Western Mosquitofish (*Gambusia affinis*)
Ecological Risk Screening Summary

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1 Native Range and Status in the United States

Native Range
From Froese and Pauly (2016):

"North and Central America: Mississippi River basin from central Indiana and Illinois in USA south to Gulf of Mexico and Gulf Slope drainages west to Mexico."

From Nico et al. (2016):

"Atlantic and Gulf Slope drainages from southern New Jersey to Mexico; Mississippi River basin from central Indiana and Illinois south to Gulf. *Gambusia holbrooki* is native to Atlantic and Gulf Slope drainages as far west as southern Alabama; *G. affinis* occurs throughout rest of the range (Rauchenberger 1989; Page and Burr 1991)."

From NatureServe (2016):

"This species is native to most of south-central United States, north to Indiana and Illinois, west to Texas, south to southern Mexico, east to Mobile River system. Populations in the drainages of the Chattahoochee and Savannah rivers (Lydeard and Wooten 1991) possibly are native (Page and Burr 2011). See Walters and Freeman (2000) for information on the distribution of *G. affinis* and *G. holbrooki* in the Conasauga River system, where *G. affinisi* is widespread and native and *G. holbrooki* is apparently introduced and expanding its range."

Status in the United States

Part of the native range of *Gambusia affinis* is in the United States (Froese and Pauly 2016; NatureServe 2016; Nico et al. 2016).

From Nico et al. (2014):

"Mosquitofish have been stocked in Alabama (Boschung 1992); Alaska (Krumholz 1948); Arizona (Dees 1961; Miller and Lowe 1967; Minckley 1969,1973; Lee et al. 1980 et seq.; Tilmant 1999; USFWS 2005); California (Dees 1961; La Rivers 1962; Minckley 1973; Moyle 1976a; Lee et al. 1980 et seq.; Moyle and Daniels 1982; Smith 1982; Stockwell et al. 1996; Taylor et al. 1982; Tilmant 1999; Matern et al. 2002; Sommer 2001); Colorado (Woodling 1985; Tyus et al. 1982; Zuckerman and Behnke 1986; Dill and Cordone 1997; Rasmussen 1998; Tilmant 1999; Sommer et al. 2001); Connecticut (Whitworth 1996); Florida (J. Chick, personal communication; J. D. Williams, personal observation); Hawaii (Brock 1960; Maciolek 1984; Tilmant 1999; Mundy 2005); Idaho (Simpson and Wallace 1978; Lee et al. 1980 et seq.; Idaho Fish and Game 1990); Illinois (Dees 1961; Smith 1979; Mills et al. 1993); Indiana (Dees 1961; Simon et al. 1992); Iowa (Harlan et al. 1987; Bernstein and Olson 2001); Kansas (Cross 1954, 1967; Clarke et al. 1958; Dees 1961; Tilmant 1999); Kentucky (Clay 1975; Burr and Warren 1986); Massachusetts (Krumholz 1948; Dees 1961); Michigan (Krumholz 1948; Hubbs and Lagler 1958; Dees 1961; Lee et al. 1980 et seq.); Minnesota (Eddy and Underhill 1974; Phillips et al. 1982); Mississippi (Krumholz 1948); Missouri (Dees 1961; Cross 1967; Pflieger 1997; Young et al. 1997); Montana (Brown and Fox 1966; Brown 1971; Lee et al. 1980 et seq.; Holton 1990); Nebraska (Haynes 1993; Lynch 1988a, 1988b, 1991; Rasmussen 1998; Steven 2004); Nevada (Miller and Alcorn 1946; Dees 1961; La Rivers 1962; Hubbs and Deacon 1964; Bradley and Deacon 1967; Lee et al. 1980 et seq.; Deacon and Williams 1984; Tilmant 1999; Vinyard 2001; USFWS 2001); New Jersey (Krumholz 1948; Fowler 1952; Dees 1961); New Mexico (Barber et al. 1929; Koster 1957; Dees 1961; Lee et al. 1980 et seq.; Tyus et al. 1982; Sublette et al. 1990; Plantania 1991); New York (Dees 1961; Lee et al. 1980 et seq.; Smith 1985; Schmidt 1986); North Carolina (Menhinick 1991); various drainage systems in Ohio (Dees 1961; Lee et al. 1980 et seq.; Trautman 1981; Hocutt et al. 1986; Burr and Page 1986); Oregon (Bond 1961, 1973, 1994; Oregon 1995); Pennsylvania (Dees 1961; Cooper 1983); Tennessee (Kuhne 1939; Etnier and Starnes 1993); Texas (Hubbs, personal communication); Utah (Rees 1934, 1945; Dees 1961; Sigler and Miller 1963; Minckley 1973; Lee et al. 1980 et seq.; Tyus et al. 1982; Tilmant 1999; USFWS 2005); Virginia (Jenkins and Burkhead 1994); Washington (Dees 1961; Wydoski and Whitney 1979; Fletcher, personal communication; USFWS 2005); West Virginia (Cincotta, personal communication); Wisconsin (Krumholz 1948; Dees 1961); Wyoming (Hubert 1994; Stone 1995), and probably other states. Also in Puerto Rico (Erdsman 1984; Lee et al. 1983)."

