Guppy (*Poecilia reticulata*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, March 2011
Revised, July 2015 and February 2018
Web Version, 4/10/2018

Photo: "Guppy Poecilia reticulata" by H. Krisp. Licensed under CC BY 3.0. Available: https://commons.wikimedia.org/wiki/File:Guppy_Poecilia_reticulata.jpg#/media/File:Guppy_Poecilia_reticulata.jpg. (July 2015).

1 Native Range and Status in the United States

Native Range

From Froese and Pauly (2017):

"South America: Venezuela, Barbados, Trinidad, northern Brazil and the Guyanas."

Status in the United States

From Nico et al. (2018):

"**Nonindigenous Occurrences**: This species is known from **Arizona** (Minckley 1973; Courtenay et al. 1984, 1991); **California** (St. Amant and Hoover 1969; Shapovalov et al. 1981; Courtenay et al. 1984, 1991; Dill and Cordone 1997; Moyle 2002); **Colorado** (Zuckerman and Behnke 1986); **Connecticut** (Whitworth 1996); **Florida** (Courtenay et al. 1974; J. D. Williams, personal observation); **Hawaii** (Brock 1960; Kanayama 1968; Maciolek 1984; Devick 1991; Tilmant 1999; Mundy 2005); **Idaho** (Linder 1964; Baxter and Simon 1970; Simpson and Wallace 1978; Courtenay 1985; Courtenay et al. 1987; Idaho Fish and Game 1990); **Missouri** (Keevin 1978); **Nevada** (Deacon et al. 1964; Bradley and Deacon 1967; Moyle 1976; Williams and Williams 1981; Courtenay and Deacon 1982, 1983; Deacon and Williams 1984); **New Mexico** (Sublette et al. 1990); **Texas** (Edwards 1976; Hubbs et al. 1978; Courtenay et al. 1984; Conner and Suttkus 1986; Courtenay et al. 1991; Hubbs et al. 1991; Howells 1992); **Utah** (F. B. Guttermuth, personal communication); **West Virginia**; **Wisconsin** (Becker 1983); and **Wyoming** (Baxter and Simon 1970; Courtenay et al. 1987; Hubert 1994; Stone 1995; Tilmant 1999). Also introduced in several reservoirs in **Puerto Rico** (Erdsman 1984; Lee et al 1980 et seq); the **U.S. Virgin Islands** (Loftus 2004); and **Guam** (S. Walsh, pers. comm.)."

"**Status:** Locally established in warmwater sites in Hawaii (Devick 1991), Idaho (Courtenay et al. 1987), New Mexico (Sublette et al. 1990), Nevada (Courtenay and Deacon 1983), Texas (Hubbs et al. 1991), and Wyoming (Courtenay et al. 1987); reported from California (Shapovalov et al. 1981), Colorado (Zuckerman and Behnke 1986), Connecticut (Whitworth 1996), Missouri (Keevin 1978), Montana (Moyle 1976), and Wisconsin (Becker 1983). Considered established in Arizona by Minckley (1973); however, according to Courtenay and Meffe (1989), populations in Arizona and Florida do not appear to be self-sustaining. Although introduced widely in Texas, the only established population is found in the San Antonio River near Brackenridge Park (Hubbs et al. 1991)."

From NatureServe (2017):

"In U.S., introduced populations have been found in warm springs and canal systems."

Shafland et al. (2008) include *P. reticulata* in their list of currently non-reproducing (formerly reproducing) exotic freshwater fishes collected from Florida fresh waters.

From Chapman et al. (1997):

"Using import and export documents we report trends in total values for the U.S. trade in ornamental fish. Also, we determined the number and value of the most commonly imported ornamental fish [as of 1992]. […] The two most popular ornamental fish species imported into the U.S. were the live bearer, guppy *Poecilia reticulata*, and the egg layer, neon tetra *Paracheirodon innesi*. These two species accounted for 37% of the total number of fish imported and were valued at approximately half a million dollars."

Means of Introduction into the United States

From Nico et al. (2018):

"Most introductions probably are fish farm or aquarium releases (e.g., Zuckerman and Behnke 1986; Courtenay and Meffe 1989; Howells 1992; Dill and Cordone 1997). Some California introductions were made intentionally for mosquito control (Shapovalov et al. 1981; Dill and Cordone 1997)."

Remarks

From CABI (2018):

"Other Scientific Names
Acanthophacelus guppii (Günther, 1866)
Acanthophacelus reticulatus (Peters, 1859)
Girardinus guppii Günther, 1866
Girardinus reticulatus (Peters, 1859)
Haridichthys reticulatus (Peters, 1859)
Heterandria guppyi (Günther, 1866)
Lebistes poecilioides De Filippi, 1861
Lebistes poeciloides De Filippi, 1861
Lebistes reticulatus (Peters, 1859)
Poecilia reticulatus Peters, 1859
Poecilioides reticulatus (Peters, 1859)"

"International Common Names
English: barbados millions; guppies; million fish; millions; millions fish; rainbow fish"

From Nico et al. (2018):

"Some fish reported from the United States as *P. reticulata* actually may represent other species in the genus. In 1989, M. Rauchenberger (personal communication) examined the *P. reticulata* voucher specimens (UF 91918) taken from Kelly Warm Springs, Wyoming, in 1984 by Courtenay et al. (1987), but she could not confirm that identification and labeled them as *Poecilia* species. In light of the enormous numbers of guppies produced in aquaculture each year and its prevalence in pet stores and the aquarium hobby, it is surprising that so few established populations exist. The guppy is known to require warm water to thrive, which may explain its inability to establish throughout most of the continental U.S. but other factors, presently unknown, must limit its distribution in suitable locations such as southern Florida."

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 *Poecilia*
                          Species *Poecilia reticulata* Peters, 1859"

"Taxonomic Status: valid"

Size, Weight, and Age Range

From Froese and Pauly (2017):

"Max length : 5.0 cm SL male/unsexed; [Kottelat and Freyhof 2007]; 6.0 cm SL (female); common length : 2.8 cm TL male/unsexed; [Hugg 1996]"

"Males mature at 2 months and females at 3 months of age [Riehl and Baensch 1991]."

