Southern White River Crayfish (*Procambarus zonangulus*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, December 2022
Revised, February 2023
Web Version, 4/10/2025

Organism Type: Crustacean
Overall Risk Assessment Category: Uncertain

Photo: Dan Johnson. Licensed under CC BY 4.0. Available: https://www.inaturalist.org/photos/54007930 (December 2022).

1 Native Range and Status in the United States

Native Range

From Fofonoff et al. (2018):

"*Procambarus zonangulus* is a Gulf coastal plain species, native to eastern Texas and the Mississippi River, Louisiana (Deng et al. 1991) to possibly Alabama (Taylor [et al.] 1996)."

Status in the United States

From Durland Donahou (2022):

"The native range of *P. zonangulus* is uncertain, but is probably the Gulf Coast Plains of Texas and Louisiana, extending into portions of southern Arkansas (Hobbs and Hobbs 1990; Walls 2009)."

"Status: Established in Maryland and West Virginia (Loughman and Welsh 2010; Maryland Department of Natural Resources 2012). *Procambarus zonangulus* is likely established in Mississippi given its occurrence in multiple drainages. Status in Alabama and Louisiana is unknown, but given the proximity to the native range, these introductions are most likely established."

From Fofonoff et al. (2018):

"'Crawdads' imported from Louisiana have been raised on the lower Eastern Shore of Maryland (MD) and Virginia (VA) since 1980 (Associated Press 1986). These stocks consist of a mixture of *P. clarkii* and 'White River Crayfish' (Harrell 1987), most likely *P. zonangulus*. Recent surveys (Maryland Biological Stream Survey, Maryland Department of Natural Resources, 1996-2007) of crayfishes in MD have found *P. zonangulus* in three aquaculture ponds on the Eastern Shore, one in the Nanticoke River drainage and two in aquaculture ponds in the Pocomoke River drainage. However, it is possible that many crayfishes identified as *P. acutus* in the earlier years of the surveys (1989-1995) were actually *P. zonangulus* (Kilian et al. 2010). Further surveys, including examination of previously collected specimens from 1995 to 2012, found that *P. zonangulus* was widespread in the Chesapeake Bay watershed, with more than 700 records, ranging from nontidal Susquehanna and upper Bay tributaries to the middle and lower Potomac and the Eastern Shore. Collections in tidal waters include specimens from lower Potomac tributaries in Charles County, Mattawoman Creek, Nanjemoy Creek Zekiah Swamp Branch, and on the Eastern Shore in Dorchester County, Little Blackwater River (2006-20012, USGS Nonindigenous Aquatic Species Program 2017)."

From Durland Donahou (2022):

"*Procambarus zonangulus* is an economically important crayfish in aquaculture (Taylor and Schuster 2004). Many aquaculture ponds are stocked with both *P. clarkii* and *P. zonangulus*. Given that *P. clarkii* has an expansive introduced range, the introduced range of *P. zonangulus* is potentially much greater than reported (Walls 2009)."

From Crandall (2010):

"This species is commercially important as a food source, as research specimens and for the pet trade (K. Crandall pers. comm. 2009)."

Regulations

Procambarus zonangulus is regulated in Florida (FFWCC 2022) and Maryland (Code of Maryland Regulations 2022). It is regulated at the genus level (*Procambarus*) in Idaho (IDDA 2022) and Virginia (Virginia DWR 2022). It is regulated at the family level (Cambaridae) in Arizona (Arizona Game and Fish Commission 2022), California (CDFW 2021), New Mexico (NMDGF 2023; except species native to the State), Nevada (Nevada Board of Wildlife Commissioners 2022), Oregon (ODFW 2022), Utah (Utah DWR 2020), Washington (Washington DFW 2022), and Wisconsin (Wisconsin DNR 2022). All species of crayfish are regulated in Pennsylvania (PFBC 2022) and species not indigenous to New Hampshire are regulated in the State (NHFG 2022). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

Means of Introductions within the United States

From Fofonoff et al. (2018):

"The widespread occurrences suggest that bait releases as well as aquaculture and food-releases have contributed to the spread of this crayfish."

Remarks

From Fofonoff et al. (2018):

"*Procambarus zonangulus* is a member of the *Procambarus acutus* species complex, consisting of several similar species in the Mississippi-Gulf Basin and Atlantic drainages, whose systematics are still unresolved (Hobbs and Hobbs 1990; Kilian et al. 2010; Huner and Barr 1991)."

From Kilian et al. (2010):

"The presence of *P. zonangulus* in Maryland brings into question all records of native *P. acutus* collected since 1996, many of which involved field identifications, because differentiating *P. zonangulus* from *P. acutus* is difficult. Species-level identification requires a form I reproductive male and the use of magnification. It is unclear at this time if records of *P. acutus* from streams and rivers throughout Maryland's Coastal Plain […] include misidentified specimens of *P. zonangulus*."

From Crandall (2010):

"This species [*Procambarus zonangulus*] is known from Alabama, Louisiana, Mississippi and Texas. Owing to taxonomic problems with this species, the range is not clearly delineated. […] Fitzpatrick (2002) considers this species more restricted to eastern Louisiana, very southern Mississippi, and very southern Alabama. Recent surveys in Alabama have not found this species.

Johnson and Johnson (2008) describe this species distribution as the flat coastal plain from Texas to Louisiana, but midway along the Texas flat coastal plain, individuals have features of both this species and *P. texanus*."