"In some cases *Gambusia* stocks native to a particular region of a state were moved within the same state, in Virginia for example (Jenkins and Burkhead 1994). In contrast, Krumholz (1948) reported that mosquitofish from southern Illinois, where the species is native, were introduced into northern Illinois, an area outside its native range. Hubbs and Lagler (1958) reported that intergrades between *G. affinis* and *G. holbrooki* have been introduced into southern Michigan, but the stock did not become established."

"Introduction of the western mosquitofish into northern California occurred in 1922 when 600 *G. affinis* were planted in Fort Sutter lily pond. Members of this population were then introduced into the vicinities of Glenn, Kern, Coachella Valley, and Los Angeles CA during the 1920s and 1930s. In 1934, *G. affinis* were also introduced into Fallon, Nevada. From Fallon, Nevada, *G. affinis* were introduced into the following areas of Nevada: Wabuska, Garrett, Parker Ranch, and Bonham Ranch in the late 1930s and early 1940s (Stockwell et al. 1996)."

From Nico et al. (2016):

"*Gambusia holbrooki* was recorded in the Great Lakes basin (IL) in 1947, but extirpated in that location in 1948. We are uncertain whether this may have been *G. affinis*."

"Established in most states where stocked outside its native range. Its establishment and spread in northern states is greatly restricted because the species are not, in general, cold tolerant. […] Established in Nebraska, although the populations suffer heavy (up to 99%) winter mortality (Haynes 1993). Pflieger (1997) noted that *Gambusia affinis* is more widespread and abundant in Missouri now than it was half a century ago. For instance, Pflieger indicated that, by the early 1980s, it had become established northward along the Mississippi River to Clark County, Missouri, and westward near the Missouri River to Andrew County, a range expansion attributed to a combination of natural dispersal and undocumented introductions."

From NatureServe (2016):

"Lynch (1992) reported that five or six populations from Georgia, Illinois, Tennessee and Texas were used for most introductions nationwide and worldwide. Within the United States, sources from Illinois, Tennessee and Texas were used to establish mosquitofish in the western half of the country. Therefore, most if not all populations in the western United States are *G. affinis*."

Means of Introductions in the United States

From Nico et al. (2014):

"Because of their reputation as mosquito-control agents, both *G. holbrooki* and *G. affinis* have been stocked routinely and indiscriminately in temperate and tropical areas around the world. In the United States the first known introductions of mosquitofish took place in the early 1900s (Krumholz 1948). In 1905 about 150 *G. affinis* were introduced into Hawaii from Texas to test their effectiveness in preying on mosquito larvae (Seale 1905), and by 1910 their descendants had been released into parts of Oahu, Hawaii, Maui, Kauai, and Molokai (Van Dine 1907; Stearns 1983). Also, in 1905 *Gambusia*, reportedly from North Carolina, were released into New Jersey waters for the purpose of controlling mosquitoes (Seal 1910; Krumholz 1948). In 1922 mosquitofish from Texas (900 from Austin and 300 from Hearne) were introduced into a lily pond a Sutter's Fort. That lily pond served as a hatchery used to spread *G. affinis* across California and Nevada during the 1920s and 1930s (Stockwell et al. 1996). Mosquitofish were commonly and widely introduced during the following decades by such organizations as the former U.S. Public Health Service, in large part because they were thought of as an effective and inexpensive means of combating malaria (Krumholz 1948). In more recent years, employees of many state and local health departments apparently view the use of mosquitofish to control mosquito larvae as an attractive alternative to the use of insecticides. In some areas range extensions have occurred through natural dispersal far from sites where originally introduced (e.g., Pflieger 1997)."