Environment

From Froese and Pauly (2017):

"Freshwater; brackish; benthopelagic; pH range: 7.0 - 8.0; dH range: 9 - 19; non-migratory."

From CABI (2018):

"*P. reticulata* can live and breed in pH of 5-9 and salinities ranging from 0 to 45 ppt. However, *P. reticulata* cannot tolerate water temperatures below 15°C, and is only found in temperate regions in artificially warmed water bodies, for example at cooling lakes of power stations. Critical thermal maxima ranging of 39-41°C and death points of 41-43°C were reported by Chung (2004) for Venezuelan guppies."

Climate/Range

From Froese and Pauly (2017):

"Tropical;[…]; 14°N - 2°N, 67°W - 52°W"

Distribution Outside the United States

Native

From Froese and Pauly (2017):

"South America: Venezuela, Barbados, Trinidad, northern Brazil and the Guyanas."

From CABI (2018):

"*P. reticulata* is native to Trinidad and Tobago and parts of South America including Venezuela, Guyana, Surinam (Farr, 1975). It also occurs in Antigua and Barbuda, Barbados, Brazil, Guyana, Netherlands Antilles, and the US Virgin Islands (Kenny, 1995), and it has been found in Barbados, Cuba and Grenada (Magurran, 2005), but it is not certain whether the species naturally colonised these regions or was introduced."

Introduced

From Froese and Pauly (2017):

"**Year / Period**	**From**	**To**	**Established**	**Ecol. effects**
unknown	Unknown	Zambia	established	
unknown	Unknown	Mauritius	unknown	
unknown	Unknown	Martinique	established	
unknown	Venezuela	Malaysia	established	
unknown	Singapore	Malaysia	established	
unknown	Brazil	Malaysia	established	
unknown	Unknown	Madagascar	established	
unknown	Unknown	Laos	not established	unknown
unknown	South America	Japan	established	unknown
unknown	Unknown	Jamaica	established	
unknown	Unknown	central Italy	established	
unknown	Unknown	Hong Kong	established	probably some
unknown	Unknown	Guam	established	
unknown	Unknown	French Polynesia	established	
unknown	Unknown	Namibia	established	unknown
unknown	Unknown	Netherlands	established	
unknown	Unknown	New Caledonia	probably established	
unknown	Unknown	Western Samoa	established	
unknown	unknown	United Arab Emirates	established	unknown
unknown	Unknown	Spain	established	
unknown	Unknown	South Africa	established	
unknown	Unknown	Slovakia	probably established	
unknown	Unknown	Seychelles	probably established	no data
unknown	unknown	Saudi Arabia	established	unknown

“Year / Period	From	To	Established	Ecol. effects
unknown	Venezuela	Reunion	established	unknown
unknown	Unknown	East Timor	established	
unknown	Unknown	Palau	established	
unknown	Unknown	Vanuatu	probably established	
unknown	Unknown	New Zealand	established	
unknown	unknown	Vanuatu	unknown	unknown
unknown	Unknown	Tahiti	established	
unknown	Unknown	Fiji	established	
unknown	Unknown	Czech Republic	probably established	
unknown	Unknown	Russia	established	unknown
unknown	Unknown	Albania	probably established	unknown
unknown	Unknown	Béni Abbès	not established	
unknown	Unknown	Australia	established	probably some
unknown	Unknown	Taiwan	established	
Unknown	Unknown	Comoros	Yes	
unknown	Unknown	Cook Islands	established	
unknown	Venezuela	Costa Rica	established	
unknown	Unknown	Cuba	established	
1930 - 1939	Unknown	Sri Lanka	established	
1960 - 1969	Unknown	Canada	not established	
1905	Hawaii	Philippines	established	some
1908	South America	India	established	probably none
1920	Unknown	Indonesia	established	some
1922	South America	USA	established	probably some
1922	Unknown	Hawaii	established	
1924	Germany?	Hungary	established	unknown
1935	Central America	Puerto Rico	established	
1937	South America	Singapore	established	probably some
1940	Unknown	Colombia	established	
1940	Central America	Peru	established	
1950	USA	Uganda	established	probably some
1950	Uganda	Kenya	established	
1957	Thailand	Bangladesh	unknown	
1960	Singapore	Thailand	established	
1963	Unknown	UK	probably not established	
1967	Unknown	Papua New Guinea	established	some
1971	Unknown	Mexico	established	
1972	UK	Nigeria	probably not established	

“Year / Period	From	To	Established	Ecol. effects
1977	Dominican Republic	Haiti	unknown	no data
1984	Unknown	Malawi	probably not established	probably none”

Means of Introduction Outside the United States

From CABI (2018):

“*P. reticulata* has been widely introduced throughout temperate and tropical regions since the early 1900s (Welcomme, 1992). Initial introductions of *P. reticulata* were conducted as a means of mosquito control in Asia, the Pacific, Africa, and Europe […] It is likely that *P. reticulata* has been introduced into many countries via accidental or intentional release of aquarium fish into waterways and many introduced populations have become established.”

Short Description

From Froese and Pauly (2017):

“Dorsal spines (total): 0; Dorsal soft rays (total): 7-8; Anal spines: 0; Anal soft rays: 8 - 10”

From CABI (2018):

“*P. reticulata* belongs to the poeciliids, a group of small freshwater fishes with internal fertilisation and viviparous reproduction. *P. reticulata* has clear sexual dimorphism. Males are 25-35 mm (SL) and have conspicuous polymorphic colour patterns consisting of combinations of black, white, red-orange, yellow, green, iridescent spots, lines and speckles. Males have a gonopdium; a slender, modified anal fin used as an intromittent organ, whereas the anal fin of females is rounded. Females are uniform silver grey, and are larger and deeper bodied than males (40-60 mm SL). Juvenile fish resemble females, and are independent from birth.”

Biology

From Froese and Pauly (2017):

“Inhabits warm springs and their effluents, weedy ditches and canals [Page and Burr 1991]. Found in various habitats, ranging from highly turbid water in ponds, canals and ditches at low elevations to pristine mountain streams at high elevations [Kenny 1995]. Occurs in wide variety of habitats with low predation pressure, usually in very small streams and densely vegetated lakes and springs [Kottelat and Freyhof 2007]. […] Feeds on zooplankton, small insects and detritus.”

