U.S. Fish & Wildlife Service

Porthole Livebearer (*Poeciliopsis gracilis*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, February 2011
Revised, February 2018
Web Version, 8/30/2019

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1 Native Range and Status in the United States

Native Range

From Nico and Neilson (2018):

"Southern Mexico to Honduras on Atlantic and Pacific slopes (Rosen and Bailey 1963; Page and Burr 1991)."

From Frías-Alvarez and Zúñiga-Vega (2016):

"*Poeciliopsis gracilis* (Poeciliidae) inhabits rivers that drain the Atlantic slope of Mexico. This species is native to the Coatzacoalcos and Papaloapan river basins, in the Mexican states of Veracruz and Oaxaca."

Status in the United States

From Nico and Neilson (2018):

"This species was first discovered in 1974 in an irrigation canal near Mecca, Riverside County, California (Mearns 1975; Hubbs et al. 1979; Shapovalov et al. 1981; Courtenay et al. 1984, 1991; Swift et al. 1993)."

"Population in Riverside County, California, was locally established (Mearns 1975; Shapovalov et al. 1981); however, it may no longer exist. Canal reportedly filled in as of 1987 (Courtenay, personal communication). Current status unknown."

From Martin and Saiki (2009):

"We sampled […] 235 porthole livebearers (*Poeciliopsis gracilis*) from a natural creek and four agricultural drains [flowing into the Salton Sea, California] during September 1999–December 2001."

From Giusti (2019):

"[…] wild populations are known to exist near the Salton Sea [California]."

This species is in trade in the United States.

From Chicago Livebearer Society (2019):

"[*Poeciliopsis gracilis*] are often readily available at bargain prices, too!"

Means of Introductions in the United States

From Nico and Neilson (2018):

"Probably due to an aquarium release or escape from a local fish farm (Mearns 1975; Lee et al. 1980 et seq.)."

Remarks

From Nico and Neilson (2018):

"Courtenay et al. (1984) and Swift et al. (1993), incorrectly citing Mearns (1975), mistakenly reported that the species was first found in California in 1965. Mearns (1975) sampled the area reguarly [*sic*] between 1964-1974 and did not collect this species, suggesting that the introduction happened early in 1974."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2018):

"Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Acanthopterygii
Order Cyprinodontiformes
Suborder Cyprinodontoidei
Family Poeciliidae
Subfamily Poeciliinae
Genus *Poeciliopsis*
Species *Poeciliopsis gracilis* (Heckel, 1848)"

From Eschmeyer et al. (2018):

"Current status: Valid as *Poeciliopsis gracilis* (Heckel 1848). Poeciliidae: Poeciliinae."

Size, Weight, and Age Range

From Nico and Neilson (2018):

"Females 5 cm SL; males 4 cm SL"

From Froese and Pauly (2017):

"Max length : 9.0 cm TL male/unsexed; [Miranda et al. 2009]"

From Frías-Alvarez et al. (2014):

"The standard length (SL) of the smallest gravid females was 18.7 [mm] (*P. gracilis*) […]"

From Gómez-Márquez et al. (2008):

"The total sample size was 1 225 *P. gracilis* individuals. Standard body length ranged from 19 to 43 mm (males) and from 20 to 50 mm (females) with weights between 0.08 to 0.72 g (males) and 0.1 to 5.0 g (females). The females were larger than males (t-student = 13.98; $p<0.05$)."

Environment

From Froese and Pauly (2017):

"Freshwater; benthopelagic; pH range: 6.5 - 7.8; dH range: ? - 25; […] 24°C - 28°C [Baensch and Riehl 1985; assumed to be recommended aquarium temperatures]"

Climate/Range

From Froese and Pauly (2017):

"Tropical; 24°C - 28°C […]; 23°N - 13°N"

Distribution Outside the United States

Native

From Nico and Neilson (2018):

"Southern Mexico to Honduras on Atlantic and Pacific slopes (Rosen and Bailey 1963; Page and Burr 1991)."

From Frías-Alvarez and Zúñiga-Vega (2016):

"*Poeciliopsis gracilis* (Poeciliidae) inhabits rivers that drain the Atlantic slope of Mexico. This species is native to the Coatzacoalcos and Papaloapan river basins, in the Mexican states of Veracruz and Oaxaca."

Introduced

From Frías-Alvarez and Zúñiga-Vega (2016):

"[…] it has been introduced and successfully established in other river basins [e.g., the Pánuco river [eastern Mexico] (Miller et al. 2005; Gutiérrez-Cabrera et al. 2005)].