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 Eucarida
Order Decapoda
Suborder Pleocyemata
Infraorder Astacidea
Superfamily Astacoidea
Family Cambaridae
Subfamily Cambarinae
Genus *Procambarus*
Subgenus *Procambarus*
Species *Procambarus zonangulus* Hobbs and Hobbs III, 1990

According to Crandall (2022) *Procambarus zonangulus* Hobbs and Hobbs III, 1990 is the current valid name for this species.

Size, Weight, and Age Range

From Durland Donahou (2022):

"Can be up to 13 cm total length (Taylor and Schuster 2004)."

From Fofonoff et al. (2018):

"These crayfish mature at ~30 mm carapace length (~60 mm total length) and frequently reach 50 mm (100 mm, total length, Deng et al. 1993). The largest reported specimen was 178 mm total length (Huner and Barr 1991)."

Environment

From Fofonoff et al. (2018):

"*Procambarus zonangulus*, like *P. clarkii*, tolerates salinities of 20-30 PSU (Huner and Barr 1991; Newsom and Davis 1994)."

"This is a freshwater species [...]"

Fofonoff et al. (2018) citing Huner and Barr (1991) and Newsom and Davis (1994), report that *P. zonangulus* tolerates water temperatures between 0 and 35°C, salinities between 0 and 20‰, and pH between 5.8 and 10.

From Swecker et al. (2010):

"This species is found in swamps, ponds, seasonally flooded low-lying areas, ditches, creeks, and moderately-sized rivers. They are typically found in slow moving water over small substrates, such as silt or sand."

Climate

From Fofonoff et al. (2018):

"Broad Temperature Range Warm-temperate"

Distribution Outside the United States

Native

The native range of *Procambarus zonangulus* is completely within the United States, see section 1.

Introduced

From Fofonoff et al. (2018):

"[…] *P. zonangulus* has, so far, only been reported from the Nile River, Egypt (Ibrahim et al. 1997, cited by Holdich et al. 2010)."

From Ibrahim et al. (1997):

"The two species coexist in mixed populations throughout most of the examined localities though *Procambarus clarkii* indicated remarkable predominance over *Procambanu zonangulus.* [sic] They, however, have established viable populations in the aquatic ecosystems of Giza, Cairo and some Nile Delta governorates."

From Aly et al. (2020):

"Previous studies indicate that two species of crayfish were introduced to the Egyptian aquatic ecosystem, *P. clarkii* and *P. zonangulus* (Fishar, 2006). During this study period [June 2014],

P. clarkii quantities were decreasing southwardly from Giza to Assiut while *P. zonangulus* was completely disappeared in [sic] the surveyed localities."

Means of Introduction Outside the United States

From Fofonoff et al. (2018):

"It is likely that it will be found in other locations where crayfish are cultured, or have been released as food."

Short Description

From Durland Donahou (2022):

"Body color is brown with a black wedge on dorsal abdomen (Walls 2009). Body color can vary; smaller individuals can be brown or tan with mottled spots (Huner 2002). Chelae possess numerous tubercles and small tubercles cover the carapace (Walls 2009). *Procambarus zonangulus* has long, narrow chelae with no space between dactyl and propodus when closed (Walls 2009). The areola of *P. zonangulus* is open, but narrow (Walls 2009). Often confused with *P. clarkii*, but there are distinct morphological differences, including a more open areola on *P. zonangulus* than on *P. clarkii* (Huner 2002). Without crayfish identification experience, *P. acutus* is indistinguishable from *P. zonangulus* (Swecker et al. 2010). *Procambarus zonangulus* has tapered gonopods, while *P. acutus* gonopods are a constant width (Walls 2009). In most *P. zonangulus* the ventral surface of the chelae is whitish, while they are a uniform color in *P. acutus* (Walls 2009)."

From Fofonoff et al. (2018):

"*Procambarus zonangulus* has an ovoid carapace and chelae (claws) covered with tubercles and granules. It has a prominent rostrum, which is strongly triangular with a median keel and a pointed tip. The two halves of the carapace are separated by a gap, whereas they join in *P. clarkii*. The chelae are somewhat narrow, cylindrical, and elongated, with a large gap at the base of the movable finger. The carpus or wrist joint bears three spines, one very large, on its interior edge. In the males, the 3rd segment (ischia) of the 3rd pair of walking legs bears copulatory hooks. The annulus ventralis (seminal receptacle) of the female is an ovoid structure located between the 4th and 5th pair of walking legs, with a sigmoid (a groove running across the center), and two groups of tubercles at the anterior border. Young Southern White River Crayfish are sandy-white, with black spots on the head, body, and tail. The adults are light brown, with a wide black stripe on the dorsal surface of the tail (Huner and Barr 1991)."

From Swecker et al. (2010):

"First form male gonopod elements with sloping shoulder and 4 elements with setae present; Rostral margins with accessory spines reduced; Areola present and separated; Distinctive dark stripe along tail; Carapace covered in tubercles producing a rough texture; Chela long and slender."

Biology

From Fofonoff et al. (2018):

"*Procambarus zonangulus* frequently co-occurs with *P. clarkii* (Red Swamp Crayfish), and is often lumped with it in ecological and aquaculture studies (Niquette and Dabrano 1991; Huner and Barr 1991). They are considered a 'tertiary burrowing' crayfish (primary burrowers burrow year-round, secondary burrowers leave the burrow during rainy periods, and tertiary burrowers inhabit the burrow during the breeding season and during droughts, but are found in open water the rest of the year). Freshwater crayfishes, of the family Cambaridae, mate by internal fertilization, with the male inserting pleopods into the females seminal (annulus ventralis) between the 4th and 5th walking legs. The female curls her abdomen far forward to create a chamber in which the eggs are driven by the pleopods. The mass of eggs becomes attached under the tail. Larval development takes place inside the egg and the young hatch as miniature adults (Barnes 1983)."