“Males are about half the size of females with colorful tail and caudal fin; the anal fin is transformed into a gonopodium for internal fertilization. Males are continuously chasing and mating females. Females can store sperms for later fertilization and may produce young every four weeks. Pregnant females are recognizable by black triangle between anal and pelvic fins.

After a gestation period of four to six weeks females give birth to 20-40 live young. No parental care is exercised and parents may even prey on their young."

From CABI (2018):

"*P. reticulata* is omnivorous; feeding on algae (approximately 50% of the wild diet), invertebrate larvae and benthic detritus (Dussault and Kramer, 1981). Within their natural range they may also prey on larvae of their own species and of *Rivulus hartii* (Houde, 1997). Experimental captive trials have found that the closely related *Gambusia holbrooki* preys on a wide range of larvae of other fish species from areas into which *P. reticulata* has also been introduced (Howe et al., 1997), suggesting that *P. reticulata* may also prey on these species."

"Females continue to reproduce to 20-34 months old, and there is no significant period of reproductive senescence."

Human Uses

From Froese and Pauly (2015):

"Fisheries: of no interest; aquarium: commercial"

From CABI (2018):

"**Economic Value**
P. reticulata has considerable economic value as an ornamental aquarium species, and is widely cultured in commercial fish hatcheries. A number of highly ornamented aquarium strains have been developed, and are extremely popular in the retail aquarium trade, being carried by up to 95% of pet shops in one region of Canada. Major producers include Singapore, Malaysia and Taiwan."

"**Social Benefit**
P. reticulata is one of the most popular aquarium fishes, and has been in the ornamental fish hobby since the early 1900s. It has high recreational and aesthetic value in captivity, but has little or no social benefit in its feral state and is not suitable for recreational fishing."

"**Environmental Services**
While initially thought to be a good candidate for mosquito control, *P. reticulata* has had mixed success in controlling mosquito populations (Juliano et al., 1989; Castleberry and Cech, 1990)."

Diseases

From Froese and Pauly (2017):

"*Aontheca* Infestation, Parasitic infestations (protozoa, worms, etc.)"
"*Camallanus* Infection 12, Parasitic infestations (protozoa, worms, etc.)"
"Columnaris Disease (e.), Bacterial diseases"
"Columnaris Disease (l.), Bacterial diseases"
"*Cryptobia* Infestation, Parasitic infestations (protozoa, worms, etc.)"

"*Eustrongylides* Infestation 2 (Larvae), Parasitic infestations (protozoa, worms, etc.)"
"Fin Rot (early stage), Bacterial diseases"
"Fin-rot Disease (late stage), Bacterial diseases"
"Fish tuberculosis (FishMB), Bacterial diseases"
"*Ichthyobodo* Infection, Parasitic infestations (protozoa, worms, etc.)"
"*Lernaea* Infestation, Parasitic infestations (protozoa, worms, etc.)"
"Nematode Infestation, Parasitic infestations (protozoa, worms, etc.)"
"Skin Flukes, Parasitic infestations (protozoa, worms, etc.)"
"Skin Fungi (*Saprolegnia* sp.), Fungal diseases"
"*Tetrahymena* Disease, Parasitic infestations (protozoa, worms, etc.)"
"White spot Disease, Parasitic infestations (protozoa, worms, etc.)"

From Tavakol et al. (2017):

"[…] the invasive Asian nematode, *Camallanus cotti* Fujita, 1927 (Nematoda: Camallanidae), is reported from the guppy (*Poecilia reticulata*) for the first time in Africa. This parasite is assumed to be introduced into Africa along with the introduction of exotic poeciliid fishes, which are known to be the most common hosts of *C. cotti* in ornamental fish industry worldwide."

From Vincent and Font (2003):

"Two of the most important freshwater helminths present in Hawaiian streams are *Camallanus cotti* Fujita, 1927 and *Bothriocephalus acheilognathi* Yamaguti, 1934. This roundworm and tapeworm have been introduced into the Hawaiian Islands indirectly through the purposeful introduction of exotic poeciliids for mosquito control and accidentally through unwanted aquarium releases (Devick, 1991; Font and Tate, 1994)."

From Harris and Lyles (1992):

"Two species of *Gyrodactylus* have been reported (Harris, 1986) from guppies in aquaria: *Gyrodactylus bullatarudis* Tumrnbull, 1956, and *Gyrodactylus turnbulli* Harris, 1986, collected from guppies imported into Britain from Singapore."

From Paperna et al. (2001):

"Systemic iridovirus-like infections have been reported from several exotic ornamental fish [including] in guppy *Poecilia reticulata* and doctor fish *Labroides dimidatus* in the USA, both South East Asian imports (Hedrick & McDowell 1995)."

From Crane and Eaton (1997):

"With regard to the host range, it is noteworthy that the name spring viraemia of carp is misleading. It is generally accepted, if not proven yet, that most if not all cyprinid species are likely to be affected to a lesser or greater degree. In addition, some non-cyprinid fish species such as […] the poeciliid guppy, *Lebistes reticulatus* (Bachmann and Ahne 1974) […] are also susceptible to infection and succumb to disease […]"

Spring viraemia of carp is an OIE-reportable disease.

Threat to Humans

From Froese and Pauly (2017):

"Potential pest"

3 Impacts of Introductions

From Nico et al. (2018):

"The guppy is considered a threat to native cyprinids and killifishes (Sigler and Sigler 1987). For instance, it has adversely affected the White River springfish, *Crenichthys baileyi*, in a Nevada spring (Deacon et al. 1964). Two subspecies of this springfish are now listed as federally endangered (U.S. Fish and Wildlife Service 1993), and three others are proposed for listing (U.S. Fish and Wildlife Service 1994). The guppy has also been implicated in the decline of the Utah sucker, *Catostomus ardens*, in a thermal spring in Wyoming (Courtenay et al. 1987). The guppy has become the dominant species in some warm water springs in the west (Courtenay, personal communication). Courtenay and Meffe (1989) summarized the effect of this species on native fishes. This species also presents a threat because it is a known carrier of certain exotic trematode parasites (Leberg and Vrijenhoek 1994)."