From Frías-Alvarez et al. (2014):

"[…] it has been introduced and successfully colonized some basins of rivers in western and central Mexico (Gutiérrez-Cabrera et al. 2005; Miller et al. 2005)."

According to Froese and Pauly (2019), *P. gracilis* is established in Venezuela.

Means of Introduction Outside the United States

From Froese and Pauly (2019):

"ornamental"

Short Description

From Rosen and Bailey (1963):

“Heckel’s diagnosis, freely translated from the German, is as follows: "*Xiphophorus gracilis* [= *Poeciliopsis gracilis*] Heckel. *Male*. Dorsal fin base short, originating toward the middle of the body; upper inclined edge of fin truncated. Anal fin with the entire base situated in front of the dorsal fin; the sword [gonopodium] slender, twice as long as the head. A longitudinal black stripe from over the operculum to the base of the caudal fin; a long black line on [the ventral edge of] the caudal peduncle to the caudal fin; all fins unmarked. *Female*. Dorsal and anal fins originating at the same level toward the middle of the body; each with a short base and with the inclined edge truncated. Coloration as in the male. Pectoral rays 1/11. Pelvic rays 1/5. Dorsal rays 2/6. Anal rays 2/6 (9 3/6). Caudal rays 7/14/7. Scales 3/29/3 and 2-3."

From Nico and Neilson (2018):

“This species exhibits a broad range in body build and coloration, especially in terms of spotting pattern (Wischnath 1993).”

From Gómez-Márquez et al. (2008):

“There was an evident sexual dimorphism in the morphological features of *P. gracilis*, being the modification of the anal fin in males to form a gonopodium the main sexual distinctive characteristic.”

Biology

From Frías-Alvarez and Zúñiga-Vega (2016):

“*P. gracilis* inhabits most types of water bodies such as streams, lagoons, pools in creeks and rivers, with a wide range of turbidity and water flow velocity (Miller et al. 2005).”

From Bussing (2008):

“Martin (1972) described the habitat of the related *Poeciliopsis gracilis* (= *P. pleurospilus*) in Honduras: "The habitat of this species is further characterized by extreme seasonality of flow varying from stagnation during the dry season to torrential flow during the wet season. Individuals were invariably captured in backwaters and isolated pools with little or no flow during dry season".”

From Froese and Pauly (2017):

“Female gives birth to 10-50 young. Sexual maturity is reached after 3 months.”

Human Uses

From Froese and Pauly (2017):

"Aquarium: commercial"

From Hernandez et al. (2010):

"The Porthole livebearer *Poecilopsis gracilis* (Pocilidae) is commonly used as a baitfish in the aquarium hobby for other aquatic species of higher commercial value. Distributed along the south part of Mexico (Contreras-Balderas 2005), the natural populations of *P. gracilis* are rapidly declined [*sic*] due to over fishing to satisfy the increasing demand of the aquarium industry."

This species is in trade in the United States.

From Chicago Livebearer Society (2019):

"[*Poeciliopsis gracilis*] are often readily available at bargain prices, too!"

Diseases

No OIE-listed diseases (OIE 2019) have been documented for this species.

From García-Vásquez et al. (2017):

"As part of ongoing surveys of the gyrodactylid parasite fauna of freshwater fishes in Mexico, we recorded the infection of three species of poeciliids (*Poecilia mexicana*, *Poeciliopsis gracilis*, and *Pseudoxiphophorus bimaculatus* [syn. = *Heterandria bimaculata*]) with *Gyrodactylus cichlidarum*, a monogenean parasite of cichlid fishes, which has been co-introduced globally with its translocated, African "tilapia" hosts. […] It is of particular concern that *G. cichlidarum* was found on poeciliids, as these invasive fishes have been introduced worldwide and could act as carriers for this parasite known to induce significant mortality of farmed tilapias − globally, the second most important freshwater aquaculture fish group, after the carps."

Poelen et al. (2014) lists the following parasites of *Poeciliopsis gracilis*: *Glossocercus auritus, Hepatocapillaria cyprinodonticola, Clinostomum complanatum, Posthodiplostomum minimum, Uvulifer* sp., *Saccocoelioides sogandaresi, Centrocestus formosanus, Glossocercus aurita, Gnathostoma turgidum, Gnathostoma lamothei, Parvitaenia cochlearii, Valipora minuta,* and *Bothriocephalus acheilognathi* (Benesh et al. 2017, Strona et al. 2013).