Remarks

From Nico et al. (2016):

"*Gambusia affinis* and *G. holbrooki* were long considered subspecies of *G. affinis*, and were only recently recognized as separate species (Wooten et al. 1988; Rauchenberger 1989; Robins et al. 1991). Complicating matters of identification, most introductions occurred before the recent taxonomic change; furthermore, the origins of introduced stocks were usually unknown or unreported. In addition, both forms were widely available and thought to have been dispersed widely by humans. As a consequence, it often is not possible to determine if many of the earlier records represent introductions of *G. affinis* or of *G. holbrooki*."

From GISD (2016):

"This species has been nominated as among 100 of the "World's Worst" invaders"

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2010):

"Kingdom Animalia
  Subkingdom Bilateria
    Infrakingdom Deuterostomia
      Phylum Chordata
        Subphylum Vertebrata
          Infraphylum Gnathostomata
            Superclass Osteichthyes
              Class Actinopterygii
                Subclass Neopterygii
                  Infraclass Teleostei

Superorder Acanthopterygii
Order Cyprinodontiformes
Suborder Cyprinodontoidei
Family Poeciliidae
Subfamily Poeciliinae
Genus *Gambusia*
Species *Gambusia affinis* (Baird and Girard, 1853)"

"Taxonomic Status: Current Standing: Valid"

From Nico et al. (2016):

"*Gambusia affinis* and *G. holbrooki* were long considered subspecies of *G. affinis*, and were only recently recognized as separate species (Wooten et al. 1988; Rauchenberger 1989; Robins et al. 1991)."

Size, Weight, and Age Range

From Froese and Pauly (2016):

"Max length: 4.0 cm TL male/unsexed; [Billard 1997]; 7.0 cm TL (female); common length: 3.9 cm TL male/unsexed; [Hugg 1996]; max. reported age: 3 years [Beverton and Holt 1959]"

From GISD (2016):

"Males grow to 40mm in length, while females reach 70mm long (FishBase, 2003)."

Environment

From Froese and Pauly (2016):

"Freshwater; brackish; benthopelagic; pH range: 6.0 - 8.0; dH range: 5 - 19; potamodromous."

From GISD (2016):

"Benthopelagic; non-migratory; lives in fresh and brackish water with a pH range of 6.0 - 8.0 and usually at temperatures between 12 - 29°C (FishBase, 2003). Mosquito fish are a remarkably hardy species, surviving in waters with little oxygen, in high salinities (including twice that of sea water) and temperatures of up to 42°C for short periods (McCullough, 1998)."

From NatureServe (2016):

"It also occurs in brackish sloughs and coastal saltwater habitats (Tabb and Manning 1961, Odum 1971). This fish is more tolerant of pollution than are most other fishes (Lewis 1970, Kushlan 1974). It tolerates dissolved oxygen levels as low as 0.18 mg/L (Ahuja 1964) but cannot tolerate extreme cold; temperature apparently limits the range northward (Hubbs 1971). However, some populations are known to overwinter under ice in Indiana and Illinois (Krumholz 1944)."

Climate/Range

From Froese and Pauly (2016):

"Subtropical; 12°C - 29°C [Pet Resources 2004]; 42°N - 26°N"

From Nico et al. (2016):

"the species are not, in general, cold tolerant"

Distribution Outside the United States

Native

Much of the native range of *Gambusia affinis* is within the United States. See Section 1 for more detailed information.

From Froese and Pauly (2016):

"North and Central America: Mississippi River basin from central Indiana and Illinois in USA south to Gulf of Mexico and Gulf Slope drainages west to Mexico."

Introduced

From Froese and Pauly (2016):

"One of the species with the widest range of introductions which acquired for itself a near pan-global distribution [Welcomme 1988]."

From Nico et al. (2014):

"Introductions of mosquitofish into New Zealand from the Hawaiian Islands showed a reduction in genetic diversity typical of introduced populations originating from a small number of colonizers (Purcell et al. 2012)."

