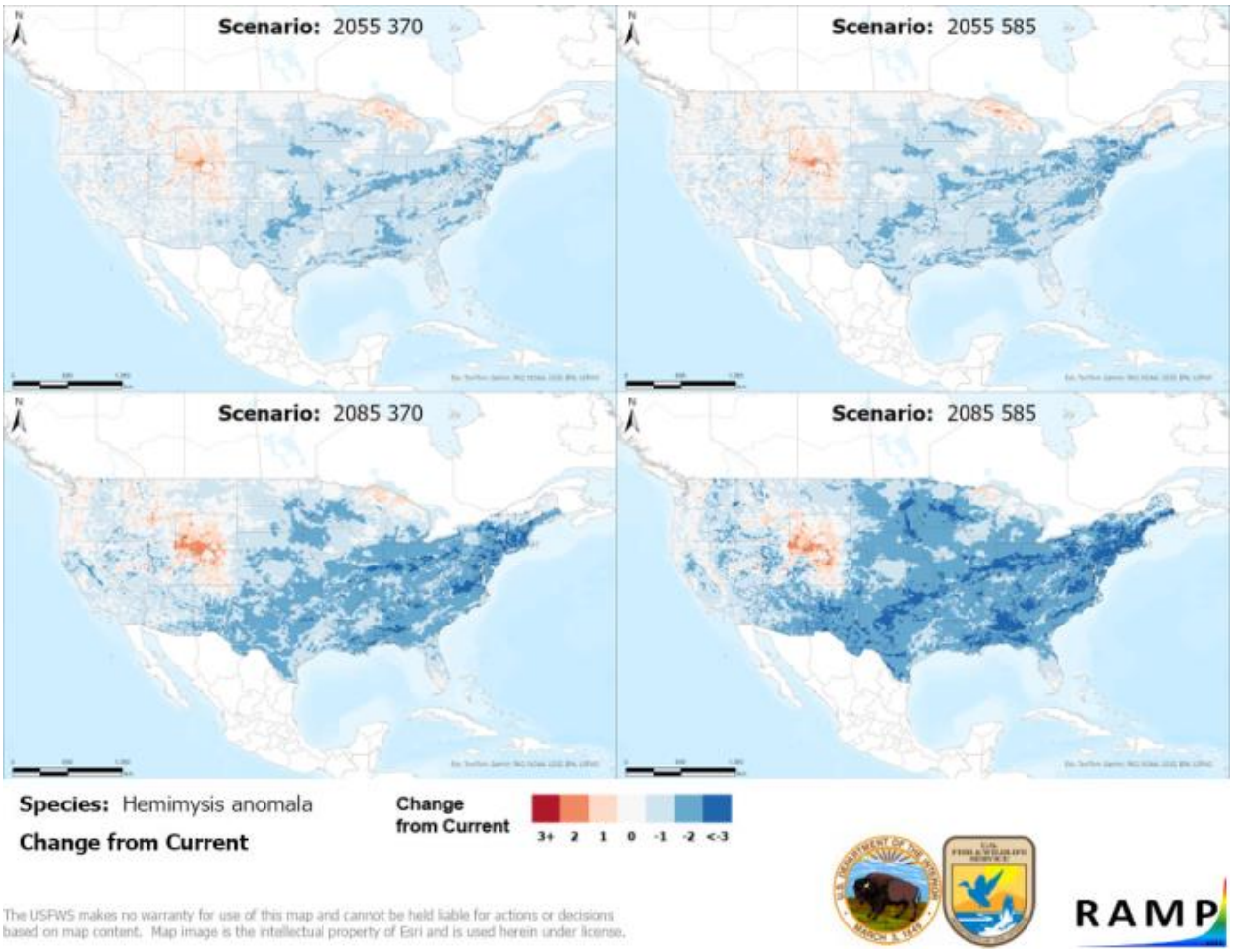

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Hemimysis anomala* based on source locations reported by GBIF Secretariat (2022) and Audzijonyte et al. (2008). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

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