Threat to Humans

From Froese and Pauly (2017):

"Harmless"

3 Impacts of Introductions

From Nico and Neilson (2018):

"Unknown."

From García-Vásquez et al. (2017):

"Both cichlids and poeciliids have been shown to be very successful invasive fishes, and their negative impacts on native biodiversity have been well documented (Canonico et al., 2005; Holitzki et al., 2013; Mendoza et al., 2015; Pyke, 2008). […] Potential hazards include infection and damage of native fishes by pathogenic [*Gyrodactylus*] *cichlidarum*, and naturally, affectations to tilapia farming − globally, the second most important freshwater aquaculture fish group, after the carps (FAO, 2014)."

From Martin and Saiki (2009):

"The orangemouth corvina (*Cynoscion xanthulus*), bairdiella (*Bairdiella icistia*), and sargo (*Anisotremus davidsonii*) were established in the Salton Sea in the 1950s and, although piscivorous, these species were not considered a threat to desert pupfish because their habitats rarely overlapped (Walker et al., 1961). However, the porthole livebearer (*Poeciliopsis gracilis*), sailfin molly, and shortfin molly (*Poecilia mexicana*) were introduced into the Salton Sea in the mid-1960s, and hybrid Mozambique and redbelly tilapias were introduced in the 1970s (Schoenherr, [1981]). In just a few years, the fish-species assemblage changed dramatically. Where the desert pupfish once was common or abundant in the Salton Sea and its shoreline pools, sailfin molly became the dominant species (Black, 1980). By 1983, dominance had shifted to hybrid Mozambique and redbelly tilapias (these two species collectively constituted ca. 75% of 2,744 fish captured in agricultural drains), with desert pupfish accounting for only five individuals (K. E. Moore, in litt.). Plummeting size of populations of desert pupfish in the Salton Sea basin, along with other losses throughout its historical range in the lower Colorado River drainage, led to listing of this species for federal protection as endangered (United States Fish and Wildlife Service, 1986)."

From Gómez-Márquez et al. (2008):

"In spite of the high demand of *P. gracilis* as a forage species in Mexico, its commercial value is very low, as from the ecological point of view there are few investigations about the impact that this introduced species causes on the native fauna and habitats in different countries."

From Mejía-Mojica et al. (2015):

"Exotic taxa such as *Amatitlania nigrofasciata*, *Pterigloplictys disjunctivus*, *Pterigloplictys pardalis*, *Poeciliopsis gracilis* and *Heterandria bimaculata*, have achieved the degree of invasive due to the fact that they are distributed of abundant manner in the entire [Chontalcoatla-Amacuzac] hydrological system [Balsas River, south-central Mexico]."

"The abundance of individuals was dominated by exotic species, which made up the 67 % of the total catch. The exotic Porthole Livebearer [*Poeciliopsis gracilis* (Heckel, 1848)] was the most abundant taxon with 43 % of the overall caught (natives and exotics combined) and 64 % of the total for the exotic species."

4 Global Distribution

Figure 1. Known global distribution of *Poeciliopsis gracilis*. Map from GBIF Secretariat (2019). Occurrences reported off the coast of Panama were excluded from the climate matching analysis because *P. gracilis* is a freshwater species and Panama is not part of the described range of the species. Occurrences in Nicaragua were excluded from the climate matching analysis because Nicaragua is not part of the described range of *P. gracilis*. Congeneric species have been reported from Nicaragua (Bussing 2008).