"Guppies, and other introduced poeciliids, have been implicated in the decline of native damselflies on Oahu, Hawaii. The distributions of the damselflies and introduced fishes were often found to be mutually exclusive, probably resulting from predation by the fish on the insects (Englund 1999)."

From GISD (2006):

"It eats the eggs of native fish species and acts as a host for the parasitic nematode *Camallanus cotti*, and the Asian tapeworm *Bothriocephalus acheilognathi* in Hawaii (Eldredge, 2000)."

"Hybrids between *P. reticulata* and *P. mexicana* and between *P. reticulata* and *Xiphophorus helleri* are shown to threaten species of native fish in the western USA (Courtenay and Meffe, 1989 in Eldredge, 2000)."

From Valero et al. (2008):

"Persistent courtship by male Trinidadian guppies (*Poecilia reticulata*) is costly for conspecific females. Since male guppies are known to attempt matings with other poeciliid females, we asked whether persistent courtship is also directed towards morphologically similar but phylogenetically distant females encountered following invasion. *Skiffia bilineata* is one of several endangered viviparous goodeids from Central México, whose remaining habitats are increasingly shared with invasive guppies. Experiments in which guppy sex ratios were manipulated to vary the proportion of heterospecific to conspecific females showed that male guppies courted and attempted forced copulations with *S. bilineata* females even when females of their own species were in excess. This behaviour places an additional, and previously unrecognized, burden on a group of endemic Mexican fishes already in risk of extinction."

From Bambaradeniya (2002):

"The Guppy (*Poecilia reticulata*), which is a prolific breeder distributed in aquatic habitats throughout Sri Lanka, has been observed to feed on the eggs of native amphibians (de Silva, 1996)."

4 Global Distribution

Figure 1. Reported global distribution of *Poecilia reticulata*. Map from GBIF Secretariat (2017). Points in Algeria, Canada, Cape Verde, Democratic Republic of the Congo, Denmark, Ecuador, Germany, Malawi, Mauritius, Morocco, Myanmar, Paraguay, Republic of the Congo, Senegal, Tanzania, United Kingdom, Vietnam were not included in the climate matching analysis because these points do not represent known established populations of *P. reticulata* (see Distribution Outside the United States). Furthermore, most points in the United States were not included in the climate matching analysis (see Figure 2 caption for more information).

5 Distribution within the United States

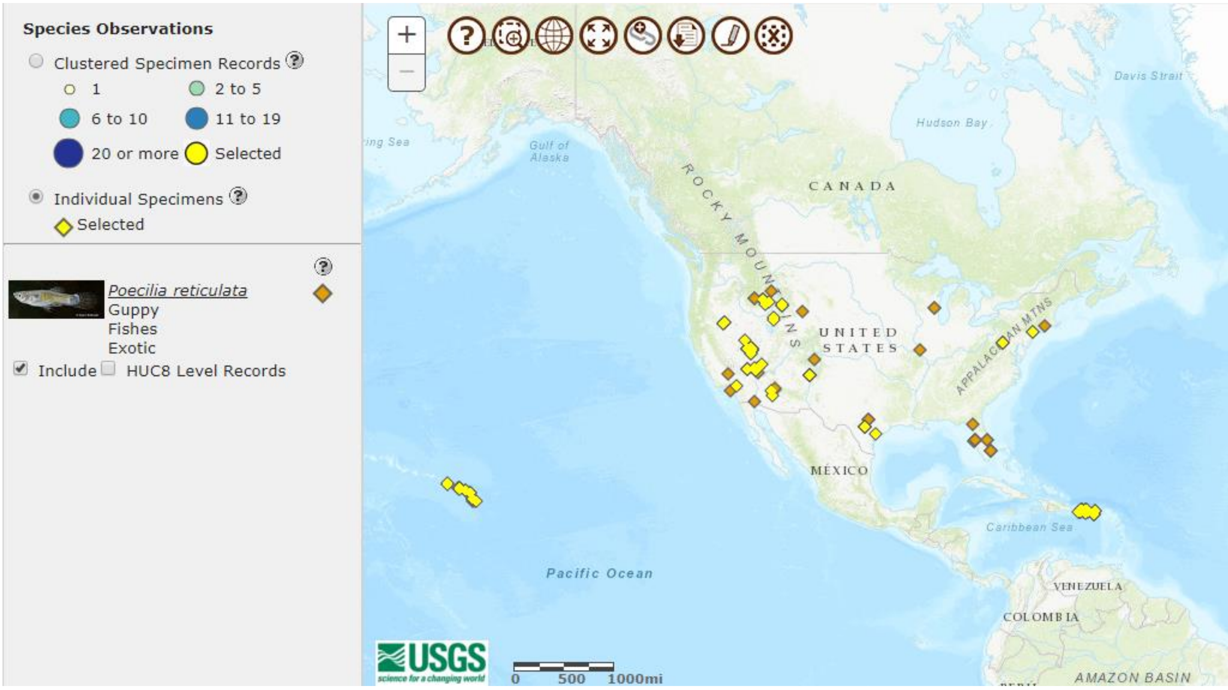

Figure 2. Reported distribution of *Poecilia reticulata* in the United States. Map from Nico et al. (2018). Yellow points represent established locations; orange points represent collection locations where the species is not established or establishment is uncertain. Only locations in Puerto Rico, Hawaii, and Texas were included in the climate matching analysis. In all other locations, *P. reticulata* is established in waters that are naturally or artificially warmed above ambient temperatures, so climate matching based on the weather stations near those locations would not accurately reflect the conditions in which *P. reticulata* is established.

6 Climate Matching

Summary of Climate Matching Analysis

The climate match (Sanders et al. 2014; 16 climate variables; Euclidean Distance) was high in Texas and southeastern Florida. Medium climate matches were seen in the Southwest, California as far north as San Francisco, along the Atlantic Coast from Florida to North Carolina, and along the Gulf Coast. Low match was found in northern areas of the contiguous U.S. Climate 6 score indicated that the contiguous U.S. has a high climate match overall. The range of scores for a high climate match is 0.103 and greater; Climate 6 score of *Poecilia reticulata* was 0.194.