"*Procambarus zo*[*n*]*angulus* constructs burrows near the water's edge which are usually under 0.5 m in length, but may extend to 4.5 m depending on soil and moisture conditions. Burrows are often partly filled with water, but crayfish are frequently out of the water because of low oxygen concentrations (Correia and Ferreira 1995; Huner and Barr 1984). Overland movements may occur in response to heavy rains, flooding, or anoxia in burrow water (Huner 1989). In the early part of its life, it is found in deeper water (up to two or three feet) in marsh lagoons. As it attains maturity, and the spawning season approaches, it migrates to the shallow water of open marshes (usually less than six inches deep). […] Both *Procambarus* spp. are omnivorous, but in Texas sloughs, female *P. zonangulus* consumed more animal food than *P. clarkii* (Deng et al. 1993)."

Human Uses

From Crandall (2010):

"This species is commercially important as a food source, as research specimens and for the pet trade (K. Crandall pers. comm. 2009)."

From McClain and Romaire (2004):

"Louisiana was first known for its crawfish thriving capture fishery, where recreational and commercial fishermen harvested crawfish from the extensive wetlands of the lower Mississippi River floodplain. The red swamp (*Procambarus clarkii*) and white river (*P. zonangulus*) crawfishes […] Crawfish aquaculture is dominated by the same two species found in the capture fishery, mainly because these crawfish are native, large, hardy, prolific, adaptable to farming conditions and are readily recognized and accepted in the marketplace."

Diseases

***Procambarus zonangulus* has been documented as susceptible to or a carrier of *Aphanomyces astaci* (crayfish plague) and white spot syndrome virus, diseases listed by the World Organisation for Animal Health (2022).**

From Svoboda et al. (2017):

"Thanks to effective defence [sic] mechanisms against *A. astaci* growth in their cuticles, North American crayfish [includes *Procambarus zonangulus*] can act as chronic carriers of the disease (Soderhall & Cerenius 1999). It is likely that numerous North American crayfish species are *A. astaci* carriers in their native American range."

From Baumgartner et al. (2009):

"In the spring of 2007, 3 farms in St. Martin and Vermilion parishes, Louisiana, USA, reported significant mortalities in their crawfish ponds characterized by >90% mortality in traps, which are designed to capture large adults. […] Dead and dying crawfish (*Procambarus clarkii* and *P. zonangulus*) were submitted to the Aquatic Diagnostic Laboratory of the Louisiana Animal Disease Diagnostic Laboratory (LADDL; Louisiana State University School of Veterinary Medicine) for examination."

"Histological findings and ISH results in *Procambarus clarkii* and *P. zonangulus* corresponded to typical lesions reported for fulminant WSSV [white spot syndrome virus] infections in penaeid shrimp, i.e. a majority of cells in ectodermal and mesodermal tissues contained hypertrophied nuclei with variably staining large homogeneous inclusions and marginated chromatin (Lo et al. 1997, Wang et al. 1997)."

Threat to Humans

From Thimothe et al. (2002):

"We monitored the presence of *L. monocytogenes* and other *Listeria* spp. in the processing environment, in raw, whole crawfish, and in cooked crawfish meat from two processing plants to better understand the sources and prevalences of these microorganisms in the crawfish production system. […] A total of 78 samples of raw, whole crawfish were tested for *Listeria* spp. These crawfish represented the species *Procambarus clarkii* and *Procambarus zonangulus*. *P. clarkii* was the predominant species, making up about 80 to 90% of the crawfish examined. The overall prevalence of *Listeria* spp. in raw, whole crawfish was 29.5% […] Although *Listeria* spp. were isolated commonly from raw, whole crawfish, all finished product samples were negative for *Listeria* spp."

3 Impacts of Introductions

From Durland Donahou (2022):

"The impacts of this species are currently unknown, as no studies have been done to determine how it has affected ecosystems in the invaded range."

From Fofonoff et al. (2018):

"No ecological impacts have been reported for *Procambarus zonangulus*. However, its introduced population has only been surveyed in Maryland (Kilian et al. 2010; USGS

Nonindigenous Aquatic Species Program 2017). Potential impacts are probably similar to those of *P. clarkii*, including burrowing, destruction of aquatic vegetation, and competition with native crayfishes."

Procambarus zonangulus is regulated in the following states (see section 1): Arizona (Arizona Game and Fish Commission 2022), California (CDFW 2021), Florida (Florida Fish and Wildlife Conservation Commission 2022), Idaho (IDDA 2022), Maryland (Code of Maryland Regulations 2022), California (California Department of Fish and Wildlife 2021), Nevada (Nevada Board of Wildlife Commissioners 2022), New Hampshire (NHFG 2022), New Mexico (NMDGF 2023), Oregon (Oregon Department of Fish and Wildlife 2022), Pennsylvania (PFBC 2022), Utah (Utah Division of Wildlife Resources 2020), Virginia (Virginia DWR 2022), Washington (Washington Department of Fish and Wildlife 2022), and Wisconsin (Wisconsin Department of Natural Resources 2022).