5 Distribution Within the United States

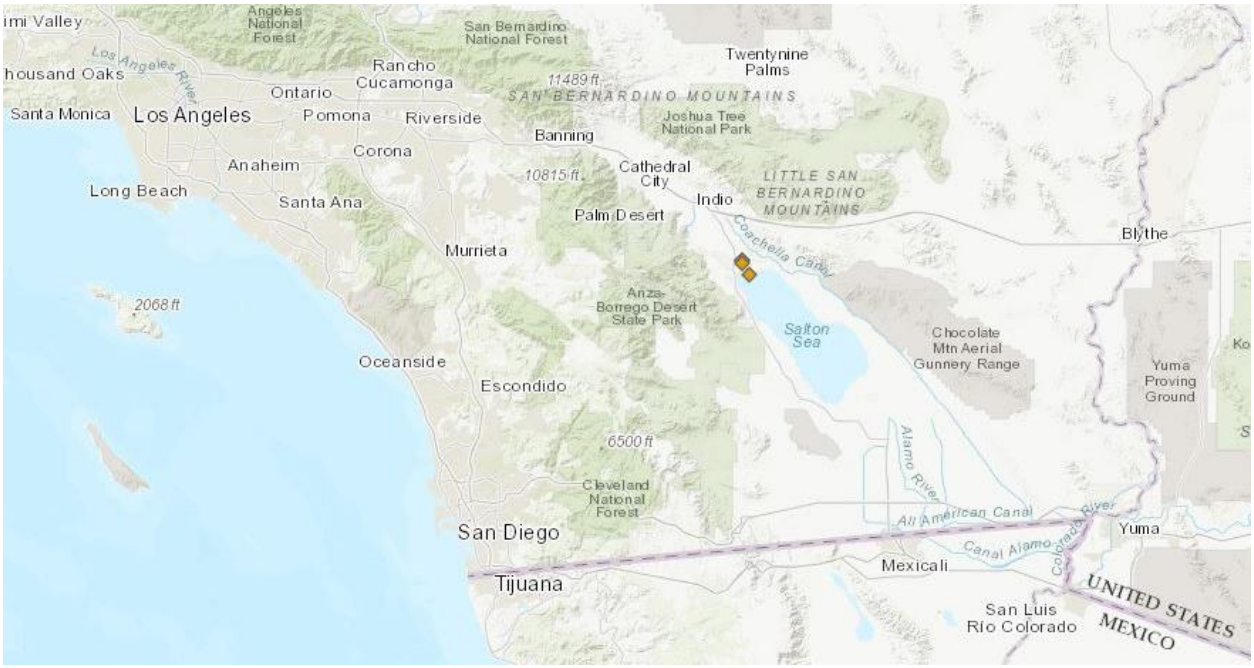

Figure 2. Known distribution of *Poeciliopsis gracilis* in the United States. Map from Nico and Neilson (2018). Although Nico and Neilson (2018) characterize the status of *P. gracilis* as unknown, with the last report in 1980, information from Martin and Saiki (2009) and Giusti (2019) indicates that it remains established.

6 Climate Matching

Summary of Climate Matching Analysis

The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.097, indicating a medium overall climate match. (Scores between 0.005 and 0.103 are classified as medium.) The climate score was high in Arizona, California, Florida, Nevada, and Texas; medium in New Mexico, Oregon, Utah, and Washington; and low in the remaining States in the contiguous United States. Locally, high match occurred in peninsular Florida, southern and western Texas, central and southern Arizona into Nevada and most of inland California. Medium match occurred in areas surrounding high matches and also in scattered patches throughout the West. The climate match was low for the remainder of the contiguous United States.