From FAO (2016):

"*Gambusia affinis affinis* - from unknown to Yugoslavia, Former Area"
Gambusia affinis affinis - from unknown to Morocco
Gambusia affinis affinis - from unknown to Solomon Is.
Gambusia affinis affinis - from unknown to Israel
Gambusia affinis affinis - from unknown to Kiribati
Gambusia affinis affinis - from USA (California) to Canada
Gambusia affinis affinis - from United States of America to Madagascar
Gambusia affinis affinis - from United States of America to Zimbabwe
Gambusia affinis affinis - from unknown to Hungary
Gambusia affinis affinis - from unknown to Northern Mariana Is.
Gambusia affinis affinis - from Syrian Arab Republic to Cyprus

Gambusia affinis affinis - from North America to China
Gambusia affinis affinis - from unknown to South Africa
Gambusia affinis affinis - from North America to Taiwan Province of China
Gambusia affinis affinis - from unknown to Central African Republic
Gambusia affinis affinis - from unknown to France
Gambusia affinis affinis - from Central America to Peru
Gambusia affinis affinis - from unknown to Greece
Gambusia affinis affinis - from United States of America to Italy
Gambusia affinis affinis - from unknown to Chile
Gambusia affinis affinis - from unknown to Mexico
Gambusia affinis affinis - from unknown to Fiji
Gambusia affinis affinis - from Australia and United States of America(Hawaii) to New Zealand
Gambusia affinis affinis - from unknown to Papua New Guinea
Gambusia affinis affinis - from Italy to Indonesia
Gambusia affinis affinis - from Italy to Sudan
Gambusia affinis affinis - from unknown to Egypt
Gambusia affinis affinis - from unknown to Argentina
Gambusia affinis affinis - from unknown to Samoa
Gambusia affinis affinis - from unknown to Thailand
Gambusia affinis affinis - from unknown to Ghana
Gambusia affinis affinis - from unknown to Malaysia
Gambusia affinis affinis - from unknown to Côte d'Ivoire
Gambusia affinis affinis - from unknown to Bolivia
Gambusia affinis affinis - from United States of America to Guam
Gambusia affinis affinis - from unknown to Australia
Gambusia affinis affinis - from unknown to Marshall Islands
Gambusia affinis affinis - from unknown to American Samoa
Gambusia affinis affinis - from United States of America to Puerto Rico
Gambusia affinis affinis - from Taiwan Island (Prov. of China) to Japan
Gambusia affinis affinis - from unknown to Micronesia
Gambusia affinis affinis - from unknown to Syria
Gambusia affinis affinis - from unknown to USSR, Former Area of
Gambusia affinis affinis - from unknown to French Polynesia
Gambusia affinis affinis - from unknown to Cook Is.
Gambusia affinis affinis - from unknown to Kiribati (Line Is.)
Gambusia affinis affinis - from South Africa to Zambia
Gambusia affinis - from Italy to India
Gambusia affinis - from unknown to Iraq
Gambusia affinis - from Untied States of America (Hawaii and Illinois) to Philippines
Gambusia affinis - from unknown to China, Hong Kong SAR
Gambusia affinis - from unknown to Kenya
Gambusia affinis - from unknown to Albania
Gambusia affinis - from unknown to Turkey
Gambusia affinis - from unknown to Romania
Gambusia affinis - from United States of America to Haiti
Gambusia affinis - from unknown to Cambodia

Gambusia affinis - from unknown to Lao People's Dem. Rep.
Gambusia affinis - from unknown to Viet Nam
Gambusia affinis - from Taiwan to Japan
Gambusia affinis - from [unknown] to Spain
Gambusia affinis - from Italy to Geogria
Gambusia affinis - from Russia to Kazakhstan
Gambusia affinis - from [unknown] to Jordan
Gambusia affinis - from USA to Madagascar
Gambusia affinis - from Italy to Sudan
Gambusia affinis - from Italy to Uzbekistan
Gambusia affinis - from (unknown) to Bangladesh
Gambusia affinis - from (unknown) to Armenia
Gambusia affinis - from (unknown) to Myanmar
Gambusia affinis - from (unknown) to Pakistan
Gambusia affinis - from (unknown) to Ukraine"

Gambusia affinis is listed as alien in the European part of Russia, Israel, Romania, Slovenia (including the Mediterranean coast), and the European part of Turkey (DAISIE 2016). It is listed as alien and established in Croatia and Greece (DAISIE 2016).

From Pallewatta et al. (2003):

"Introduced to Singapore."

Means of Introduction Outside the United States

From Nico et al. (2014):

"Western mosquitofish have been widely introduced outside of the continental United States for mosquito control purposes (Krumholz 1948; Purcell et al. 2012)."