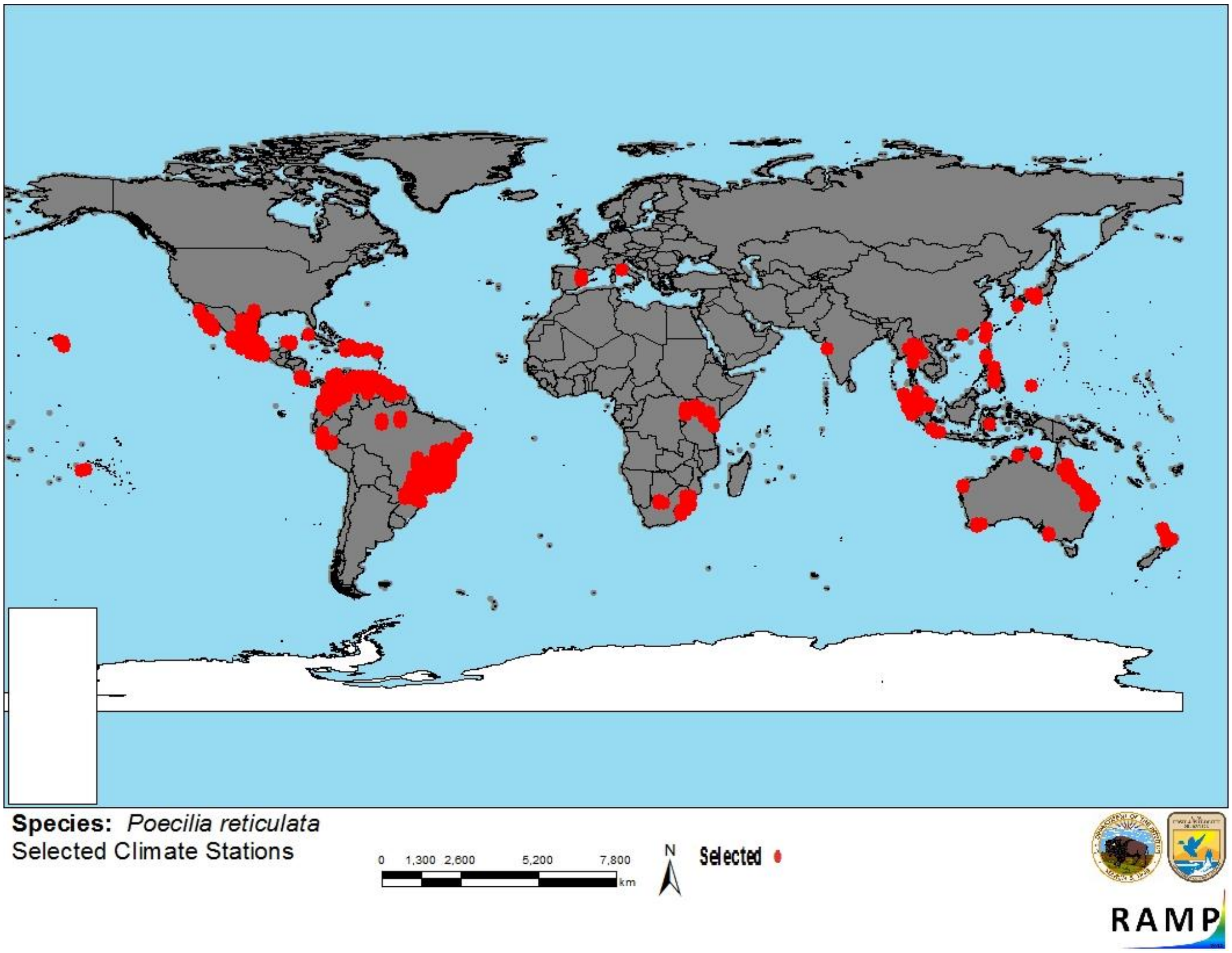

Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Poecilia reticulata* climate matching. Source locations from Froese and Pauly (2017), GBIF Secretariat (2017), and Nico et al. (2018).