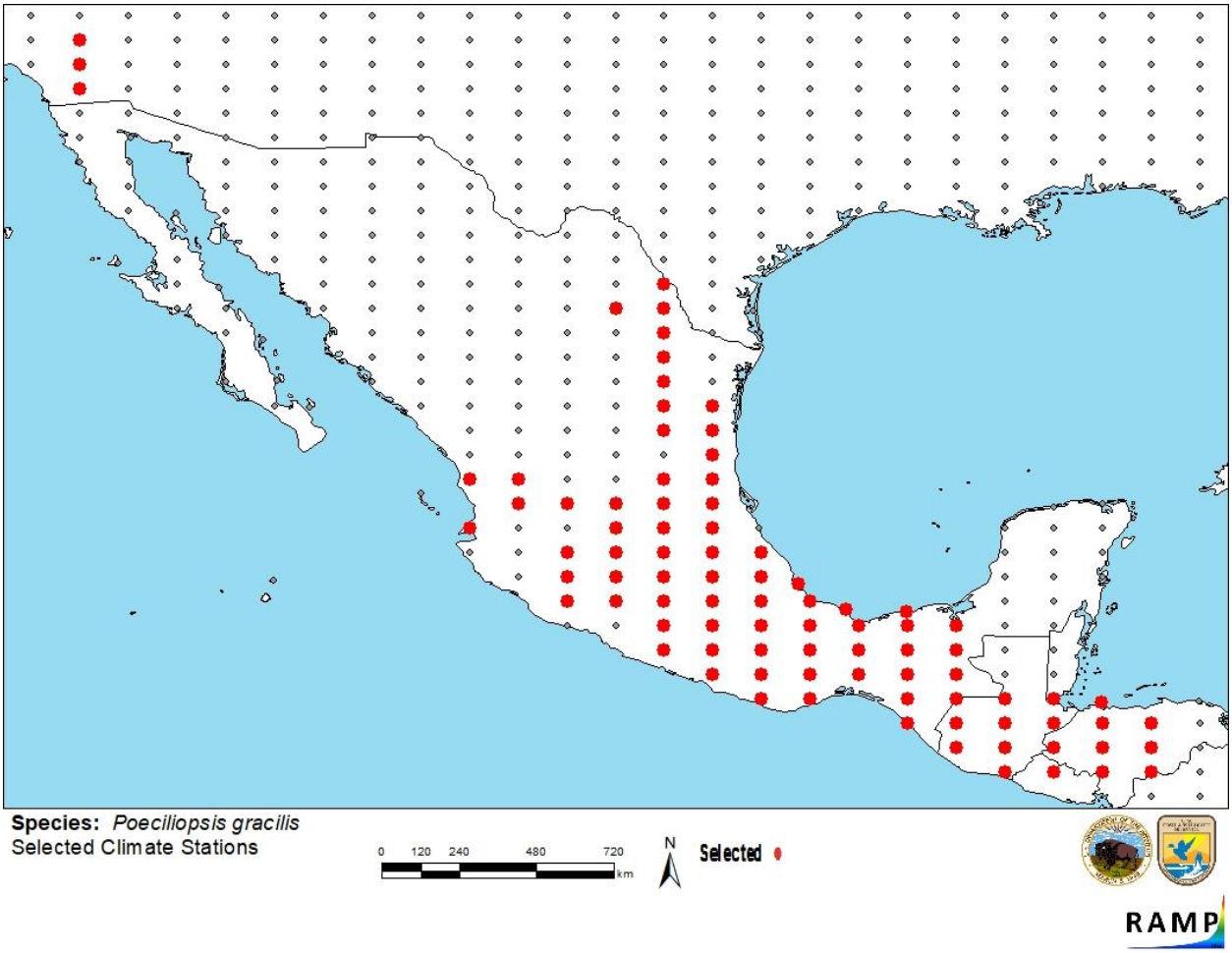

Figure 3. RAMP (Sanders et al. 2018) source map showing weather stations selected as source locations (red; United States, Mexico, Guatemala, Belize, El Salvador, Honduras, Nicaragua) and non-source locations (gray) for *Poeciliopsis gracilis* climate matching. Source locations from GBIF Secretariat (2019). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

