Bloody Red Shrimp (*Hemimysis anomala*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, February 2011
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1 Native Range and Status in the United States

Native Range

From Kipp et al. (2018):

"*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. (2018):

"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.). A population density of 0.5 ± 0.1 individuals/L recorded at the Lake Michigan site (Pothoven et al. 2007) is already within the range found in some European reservoirs invaded by *H. anomala*, and is higher than maximum densities recorded for several other mysids (Ketelaars et al. 1999)."

"H. 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."

From Marty et al. (2010):

"Since 2006, the known distribution of *Hemimysis anomala* has greatly expanded in the Great Lakes ecosystem, with, to date, 45 sites of occurrence among 91 monitored sites, located in four of the Great Lakes and the upper St. Lawrence River."

"*Hemimysis* is now well distributed throughout the Great Lakes, having successfully invaded at least four of the lakes. Its status in Lake Superior and inland lakes within the Great Lakes watershed is unclear, as little sampling has been conducted there to date. If *Hemimysis* have invaded the nearshore waters sampled by boat during this survey, then their densities are so low that they are not easily detected using vertical net hauls."

Means of Introductions in the United States

From Kipp et al. (2018):

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

Remarks

From Kipp et al. (2018):

"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. *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."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2018):

"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"

"Taxonomic Status: valid"

Size, Weight, and Age Range

From Kipp et al. (2018):

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

Environment

From Kipp et al. (2018):

"Most mysid species are found in marine environments, but 3% (25 species) inhabit fresh to brackish water. *Hemimysis anomala* is a brackish-water mysid able to adapt to freshwater environments (Pienimäki and Leppäkoski 2004; Jazdzewski et al. 2005). 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). Individuals remain near profundal sediments during the day, migrate in swarms to the upper water column at twilight, then return to the profundal zone at dawn (Borcherding et al. 2006; Janas and Wysocki 2005). Only males tend to undergo these migrations. Juvenile *H. anomala* often inhabit different positions (usually higher) in the water column than adults, possibly to avoid cannibalism (Ketelaars et al. 1999). Being more transparent, juveniles may be less at risk of fish predation than adults. The adults are fast swimmers, moving at several centimeters per second when alarmed (Borcherding et al. 2006). Bloody-red mysids have been collected at depths ranging from 0.5 m to 50 m, although they generally inhabit 6 m to 10 m depths (Salemaa and Hietalahti 1993). They favor rocky substrate (Janas and Wysocki 2005), are less abundant on soft sediments, and are usually scarce in areas of dense vegetation or high siltation (Pothoven et al. 2007). They generally avoid areas where other mysid species are found (Salemaa and Hietalahti 1993)."

Climate/Range

From Kipp et al. (2018):

"It tolerates salinity concentrations of 0–19 ppt (bij de Vaate et al. 2002; Borcherding et al. 2006) and prefers water temperatures of 9–20°C. Populations may survive temperatures of 0°C over winter, but not without substantial mortality (Borcherding et al. 2006)."

Distribution Outside the United States

Native

From Kipp et al. (2018):

"*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 Kipp et al. (2018):

This Ponto-Caspian species […] has an extensive recent invasion history in Europe (Ricciardi and Rasmussen 1998). It was discovered in the Baltic Sea in the Gulf of Finland in 1992 and subsequently spread 200 km along the coast (Salemaa and Hietalahti 1993; Lindberg and Svensson 2004). […] It was recorded in the Rhine River in 1997 (Borcherding et al. 2006), the Netherlands by 1998, Belgium by 1999, and the United Kingdom by 2004 (Holdich et al. 2006)."

Means of Introduction Outside the United States
From Kipp et al. (2018):

"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)."

Short Description
From Kipp et al. (2018):

"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. (2018):

"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 Kipp and Ricciardi (2007):

"[…] 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 OIE reportable diseases have been documented for this species.

Threat to Humans

No information has been reported for this species.

3 Impacts of Introductions

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 Kipp et al. (2018):

"A) *Realized:* There are no recorded impacts yet associated with the recent introduction of this species to the Great Lakes.