4 History of Invasiveness

The history of invasiveness for *Procambarus zonangulus* is Data Deficient. There are records of established populations beyond this species' native range in eastern Maryland, northeast West Virginia, Mississippi, and coastal Alabama. *P. zonangulus* has also been reported as introduced to Egypt, however recent surveys did not detect this species. No information was found regarding impacts of those introductions. *P. zonangulus* is used in trade as a commercial food source, however, no information on volume or duration of trade was available.

5 Global Distribution

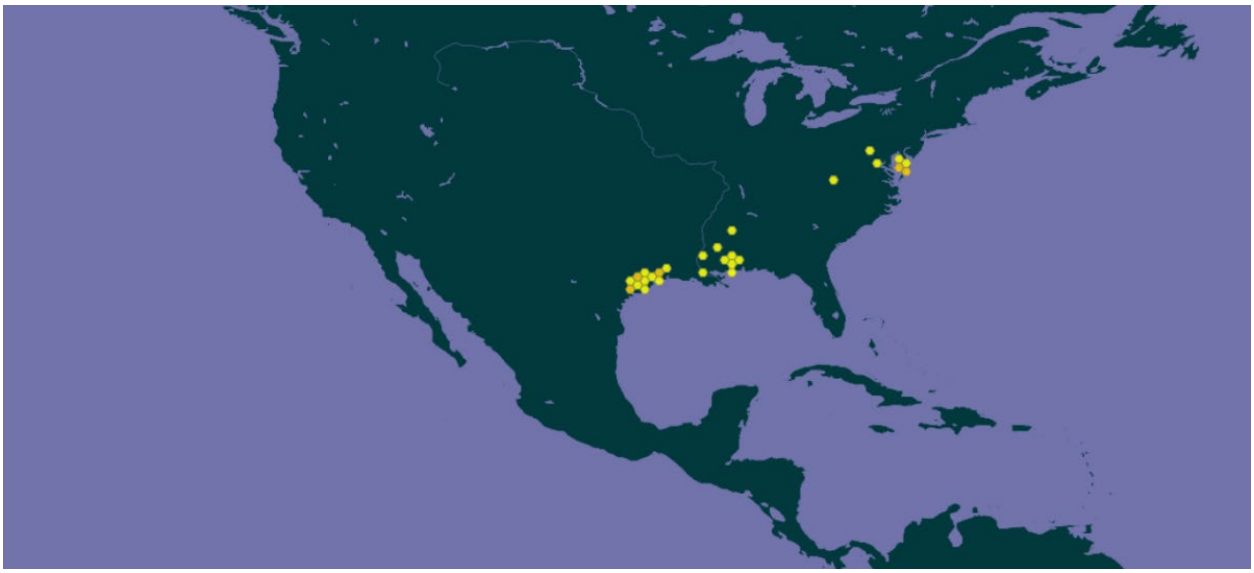

Figure 1. Reported global distribution of *Procambarus zonangulus*. Map from GBIF Secretariat (2022). Observations are reported from the United States in Texas, Louisiana, Mississippi, Alabama, West Virginia, Virginia, and Maryland. The point in western Virginia was excluded

from the climate matching analysis because it occurred outside the documented range of *P. zonangulus.*

No georeferenced occurrence points for the species' reported distribution in Egypt were found. Aly et al. (2020) indicated that *P. zonangulus* may no longer be extant in Egypt.

6 Distribution Within the United States

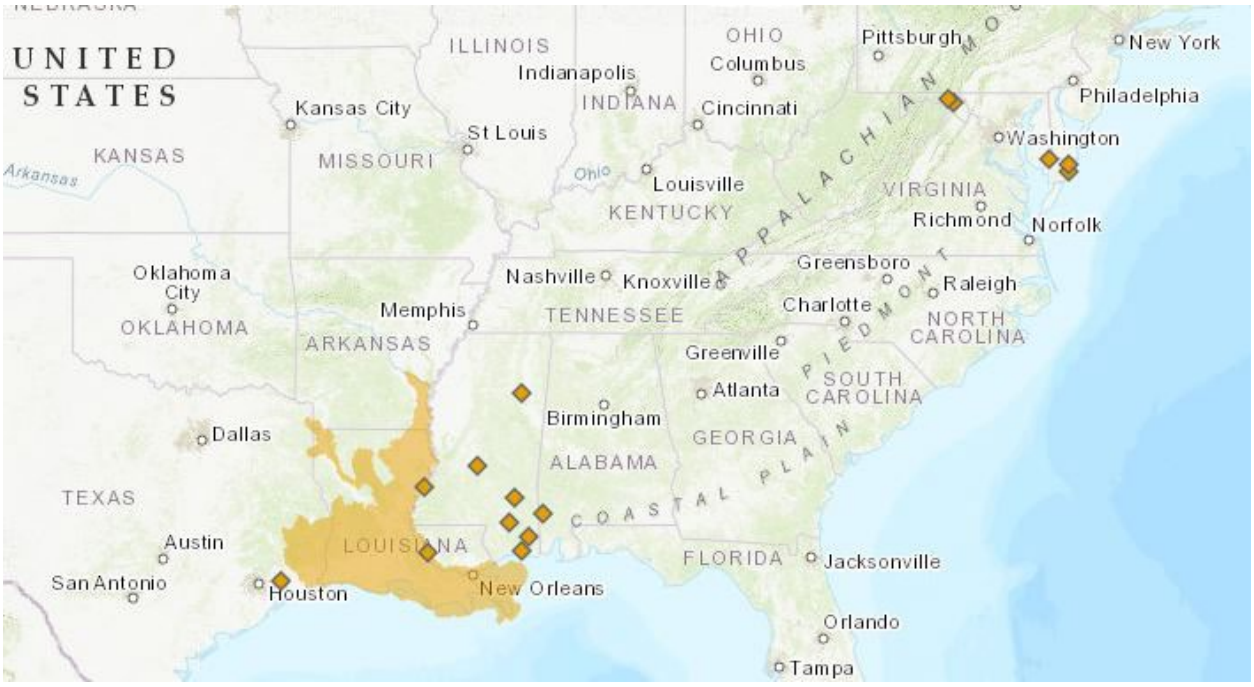

Figure 2. Reported distribution of *Procambarus zonangulus* in the United States. Map from Durland Donahou (2022). Observations are reported from Texas, Louisiana, Arkansas, Mississippi, Alabama, West Virginia, and Maryland. Native range of the species is indicated by the orange polygon. Occurrences outside the native range are represented by orange diamonds.