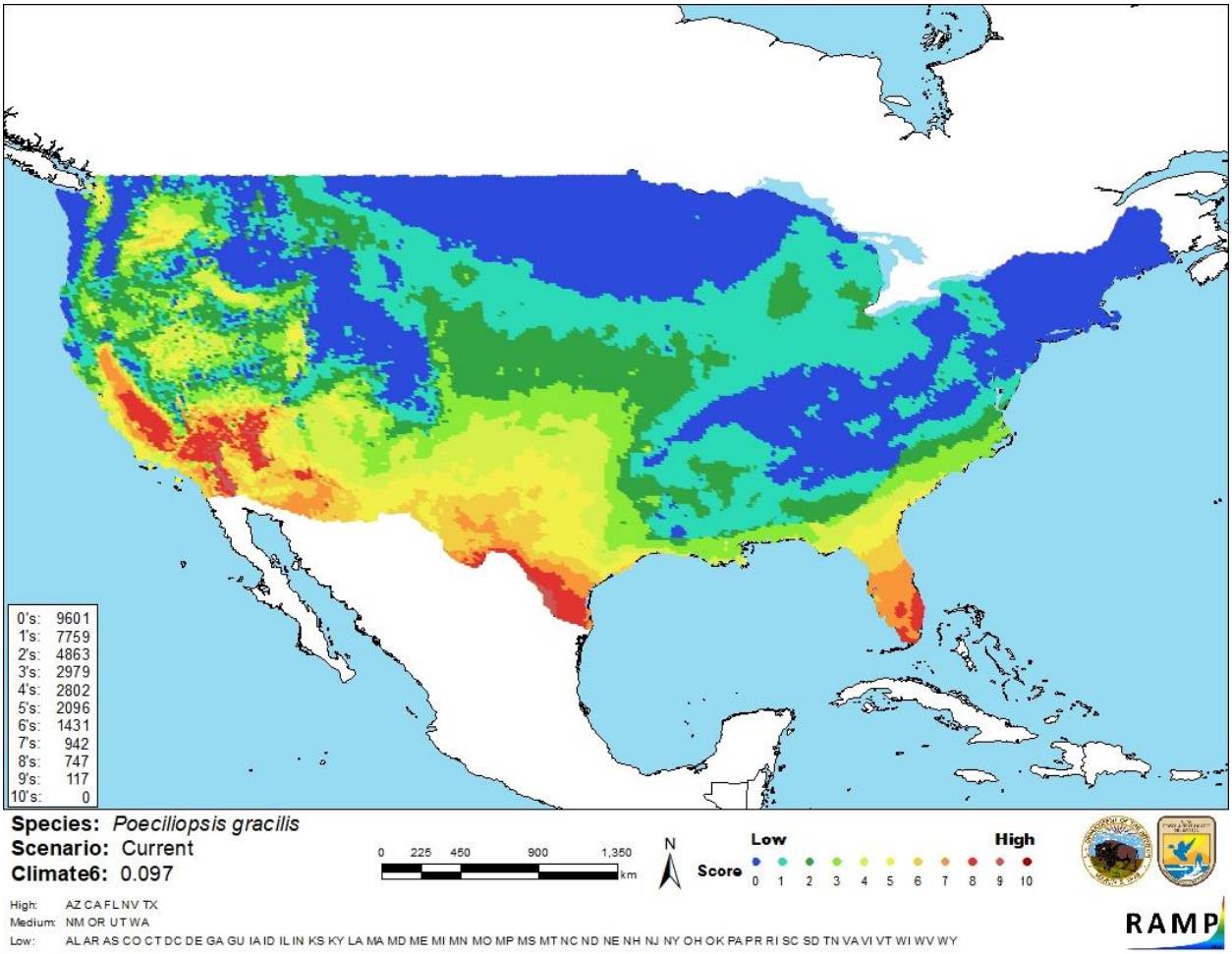

Figure 4. Map of RAMP (Sanders et al. 2018) climate matches for *Poeciliopsis gracilis* in the contiguous United States based on source locations reported by GBIF Secretariat (2019). 0 = Lowest match, 10 = Highest match.

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

There is substantial information documenting the biology and distribution, including introduced distribution, of *Poeciliopsis gracilis*. No credible, well-documented negative impacts of introduction of this species have been reported in scientific literature, although there are some indications of possible negative effects. Further information is necessary to adequately assess the risk this species poses, so certainty of this assessment is low.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Poeciliopsis gracilis, Porthole Livebearer, is a small livebearing fish native to Mexico and Central America. It is used in the aquarium trade. This species has been introduced and become established outside of its native range in the United States, Mexico, and Venezuela. *P. gracilis* can become abundant where introduced. Impacts to native fish populations have been documented for communities of nonnative fishes to which *P. gracilis* belongs, but not for *P. gracilis* individually. The history of invasiveness is classified as "none documented." *P. gracilis* is a host to the pathogenic parasite *Gyrodactylus cichlidarum*, which presents a threat to tilapia aquaculture. *P. gracilis* has a medium climate match with the contiguous United States. The areas of the highest match are in the far southern and southwestern United States, especially in Arizona, California, Florida, Nevada, and Texas. Because no negative impacts of introductions of this species have been conclusively documented, certainty of this assessment is low. Overall risk assessment category is Uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 3): None Documented**
- **Climate Match (Sec. 6): Medium**
- **Certainty of Assessment (Sec. 7): Low**
- **Overall Risk Assessment Category: Uncertain**

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.

Bussing, W. A. 2008. A new species of poeciliid fish, *Poeciliopsis santaelena*, from Peninsula Santa Elena, Area de Conservación Guanacaste, Costa Rica. Revista de Biologia Tropical 56(2):829-838.

Chicago Livebearer Society. 2019. *Poecilopsis gracilus* [*sic*]. Available: https://www.chicagolivebearer.com/index.php/livebearer-profiles/49-poecilopsis-gracilus. (August 2019).

Eschmeyer, W. N., R. Fricke, and R. van der Laan, editors. 2018. Catalog of fishes: genera, species, references. Available: http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. (February 2018).

Frías-Alvarez, P., and J. J. Zúñiga-Vega. 2016. Superfetation in live-bearing fishes is not always the result of a morphological constraint. Oecologia 181(3):645-658.

Frías-Alvarez, P., C. M. Garcia, L. F. Vázquez-Vega, and J. J. Zúñiga-Vega. 2014. Spatial and temporal variation in superfoetation and related life history traits of two viviparous fishes: *Poeciliopsis gracilis* and *P. infans*. Naturwissenschaften 101(12):1085-1098.

Froese, R., and D. Pauly, editors. 2017, 2019. *Poeciliopsis gracilis* (Heckel, 1848). FishBase. Available: http://www.fishbase.org/summary/Poeciliopsis-gracilis.html. (February 2018, August 2019).