From GISD (2016):

"Biological control: Widely introduced for mosquito control. (FishBase, 2003)
Ship: Brought to New Zealand by ship. (McDowall, 1990)
Taken to botanical garden/zoo: Survivors of the sea voyage to New Zealand were released into a pond in the Auckland Botanical Gardens. (McDowall, 1990)"

From FAO (2016):

"Reasons of Introduction: 1) ornamental"

From FAO (2016):

"Reasons of Introduction: 1) research"

Short Description

From Froese and Pauly (2016):

"Dorsal spines (total): 0; Dorsal soft rays (total): 7-9; Anal spines: 0; Anal soft rays: 9 - 10. Origin of dorsal fin opposite 7th anal ray. Length of anal base much less than half distance from caudal. 8 horizontal scale rows between back and abdomen. Ventrals terminate immediately before anal fin. Pelvic fins reach ventrals."

From Nico et al. (2016):

"Mosquitofish is a small, live-bearing fish, is dull grey or brown in color with no bars of bands on the sides, and has a rounded tail. Its body is short, its head flattened, and its mouth pointed upward for surface feeding."

From GISD (2016):

"A stout little fish, the back a little arched in front of the dorsal fin and the belly deep in front of the anal. The head is large with a flattened upper surface, the mouth small, upturned and protrusible, and not reaching as far back as the front of the eyes. The eyes are very large relative to the body. The single, soft-rayed dorsal fin is short-based, high and rounded, while the caudal peduncle is long, deep and compressed, and the caudal fin is rounded. The head and trunk are covered with large scales and there is no lateral line. The back is a greenish olive to brownish, the sides grey with a bluish sheen, and the belly a silvery white. A well-defined black spot on the upper rear abdomen is surrounded by a golden patch above and behind the vent. In mature females there is also a black patch above and somewhat forward of the vent. The ventral surface of the head is a steely blue with a diagonal chin stripe below the eyes. The eyes are greyish to olive, the dorsal fin has small black spots, and the caudal fin has several indistinct cross rows of small black spots. The anal, pelvic and pectoral fins are a translucent pale amber. (McDowall, 1990)."

From NatureServe (2016):

"*G. affinis* usually has six dorsal rays and lacks prominent teeth on gonopodial ray three. Both subspecies have a chromosome number of 2n = 48 but female *G. affinis* possess a large heteromorphic sex chromosome which is lacking in *G. holbrooki* (Black and Howell 1979)."

"In Arizona, *G. affinis* may be confused with Poeciliopsis occidentalis, the Sonoran topminnow. In topminnows the gonopodium is asymmetrical to the left, large hooks and serrae absent on gonopodial tip, and the gonopodium reaches beyond the snout when directed forward. The pelvic fins of males are unmodified and somewhat reduced. Many breeding males will be blackened. In *G. affinis* the gonopodium is symmetrical with large hooks and serrae on the tip. The pelvic fins of males are modified with a fleshy appendage on the distal third of the first, short, unbranched ray. Males are rarely blackened."

Biology

From Froese and Pauly (2016):

"Pelagic and surface predatory fish [Howell et al. 2013]. Feed on zooplankton, small insects and detritus [Man and Hodgkiss 1981, Etnier and Starnes 1993]. Used as live food for carnivorous aquarium fishes. Viviparous [Man and Hodgkiss 1981, Billard 1997]. Effective in mosquito control and widely introduced, but found to compete with indigenous fish and to upset the ecological balance [Shrestha 1990]."

"Most abundant in lower reaches of streams [Yamamoto and Tagawa 2000]. Adults inhabit standing to slow-flowing water; most common in vegetated ponds and lakes, backwaters and quiet pools of streams. Found frequently in brackish water [Man and Hodgkiss 1981]."

From Nico et al. (2016):

"Western Mosquitofish is a small live-bearing fish that feeds primarily on zooplankton and invertebrate prey at the top of the water column. Adults are known to feed on their young opportunistically (Benoit et al. 2000). This species is also well known for its high feeding capacity. Chips (2004) observed maximum consumption rates of 42–167% of their body weight per day. These organisms also require a high density of refuges to maintain populations at or near their asymptotic density (Benoit et al. 2000). Interestingly, equal numbers of male and female mosquitofish occur in the ovary and at birth while adult populations contain a disproportionately large number of females and exhibit increased male mortality after recruitment (Haynes and Cashner 1995). This is probably due to the females' ability to store sperm, a trait that renders males largely unnecessary after insemination and whose presence becomes merely increased competition for developing young."