7 Climate Matching

Summary of Climate Matching Analysis

The climate matching analysis for *Procambarus zonangulus* to the contiguous United States found high climate matches throughout most of the eastern, southeastern, and southern regions, including the western Gulf Coast where *Procambarus zonangulus* is native. Medium climate match was found in the Great Lakes, northern New England, the Midwest, and in patches in the Western Mountains and Colorado Plateau. Low matches occurred mainly in western regions of the contiguous United States. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.415, indicating that Yes, there is establishment concern for this species outside its native range. 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). Although *P. zonangulus* has also been reported as introduced to Egypt, no georeferenced locations were found and recent surveys did not detect this species; the status of this potential introduction is unknown. The climate match with the contiguous United States may be underestimated if reported occurrences in Egypt in-fact represent an established population.

Projected climate matches in the contiguous United States under future climate scenarios are available for *Procambarus zonangulus* (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.

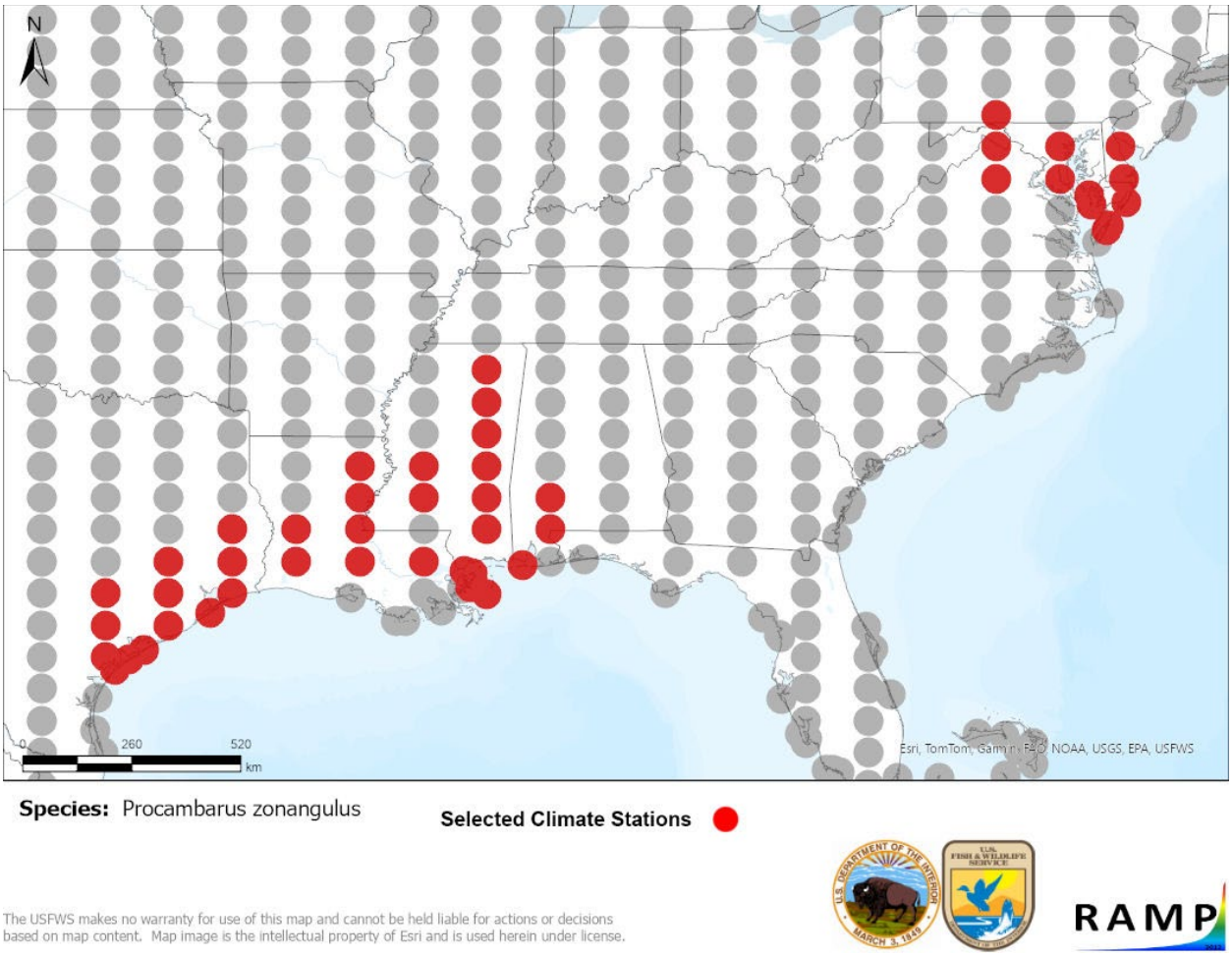

Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations in the eastern United States selected as source locations (red) and non-source locations (gray) for *Procambarus zonangulus* climate matching. Source locations from GBIF Secretariat (2022). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