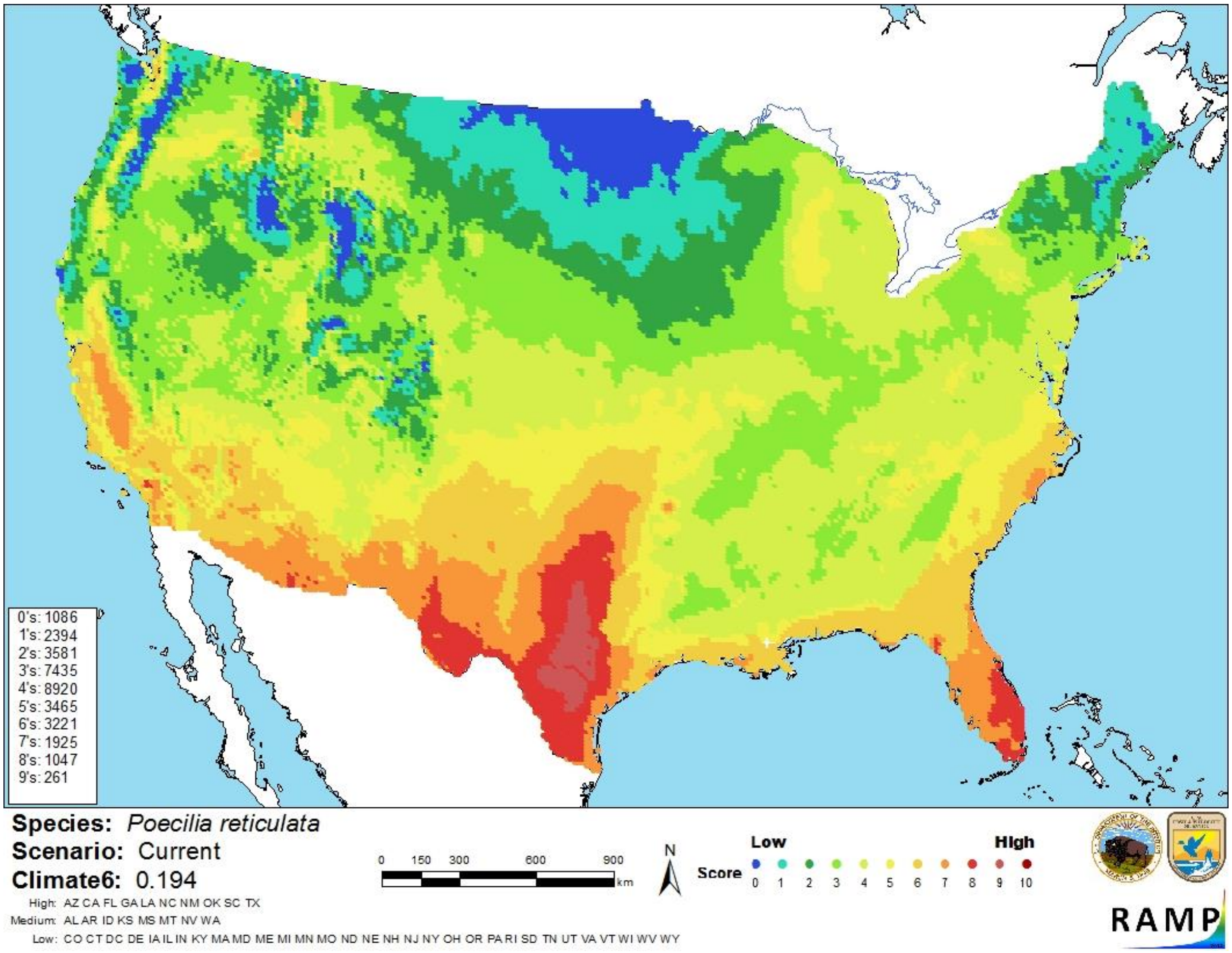

Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *Poecilia reticulata* in the contiguous United States based on source locations reported by Froese and Pauly (2017), GBIF Secretariat (2017), and Nico et al. (2018). 0=Lowest match, 10=Highest match. Counts of climate match scores are tabulated 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

P. reticulata is a well-studied species. Negative impacts from introductions of this species are documented in the scientific literature, but somewhat sparse given the number of countries in which this species has become established. Certainty of this assessment is medium.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Poecilia reticulata is a popular fish for aquaria and for research, and it was originally introduced to many countries as a method of mosquito control. Where introduced, *P. reticulata* has been documented to have adverse impacts on native fishes, amphibians, and invertebrates through competition, predation, and disease. *P. reticulata* is currently established numerous local warm springs in the western U.S., where it has been implicated in the decline of White River springfish (*Crenichthys baileyi*) and Utah sucker (*Catostomus ardens*). Climate match to the contiguous U.S. is high, with highest matches in Florida and Texas. However, other factors may be limiting risk of establishment in those States since *P. reticulata* is established in only one location in Texas, despite the species being one of the most widely traded species in the aquarium trade for more than a century. Overall risk posed by this species is characterized as high, particularly within thermal spring ecosystems supporting vulnerable fish assemblages.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): Medium**
- **Remarks/Important additional information: Carries the pathogen causing OIE-reportable Spring Viraemia of Carp.**
- **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.

Bambaradeniya, C. N. B. 2002. The status and implications of alien invasive species in Sri Lanka. Zoos' Print Journal 17(11):930-935.

CABI. 2018. *Poecilia reticulata* (guppy) [original text by L. Jordan]. CAB International, Wallingford, UK. Available: http://www.cabi.org/isc/datasheet/68208. (February 2018).

Chapman, F. A., S. A. Fitz-Coy, E. M. Thunberg, and C. M. Adams. 1997. United States of America trade in ornamental fish. Journal of the World Aquaculture Society 28(1):1-10.

Crane, M. S., and B. T. Eaton. 1997. Spring viraemia of carp virus (*Rhabdovirus carpio*): a biological control agent? Pages 87-107 *in* J. Roberts, and R. Tilzey. Controlling carp: exploring the options for Australia. CSIRO Land and Water, Griffith, New South Wales, Australia.

Froese, R., and D. Pauly, editors. 2017. *Poecilia reticulata* Peters, 1859. FishBase. Available: http://fishbase.org/summary/Poecilia-reticulata.html. (February 2018).

GBIF Secretariat. 2017. GBIF backbone taxonomy: *Poecilia reticulata* Peters, 1859. Global Biodiversity Information Facility, Copenhagen. Available: http://www.gbif.org/species/2350050. (February 2018).

GISD (Global Invasive Species Database). 2006. *Poecilia reticulata* (fish). IUCN Invasive Species Specialist Group, Gland, Switzerland. Available: http://www.issg.org/database/species/ecology.asp?si=683&fr=1&sts=sss&lang=EN. (July 2015).

Harris, P. D., and A. M. Lyles. 1992. Infections of *Gyrodactylus bullatarudis* and *Gyrodactylus turnbulli* on guppies (*Poecilia reticulata*) in Trinidad. The Journal of Parasitology 78(5):912-914.

ITIS (Integrated Taxonomic Information System). 2018. *Poecilia reticulata* Peters, 1859. Integrated Taxonomic Information System, Reston, Virginia. Available: http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=165903#null. (February 2018).

NatureServe. 2017. NatureServe Explorer: an online encyclopedia of life, version 7.1. NatureServe, Arlington, Virginia. Available: http://explorer.natureserve.org. (February 2018).

Nico, L., M. Neilson, and B. Loftus. 2018. *Poecilia reticulata* Peters, 1859. USGS Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=863. (February 2018).

Paperna, I., M. Vilenkin, and A. P. A. de Matos. 2001. Iridovirus infections in farm-reared tropical ornamental fish. Diseases of Aquatic Organisms 48:17-25.

Sanders, S., C. Castiglione, and M. Hoff. 2014. Risk Assessment Mapping Program: RAMP. U.S. Fish and Wildlife Service.

Shafland, P. L., K. B. Gestring, and M. S. Stanford. 2008. Categorizing introduced fishes collected from public waters. Southeastern Naturalist 7(4):627-636.

Tavakol, S., A. Halajian, W. J. Smit, A. Hoffman, and W. J. Luus-Powell. 2017. Guppies (*Poecilia reticulata*) introducing an alien parasite, *Camallanus cotti* (Nematoda: Camallanidae) to Africa, the first report. Parasitology Research 116:3441-3445.

Valero, A., C. M. Garcia, and A. E. Magurran. 2008. Heterospecific harassment of native endangered fishes by invasive guppies in Mexico. Biology Letters 4:149-152.