García-Vásquez, A., U. Razo-Mendivil, and M. Rubio-Godoy. 2017. Triple trouble? Invasive poeciliid fishes carry the introduced tilapia pathogen *Gyrodactylus cichlidarum* in the Mexican highlands. Veterinary Parasitology 235:37-40.

GBIF Secretariat. 2019. GBIF backbone taxonomy: *Poeciliopsis gracilis*, Heckel, 1848. Global Biodiversity Information Facility, Copenhagen. Available: https://www.gbif.org/species/2350503. (August 2019).

Giusti, G. A., editor. 2019. Porthole Livebearer. *In* California Fish Website. University of California Agriculture and Natural Resources, Lakeport, California. Available: http://calfish.ucdavis.edu/species/?uid=116&ds=698. (August 2019).

Gómez-Márquez, J. L., B. Peña-Mendoza, I. H. Salgado-Ugarte, A. K. Sánchez-Herrera, and L. Sastré-Baez. 2008. Reproduction of the fish *Poeciliopsis gracilis* (Cyprinodontiformes: Poeciliidae) in Coatetelco, a tropical shallow lake in Mexico. Revista de Biología Tropical 56(4):1801-1812.

Hernandez, L. H. H., T. C. Barrera, J. C. Mejia, G. C. Mejia, M. Del Carmen, M. Dosta, R. De Lara Andrade, and J. A. M. Sotres. 2010. Effects of the commercial probiotic *Lactobacillus casei* on the growth, protein content of skin mucus and stress resistance of juveniles of the Porthole livebearer *Poeciliopsis gracilis* (Poeciliidae). Aquaculture Nutrition 16(4):407-411.

ITIS (Integrated Taxonomic Information System). 2018. *Poeciliopsis gracilis* (Heckel, 1848). Integrated Taxonomic Information System, Reston, Virginia. Available: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=165917#null. (February 2018).

Martin, B. A., and M. K. Saiki. 2009. Trophic relationships of small nonnative fishes in a natural creek and several agricultural drains flowing into the Salton Sea, and their potential effects on the endangered desert pupfish. The Southwestern Naturalist 54(2):156-165.

Mejía-Mojica, H., T. Contreras-MacBeath, and G. Ruiz-Campos. 2015. Relationship between environmental and geographic factors and the distribution of exotic fishes in tributaries of the Balsas river basin, Mexico. Environmental Biology of Fishes 98(2):611-621.

Nico, L., and M. Neilson. 2018. *Poeciliopsis gracilis* (Heckel, 1848). U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=865. (February 2018).

OIE (World Organisation for Animal Health). 2019. OIE-listed diseases, infections and infestations in force in 2019. World Organisation for Animal Health, Paris. Available: http://www.oie.int/animal-health-in-the-world/oie-listed-diseases-2019/. (August 2019).

Poelen, J. H., J. D. Simons, and C. J. Mungall. 2014. Global Biotic Interactions: an open infrastructure to share and analyze species-interaction datasets. Ecological Informatics 24:148-159.

Rosen, D. E., and R. M. Bailey. 1963. The poeciliid fishes (Cyprinodontiformes): their structure, zoogeography, and systematics. Bulletin of the American Museum of Natural History 126(1):1-176.

Sanders, S., C. Castiglione, and M. H. Hoff. 2018. Risk Assessment Mapping Program: RAMP, version 3.1. U.S. Fish and Wildlife Service.

10 References Quoted But Not Accessed

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.

Baensch, H.A., and R. Riehl. 1985. Aquarien atlas volume 2. Mergus, Verlag für Natur-und Heimtierkunde GmbH, Melle, Germany.

Benesh, D. P., K. D. Lafferty, and A. Kuris. 2017. A life cycle database for parasitic acanthocephalans, cestodes, and nematodes. Ecology 98(3):882-882.

Black, G. F. 1980. Status of the desert pupfish, *Cyprinodon macularius* (Baird and Girard), in California. California Department of Fish and Game, Inland Fisheries Endangered Species Program Special Publication 80-1.

Canonico, G. C., A. Arthington, J. K. McCrary, and M. L. Thieme. 2005. The effects of introduced tilapias on native biodiversity. Aquatic Conservation-Marine and Freshwater Ecosystems 15:463–483.

Contreras-Balderas, S. 2005. Fish viviparity: diversity, biogeography and conservation. Pages 31-39 *in* M. C. Uribe and J. H. Grier, editors.Viviparous fishes. New Life Publications, Homestead, Florida.