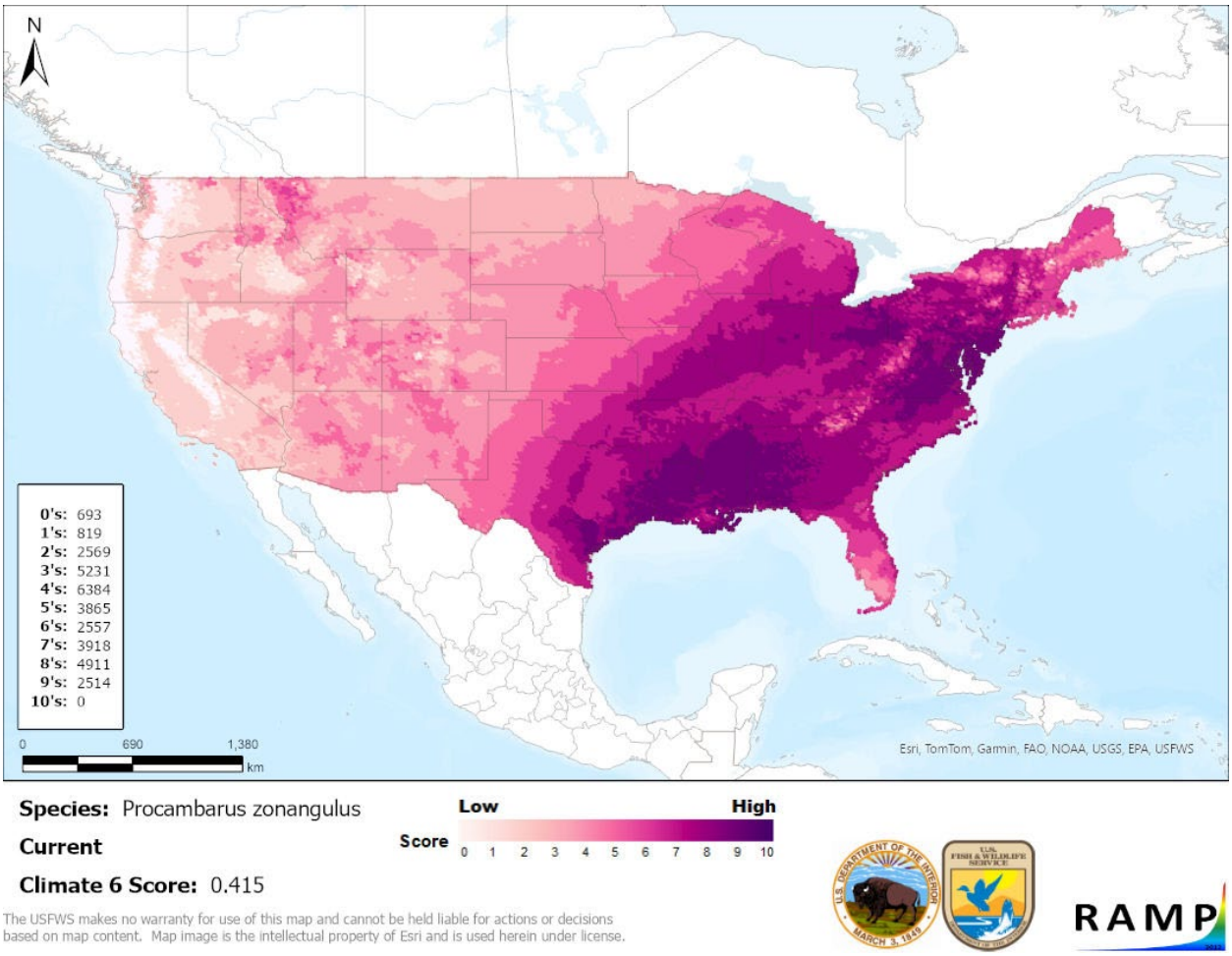

Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Procambarus zonangulus* in the contiguous United States based on source locations reported by GBIF Secretariat (2022). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The Certainty of Assessment for *Procambarus zonangulus* is Low. Quality information on this species' distribution, biology, and ecology is available. There is some uncertainty regarding the species native range due to being part of a species complex and difficulty of field identifications. Records of introductions and establishment of nonnative populations were found but there was no information found regarding impacts.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Procambarus zonangulus, Southern White River Crayfish, is a species of crayfish that is native to the Gulf Coast region of the United States. *P. zonangulus* has been reported as introduced beyond its native range in eastern Maryland, northeast West Virginia, Mississippi, and coastal Alabama. Outside of the United States, it has been reported as introduced to the Nile River in

Egypt, but it may no longer be extant there. *P. zonangulus* is commonly used in aquaculture and has been documented as a carrier of crayfish plague and white spot syndrome virus. *P. zonangulus* is used in trade, primarily as a commercial food source. Possession or trade of this species is regulated in several U.S. States. The History of Invasiveness for *P. zonangulus* is classified as Data Deficient due to the lack of information regarding impacts from introductions. The climate matching analysis for the contiguous United States indicates establishment concern for this species outside its native range. Areas of high match were found both in its native range of the western Gulf Coast, and outside its native range throughout most of the eastern, southeastern, and southern portions of the contiguous United States. The Certainty of Assessment for this ERSS is classified as Low due to the lack of information regarding impacts of introduction. The Overall Risk Assessment Category for *P. zonangulus* in the contiguous United States is Uncertain.