Vincent, A. G., and W. F. Font. 2003. Seasonal and yearly population dynamics of two exotic helminths, *Camallanus cotti* (Nematoda) and *Bothriocephalus acheilognathi* (Cestoda), parasitizing exotic fishes in Waianu Stream, O’ahu, Hawaii. The Journal of Parasitology 89(4):756-760.

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.

Bachmann, P. A., and W. Ahne. 1974. Biological properties and identification of the agent causing swim bladder inflammation in carp. Archiv für die gesamte Virusforschung 44:261-269.

Baxter, G. T., and J. R. Simon. 1970. Wyoming fishes. Wyoming Game and Fish Department Bulletin 4, Cheyenne, Wyoming.

Becker, G. C. 1983. Fishes of Wisconsin. University of Madison Press, Madison, Wisconsin.

Bradley, W. G., and J. E. Deacon. 1967. The biotic communities of southern Nevada. Nevada State Museum Anthropological Papers 13(4):201-273.

Brock, V. E. 1960. The introduction of aquatic animals into Hawaiian waters. International Revue der Gesamten Hydrobiologie 45(4):463-480.

Castleberry, D. T., and J. J. Cech, Jr. 1990. Mosquito control in wastewater: a controlled and quantitative comparison of pupfish (*Cyprinodon nevadensis amargosae*), mosquitofish (*Gambusia affinis*) and guppies (*Poecilia reticulata*) in sago pondweed marshes. Journal of the American Mosquito Control Association 6(2):223-228.

Chung, K. 2004. Critical thermal maxima and acclimation rate of the tropical guppy *Poecilia reticulata*. Hydrobiologia 462:253-257.

Conner, J. V., and R. D. Suttkus. 1986. Zoogeography of freshwater fishes of the western Gulf slope of North America. Pages 413-456 *in* C.H. Hocutt and E.O. Wiley, editors. The zoogeography of North American freshwater fishes. John Wiley and Sons, New York.

Courtenay, W. R., Jr. 1985. Florida Atlantic University Quarterly Reports for 1985 to the U.S. Fish and Wildlife Service, Gainesville, Florida.

Courtenay, W. R., Jr., and J. E. Deacon. 1982. Status of introduced fishes in certain spring systems in southern Nevada. Great Basin Naturalist 42(3):361-366.

Courtenay, W. R., Jr., and J. E. Deacon. 1983. Fish introductions in the American southwest: a case history of Rogers Spring, Nevada. Southwestern Naturalist 28:221-224.

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. 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.

Courtenay, W. R., Jr., and G. K. Meffe. 1989. Small fishes in strange places: a review of introduced poeciliids. Pages 319-331 *in* G. K. Meffe, and F. F. Snelson, Jr., editors. Ecology and evolution of livebearing fishes (Poeciliidae). Prentice Hall, Englewood Cliffs, New Jersey.

Courtenay, W. R., Jr., C. R. Robins, R. M. Bailey, and J. E. Deacon. 1987. Records of exotic fishes from Idaho and Wyoming. Great Basin Naturalist 47(4):523-546.

Courtenay, W. R., Jr., H. F. Sahlman, W. W. Miley, II, and D. J. Herrema. 1974. Exotic fishes in fresh and brackish waters of Florida. Biological Conservation 6(4):292-302.

Deacon, J. E., C. Hubbs, and B. J. Zahuranec. 1964. Some effects of introduced fishes on the native fish fauna of southern Nevada. Copeia 1964(2):384-388.

Deacon, J. E., and J. E. Williams. 1984. Annotated list of the fishes of Nevada. Proceedings of the Biological Society of Washington 97(1):103-118.

De Silva, A. 1996. The herpetofauna of Sri Lanka: a brief review. Graphic Land, Kandy, Sri Lanka.

Devick, W. S. 1991. Patterns of introductions of aquatic organisms to Hawaiian freshwater habitats. Pages 189-213 *in* W. S. Devick, editor. New directions in research, management and conservation of Hawaiian freshwater stream ecosystems: proceedings of the 1990 symposium on freshwater stream biology and fisheries management. Division of Aquatic Resources, Hawaii Department of Land and Natural Resources, Honolulu, Hawaii.

Dill, W. A., and A. J. Cordone. 1997. History and status of introduced fishes in California, 1871-1996. California Department of Fish and Game Fish Bulletin 178.

Dussault, G., and D. L. Kramer. 1981. Food and feeding behaviour of the guppy, *Poecilia reticulata* (Pisces: Poeciliidae). Canadian Journal of Zoology 59:684-701.

Edwards, R. J. 1976. Relative and seasonal abundance of the fish fauna in an urban creek ecosystem. Masters thesis. University of Texas, Austin.

Eldredge, L. G. 2000. Numbers of Hawaiian species. Bishop Museum Occasional Papers 63(Supplement 5):3-8.

Englund, R. A. 1999. The impacts of introduced poeciliid fish and Odonata on the endemic *Megalagrion* (Odonata) damselflies of Oahu Island, Hawaii. Journal of Insect Conservation 3:225-243.

Erdsman, D. S. 1984. Exotic fishes in Puerto Rico. Pages 162-176 *in* W. R. Courtenay, Jr., and J. R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Maryland.

Farr, J. A. 1975. Role of predation in evolution of social behavior of natural populations of guppy, *Poecilia reticulata* (Pisces-Poeciliidae). Evolution 29:151-158.

Font, W. F., and D. C. Tate. 1994. Helminth parasites of native Hawaiian freshwater fishes: an example of extreme ecological isolation. Journal of Parasitology 80:682-688.

Harris, P. D. 1986. Species of *Gyrodactylus* von Nordmann 1832 (Monogenea, Gyrodactylidea) from poeciliid fishes with a description of *G. turnbulli* sp. n. from the guppy *Poecilia reticulata* (Peters). Journal of Natural History 20:183-191.

Hedrick, R. P., and T. S. McDowell. 1995. Properties of iridoviruses from ornamental fish. Veterinary Researcj 26:423-427.

Houde, A. 1997. Sex, color, and mate choice in guppies. *In* Monographs in behaviour and ecology. Princeton University Press, Princeton, New Jersey.