B) *Potential:* Ponto-Caspian mysids differ from the North American mysid *Mysis relicta*, by their adaptation to warmer temperatures (Bondarenko and Yablonskaya 1979). Therefore, *H. anomala* could become abundant in many areas of the Great Lakes that are currently devoid of mysids. Judging by its impacts in some European reservoirs (Ketelaars et al. 1999), *H. anomala* may reduce zooplankton biomass and diversity in these areas, with cladocerans, rotifers and ostracods being most affected. *H. anomala* may compete with, or prey upon, other invertebrate predators, such as *Bythotrephes longimanus* and *Leptodora kindti*. Its omnivory may also reduce local phytoplankton if small-sized juvenile mysids are abundant (Ketelaars et al. 1999); however, phytoplankton biomass typically increases (sometimes doubling) in lakes following mysid invasions (Borcherding et al. 2006). *Hemimysis* feeds rapidly, even at low prey densities, and its fecal pellets may alter the local physico-chemical environment (Ketelaars et al. 1999; Olenin and Leppäkoski 1999; Pienimäki and Leppäkoski 2004). *Hemimysis anomala* is considered a high-energy food source due to its lipid content, which can increase growth rates for planktivores (Borcherding et al. 2006). In some lakes mysid (*Mysis spp*.) introductions have preceded the increased growth of salmonids, whereas in other lakes they are associated with rapid declines in abundance and productivity of pelagic fishes (Lasenby et al. 1986; Langeland et al. 1991; Spencer et al. 1991). A mysid introduction can also increase the biomagnification of contaminants in piscivores, through a lengthening of the food chain; for example, concentrations of polychlorinated biphenyls and mercury in fishes have been shown to be higher in lakes containing mysids than in mysid-free lakes (cf. Rasmussen et al. 1990; Cabana et al. 1994). Furthermore, through direct transmission and indirect effects on the food web, introduced mysids may cause increased parasitism by nematodes, cestodes and acanthocephalans in fishes (Lasenby et al. 1986; Northcote 1991)."

From Pathoven et al. (2007):

"[…] *H. anomala* possesses several life history features that may facilitate its establishment in new habitats including rapid growth and maturation (Ioffe et al. 1968, Ioffe 1973). In the Zaporozhie Reservoir, this mysid breeds from April to October producing four generations a year (Ioffe 1973). Ovigerous females appear when water temperatures reach 8–9°C and at 11–12°C females carry neonates in their marsupium. Females of the first generation born in late May (10–16°C) start to breed 45 days later; second and third generations reach sexual maturity in less than a month (Ioffe 1973)."

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."

4 Global Distribution

Figure 1. Known global distribution of *H. anomala*, reported from northeastern North America and from Europe. Map from GBIF Secretariat (2017).

5 Distribution Within the United States

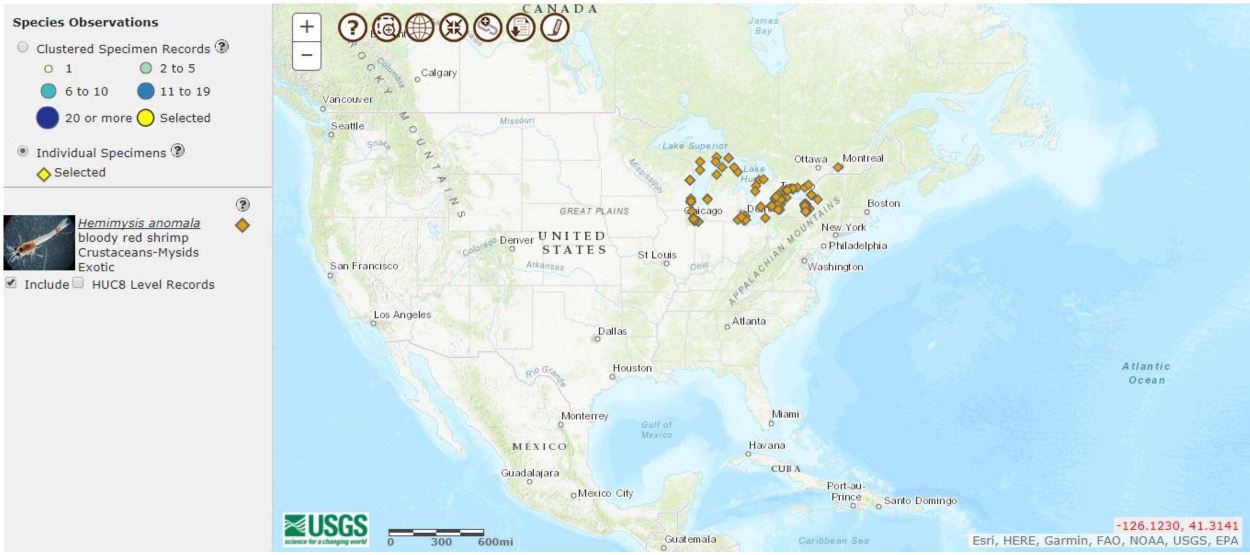

Figure 2. Known distribution of *H. anomala* in the United States. Map from Kipp et al. (2018).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match (Sanders et al. 2014; 16 climate variables; Euclidean Distance) was high in The Great Lakes region, the northwestern portion of New England, and in small areas from

Colorado up through Montana. Low matches occurred in Florida, the Gulf Coast, the Southwest, the Pacific Northwest, and California. Medium matches occurred throughout the rest of the country. Climate 6 match 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 *H. anomala* is 0.234.