Assessment Elements

- **History of Invasiveness (see section 4): Data Deficient**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): Low**
- **Remarks, Important additional information: Susceptible to crayfish plague and white spot syndrome virus infections, which are WOAH-reportable diseases.**
- **Overall Risk Assessment Category: Uncertain**

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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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).

Under the future climate scenarios (figure A1), on average, high climate match for *Procambarus zonangulus* was projected to occur in the Appalachian Range, Great Lakes, Mid-Atlantic, and Southeast regions of the contiguous United States. Specifically in time step 2055, under both SSP3 and SSP5, the area of high match includes the native range of the species along the western Gulf Coast. Areas of low climate match were projected to occur in California, the Great Basin, Northern Pacific Coast, and Western Mountains regions. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.416 (model: MPI-ESM1-2-HR, SSP5, 2085) to a high of 0.475 (model: IPSL-CM6A-LR, SSP3, 2085). 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 (0.415, figure 4) falls below 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 Northeast saw a large increase in the climate match relative to current conditions. Additionally, areas within the Colorado Plateau, Great Lakes, Northern Plains, and Western Mountains saw a moderate increase in the climate match relative to current conditions. Under one or more time step and climate scenarios, areas within the Appalachian Range, Gulf Coast, Mid-Atlantic, and Southeast saw a moderate decrease in the climate match relative to current conditions. These areas included the species' native range. No large decreases were observed regardless of time step and climate scenarios. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).

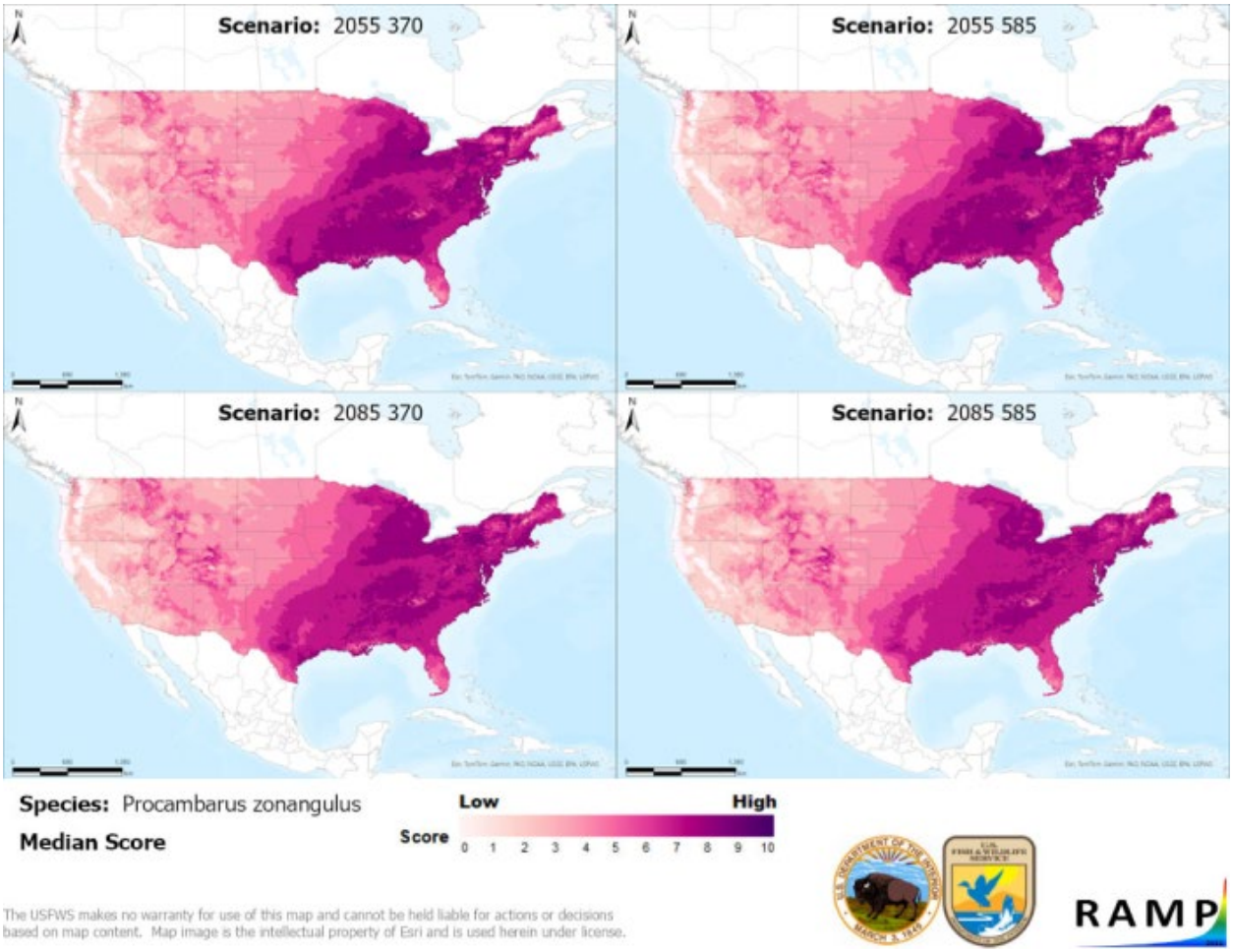

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Procambarus zonangulus* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2022). Shared 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.