Howe, E., C. Howe, R. Lim, and M. Burchett. 1997. Impact of the introduced poeciliid *Gambusia holbrooki* (Girard, 1859) on the growth and reproduction of *Pseudomugil signifer* (Kner, 1865) in Australia. Marine and Freshwater Research 48(5):425-433.

Howells, R. G. 1992. Annotated list of introduced non-native fishes, mollusks, crustaceans and aquatic plants in Texas waters. Texas Parks and Wildlife Department, Management Data Series 78, Austin, Texas.

Hubbs, C., R. J. Edwards, and G. P. Garrett. 1991. An annotated checklist of freshwater fishes of Texas, with key to identification of species. Texas Journal of Science, Supplement 43(4):1-56.

Hubbs, C., T. Luciere, G. P. Garret, R. J. Edwards, S. M. Dean, and E. Marsh. 1978. Survival and abundance of introduced fishes near San Antonio, Texas. Texas Journal of Science 30(4):369-376.

Hubert, W. 1994. Exotic fish. Pages 158-174 *in* T. L. Parrish, and S. H. Anderson, editors. Exotic species manual. Wyoming Game and Fish Department, Laramie, Wyoming.

Hugg, D. O. 1996. MAPFISH georeferenced mapping database. Freshwater and estuarine fishes of North America. Life Science Software, Edgewater, Maryland.

Idaho Department of Fish and Game. 1990. Fisheries management plan 1991-1995. Appendix I - a list of Idaho fishes and their distribution by drainage. Idaho Department of Fish and Game.

Juliano, R., R. Guerrero III, and I. Ronquillo. 1989. The introduction of exotic aquatic species in the Philippines. Pages 83-90 *in* S. S. De Silva, editor. Exotic aquatic organisms in Asia. Proceedings of the workshop on introduction of exotic aquatic organisms in Asia. Asian Fisheries Society Special Publication 3. Asian Fisheries Society, Manila, Philippines.

Kanayama, R. K. 1968. Hawaii's aquatic animal introductions. Proceedings of the Annual Conference of Western Association State Game and Fish Commissioners 47:123-131.

Kenny, J. S. 1995. Views from the bridge: a memoir on the freshwater fishes of Trinidad. J. S. Kenny, Maracas, St. Joseph, Trinidad and Tobago.

Keevin, T. M. 1978. A distributional and faunistic analysis of the small stream fishes of St. Louis and St. Louis County, Missouri. Master's thesis. Southern Illinois University, Edwardsville, Illinois.

Kottelat, M., and J. Freyhof. 2007. Handbook of European freshwater fishes. Publications Kottelat, Cornol, Switzerland.

Leberg, P. L., and R. C. Vrijenhoek. 1994. Variation among desert topminnows in their susceptibility to attack by exotic parasites. Conservation Biology 8:419-424.

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

Linder, A. D. 1963. Idaho's alien fishes. Tebiwa 6(2):12-15.

Loftus, W. F. 2004. Assesment of heavy rainfall event on the inland habitats and fishes of Virgin Islands National Park, St. John, USVI. Report submitted to the National Park Service, Inventory and Monitoring Program.

Maciolek, J. A. 1984. Exotic fishes in Hawaii and other islands of Oceania. Pages 131-161 *in* W. R. Courtenay, Jr., and J. R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Maryland.

Magurran, A. E. 2005. Evolutionary ecology: the Trinidadian guppy. Oxford University Press, Oxford, U.K.

Minckley, W. L. 1973. Fishes of Arizona. Arizona Fish and Game Department. Sims Printing Company, Inc., Phoenix, Arizona.

Moyle, P. B. 1976. Inland fishes of California. University of California Press, Berkeley, California.

Moyle, P. B. 2002. Inland fishes of California, 2nd edition. University of California Press, Berkeley, California.

Mundy, B. C. 2005. Fishes of the Hawaiian Archipelago. Bishop Museum Bulletins in Zoology 6.

Page, L. M., and B. M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company, Boston.

Riehl, R., and H. A. Baensch. 1991. Aquarien Atlas, volume 1. Mergus, Verlag für Natur-und Heimtierkunde, Melle, Germany.

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.

Sigler, W. F., and J. W. Sigler. 1987. Fishes of the Great Basin: a natural history. University of Nevada Press, Reno, Nevada.

Simpson, J., and R. Wallace. 1978. Fishes of Idaho. University of Idaho Press, Moscow, Idaho.

St. Amant, J. A., and F. G. Hoover. 1969. Addition of *Misgurnus anguillicaudatus* (Cantor) to the California fauna. California Fish and Game 57(2):330-331.

Stone, M. D. 1995. Fish stocking programs in Wyoming: a balanced perspective. Pages 47-51 *in* H. L. Schramm, Jr., and R. G. Piper, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium 15.

Sublette, J. E., M. D. Hatch, and M. Sublette. 1990. The fishes of New Mexico. University of New Mexico Press, Albuquerque, New Mexico.

Tilmant, J. T. 1999. Management of nonindigenous aquatic fish in the U.S. National Park System. National Park Service.

U. S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants. 50 CFR 17.11 & 17.12. Federal Register, August 23, 1993. U.S. Department of the Interior, Washington, D.C.

U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants: animal candidate review for listing as endangered or threatened species. 50 CFR 17.11 & 17.12. Federal Register, November 15, 1994. 59(219):58982-589028. U.S. Department of the Interior, Washington, D.C.

Welcomme, R. 1992. A history of international introductions of inland aquatic species. Introductions and transfers of aquatic species. ICES Marine Science Symposia 194:3-14.

Whitworth, W. R. 1996. Freshwater fishes of Connecticut. State Geological and Natural History Survey of Connecticut, Bulletin 114.

Williams, C. D., and J. E. Williams. 1981. Distribution and status of native fishes of the Railroad Valley system, Nevada. Cal-Neva Wildlife Transactions 1981:48-51.

Zuckerman, L. D., and R. J. Behnke. 1986. Introduced fishes in the San Luis Valley, Colorado. Pages 435-452 *in* R. H. Stroud, editor. Fish culture in fisheries management. Proceedings of a symposium on the role of fish culture in fisheries management at Lake Ozark, Missouri, March 31-April 3, 1985. American Fisheries Society, Bethesda, Maryland.