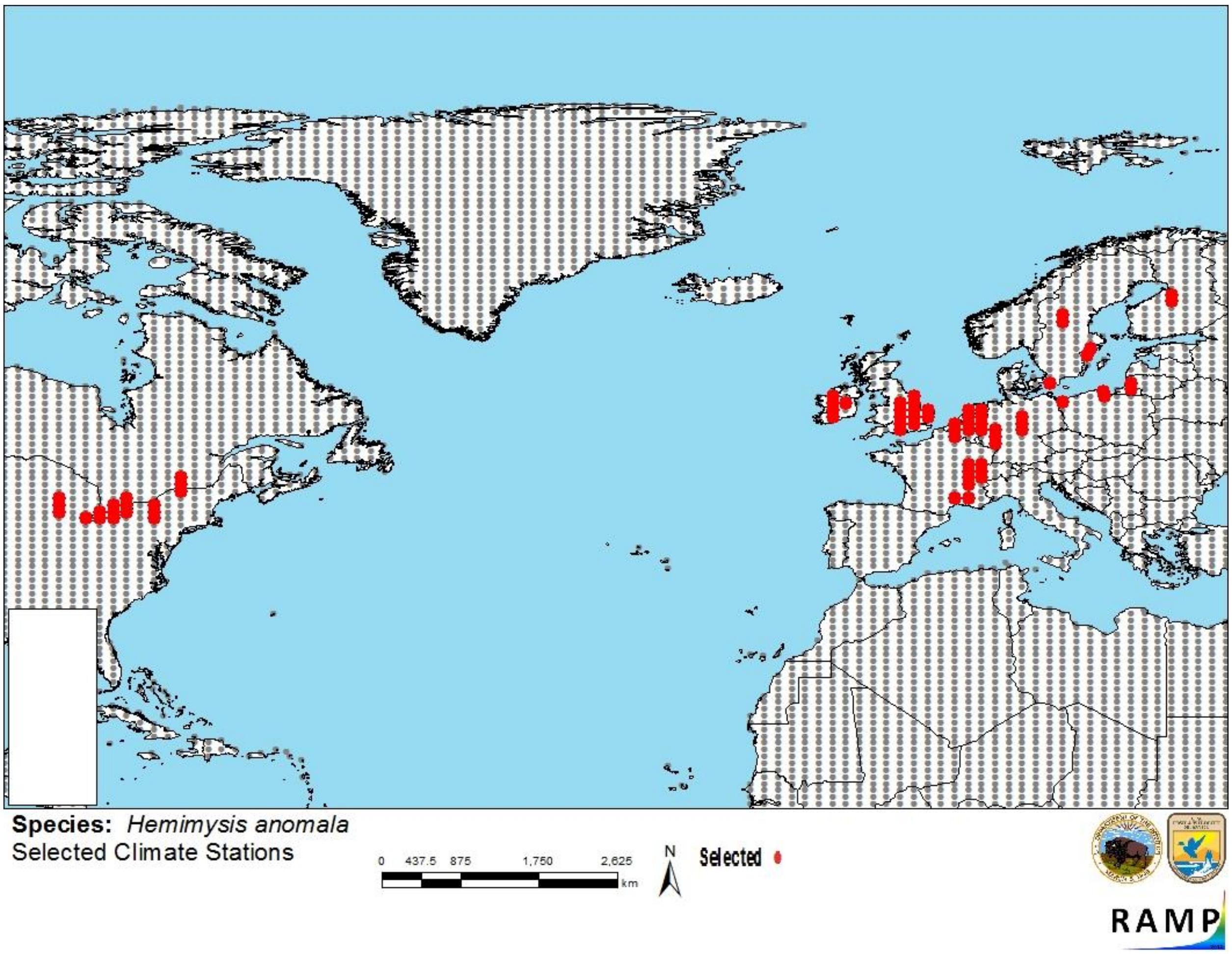

Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red; United States, Canada, Ireland, United Kingdom, Sweden, The Netherlands, Belgium, Germany, France, Switzerland, Finland) and non-source locations (gray) for *H. anomala* climate matching. Source locations from GBIF Secretariat (2017).