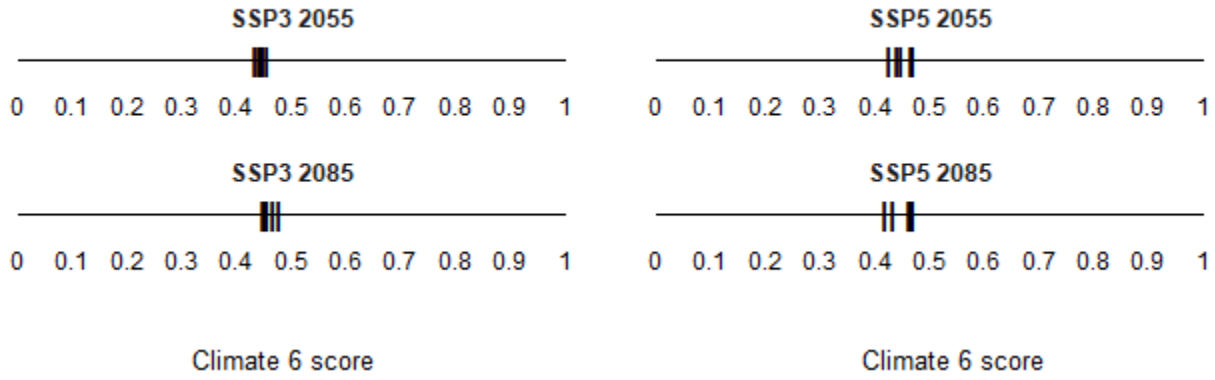

Figure A2. Comparison of projected future Climate 6 scores for *Procambarus zonangulus* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; 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.

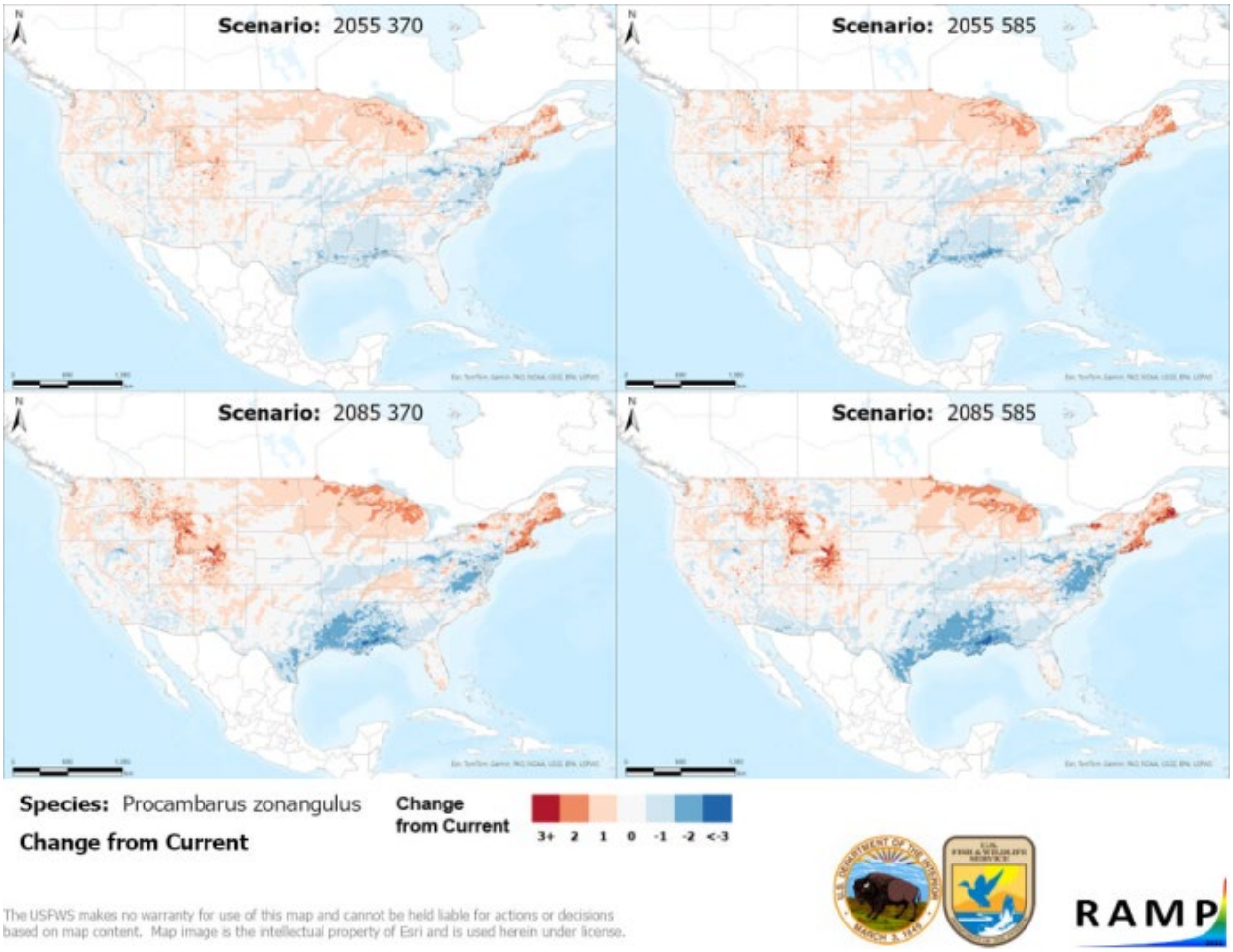

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Procambarus zonangulus* based on source locations reported by GBIF Secretariat (2022). 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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