Courtenay, W. R., Jr., D. A. Hensley, J. N. Taylor, and J. A. McCann. 1984. Distribution of exotic fishes in the continental United States. Pages 41-77 *in* W. R. Courtenay, Jr., and J. R. Stauffer, Jr., editors. Distribution, biology and management of exotic fishes. Johns Hopkins University Press, Baltimore, Maryland.

Courtenay, W. R., Jr., D. P. Jennings, and J. D. Williams. 1991. Appendix 2: exotic fishes. Pages 97-107 *in* C. R. Robins, R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott, editors. Common and scientific names of fishes from the United States and Canada, 5th edition. American Fisheries Society Special Publication 20. American Fisheries Society, Bethesda, Maryland.

FAO. 2014. FAO Yearbook. Fishery and Aquaculture Statistics. 2012. Food and Agriculture Organization of the United Nations, Rome.

Gutiérrez-Cabrera, A. E., G. Pulido-Flores, S. Monks, and J. C. Gaytán-Oyarzún. 2005. Presencia de *Bothriocephalus acheilognathi* Yamaguti, 1934 (Cestoidea: Bothriocephalidae) en peces de Metztitlán, Hidalgo, México. Hidrobiológica 15:283-288.

Heckel, J. 1848. Eine neue Gattung von Poecilien mit rochenartigem Anklammerungs-Organe. Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe 1(1-5):289-303.

Holitzki, T. M., R. A. MacKenzie, T. N. Wiegner, and K. J. McDermid. 2013. Differences in ecological structure, function, and native species abundance between native and invaded Hawaiian streams. Ecological Applications 23:1367-1383.

Hubbs, C. L., W. I. Follett, and L. J. Dempster. 1979. List of the fishes of California. California Academy Science Occasional Papers 133.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh.

Martin, M. 1972. A biogeographic analysis of the freshwater fishes of Honduras. Doctoral dissertation. University of Southern California, Los Angeles, California.

Mearns, A. J. 1975. *Poeciliopsis gracilis* (Heckel), a newly introduced poeciliid fish in California. California Fish and Game 61(4):251-253.

Mendoza, R., S. Luna, and C. Aguilera. 2015. Risk assessment of the ornamental fish trade in Mexico: analysis of freshwater species and effectiveness of the FISK (Fish Invasiveness Screening Kit). Biological Invasions 17:3491–3502.

Miller, R. R., W. L. Mincley, and S. M. Norris. 2005. Freshwater fishes of Mexico. University of Chicago Press, Chicago, Illinois.

Miranda, R., D. Galicia, S. Monks, and G. Pulido-Flores. 2009. Weight-length relationships of some native freshwater fishes of Hidalgo state, Mexico. Journal of Applied Ichthyology 25:620-621.

Page, L. M., and B. M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. The Peterson Field Guide Series, volume 42. Houghton Mifflin Company, Boston.

Pyke, G. H. 2008. Plague minnow or mosquito fish? A review of the biology and impacts of introduced *Gambusia* species. Annual Review of Ecology, Evolution, and Systematics 39:171-191.

Schoenherr, A. A. 1981. The role of competition in the replacement of native fishes by introduced species. Pages 183-203 *in* R. J. Naiman and D. L. Soltz, editors. Fishes in North American deserts. Wiley-Interscience, New York.

Shapovalov, L., A. J. Cordone, and W. A. Dill. 1981. A list of freshwater and anadromous fishes of California. California Fish and Game 67(1):4-38.

Strona, G., M. Lourdes, D. Palomares, N. Bailly, P. Galli, and K. D. Lafferty. 2013. Host range, host ecology, and distribution of more than 11800 fish parasite species. Ecology 94:544.

Swift, C. C., T. R. Haglund, M. Ruiz, and R. N. Fisher. 1993. The status and distribution of the freshwater fishes of southern California. Bulletin of the Southern California Academy of Science 92(3):101-167.

United States Fish and Wildlife Service. 1986. Endangered and threatened wildlife and plants; determination of endangered status and critical habitat for the desert pupfish. Federal Register 51:10842-10851.

Walker, B. W., R. R. Whitney, and G. W. Barlow. 1961. Fishes of the Salton Sea. Pages 77-91 *in* B. W. Walker, editor. The ecology of the Salton Sea, California in relation to the sport fishery. California Fish and Game Fishery Bulletin 113:1-20.

Wischnath, L. 1993. Atlas of livebearers of the world. T. F. H. Publications, Neptune, New Jersey.