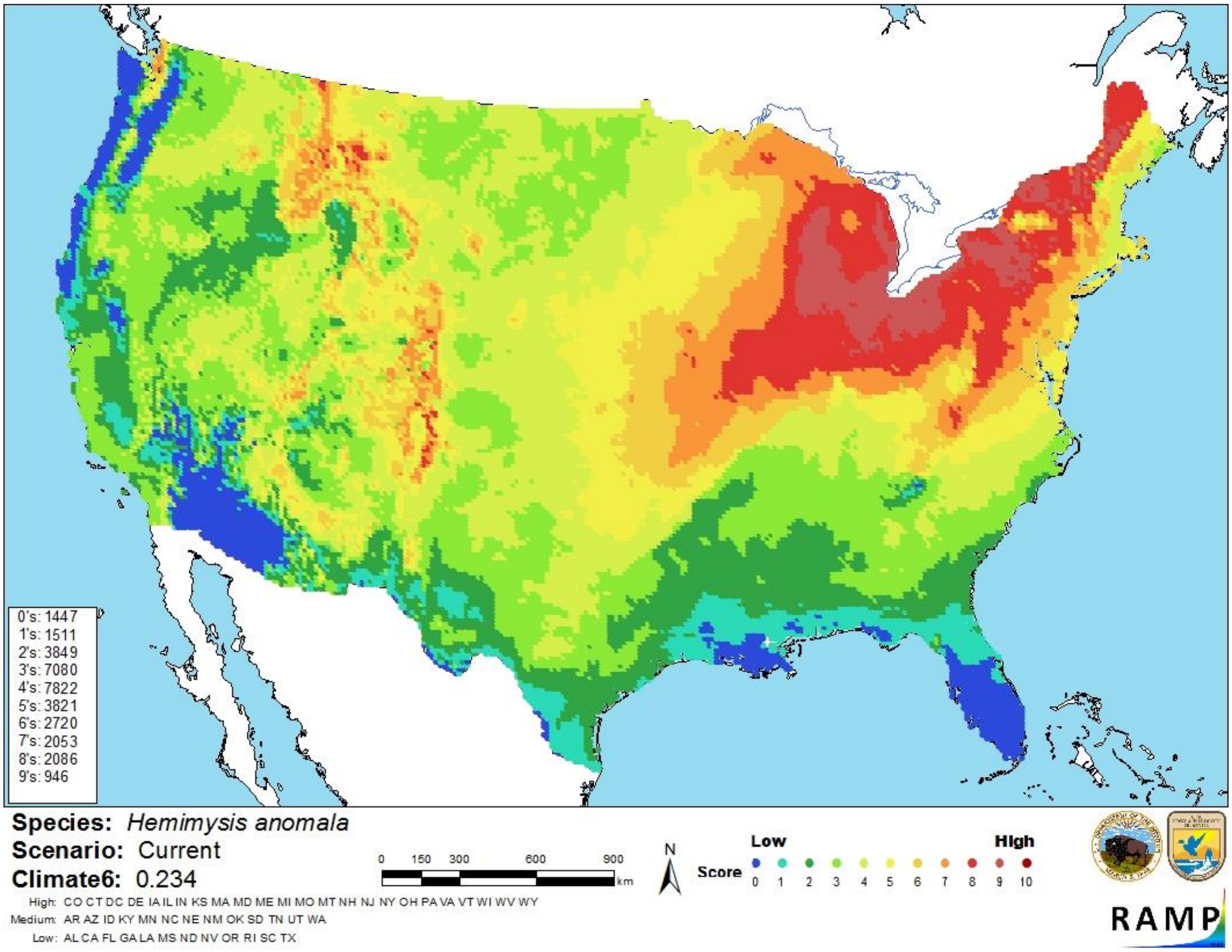

Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *H. anomala* in the contiguous United States based on source locations reported by GBIF Secretariat (2017). 0=Lowest match, 10=Highest match. Counts of climate match scores are tabulated on the left.

The "High", "Medium", and "Low" climate match categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

Information on the biology and distribution of *H. anomala* is widely available. Negative impacts from introductions of this species throughout Europe are adequately documented in the scientific literature. Kipp et al. (2018) explains that "there are no recorded impacts yet associated with the recent introduction of this species to the Great Lakes", but the list of potential impacts is long.

Further information is needed to evaluate the negative impacts the species is having in the United States. Certainty of this assessment is medium.

8 Risk Assessment

Summary of Risk to the Continental United States

Hemimysis anomala is a mysid native to freshwater margins of the Black Sea, the Azov Sea and the eastern Ponto-Caspian Sea. Though it is a brackish-water mysid, it is able to adapt to freshwater environments. This species has become established outside of its native range throughout Europe and the Great Lakes region of the United States. It is well documented that the establishment of *H. anomala* in Europe has led to a reduction of algal and zooplankton biomass and has altered patterns of energy flow to higher trophic levels. No conclusive impacts have been documented in the United States. Certainty of this assessment is medium. Climate match with the United States is high. Overall risk posed by this species is high.

Assessment Elements

- **History of Invasiveness (Sec. 3):** High
- **Climate Match (Sec. 6):** High
- **Certainty of Assessment (Sec. 7):** Medium
- **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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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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