From NatureServe (2016):

"Fish born early in the spring may reproduce later in the summer and fall. Those born late in the reproductive season overwinter before reproducing (Krumholz 1948). In southcentral Texas, young may be collected from March to October with a peak in abundance in April (Davis 1978). In some constant temperature springs, these fish cease reproduction in winter (Brown and Fox 1966, Davis 1978). However, some populations from thermal habitats (such as cooling ponds and lakes) reproduce year-round (Ferens and Murphy 1974, Bennett and Goodyear 1978). At the Savannah River Power Plant site, South Carolina, fish reproduce throughout the winter although at much reduced brood sizes (Meffe, pers. comm., cited in Constantz 1989). These same workers found that the percentage of reproductively active females increased with increasing water temperature."

"Mosquitofish have internal fertilization and are ovoviviparous (Sublette et al. 1990). Females can store sperm from one copulation and fertilize several broods sequentially (Krumholz 1948). After a gestational period of 21 to 28 days, the young are born alive at a size of approximately eight to nine mm total length (Krumholz 1948). Larger females produce more offspring (Krumholz 1948). Brood sizes of one to 315 young have been reported (Barney and Anson 1921, Moyle 1976). Females annually have four to five broods (Krumholz 1948). Sex ratios are 1:1 at birth, but in older cohorts, the number of males declines relative to the number of females (Krumholz 1948). Under optimal conditions females can become gravid at 6 weeks of age, produce 2-3 broods in first summer. Few individuals live more than 15 months (Moyle 1976)."

"Life history is flexible, varies with environmental conditions (Stearns 1983)."

"Predators include water snakes (Nerodia) (Mushinsky and Hebrard 1977, Kofron 1978), water birds (Kushlan 1974), spiders (Suhr and Davis 1974), and fishes such as black basses and gars (Hunt 1953)."

"Opportunistic omnivore; eats mainly small invertebrates, often taken near water surface. Also eats small fishes and, in the absence of abundant animal food, algae and diatoms (Moyle 1976)."

"Mosquitofish are principally carnivorous, and have strong, conical teeth and short guts (Meffe et al. 1983, Turner and Snelson 1984). They are reported to feed on rotifers, snails, spiders, insect larvae, crustaceans, algae, and fish fry, including their own progeny (Barnickol 1941, Minckley 1973, Meffe and Crump 1987). Cannibalism has been documented by several authors (Seale 1917, Krumholz 1948, Walters and Legner 1980, Harrington and Harrington 1982). Plant material is taken occasionally (Barnickol 1941) and may make up a significant portion of the diet during periods of scarcity of animal prey (Harrington and Harrington 1982). Grubb (1972) showed that anuran eggs from temporary ponds were preferentially selected over those breeding in permanent systems. Several workers have documented changes in the prey community after mosquitofish introduction (Hurlbert et al. 1972, Farley and Younce 1977, Hurlbert and Mulla 1981, Walters and Legner 1980)."

"Due to their name, these fishes are popularly believed to be "super" mosquito-larvae predators. Reddy and Shankuntala (1979), however, found that adult females grew poorly on a diet of mosquito larvae, but they grew quickly on tubifex worms. These results matched the outcome of preference tests, i.e. worms were chosen over mosquito larvae. Cech et al. (1980) found that juveniles grew more quickly when they were raised on brine shrimp nauplii than tubifex worms. Many biologists have concluded these fishes are no more effective in mosquito-larval control than various native fishes (Cross 1967). The effectiveness of predation on mosquito larvae decreases as water volume decreases (Reddy and Pandian 1973)."

"Habitat includes river channels, margins, backwaters; springs, marshes, and artificial habitats of all kinds (Minckley et al. 1991). Often this species occurs in shallow, often stagnant, ponds and the shallow edges of lakes and streams where predatory fishes are largely absent and temperatures are high. It is most abundant in shallow water with thick vegetation (Hubbs 1971)."

Human Uses

From Froese and Pauly (2016):

"Fisheries: minor commercial; aquarium: commercial"

From GISD (2016):

"Used as live food for carnivorous aquarium fishes and also used as mosquito control (FishBase, 2003)."

Diseases

No records of OIE reportable diseases were found.

From Froese and Pauly (2016):

"Rhabdochona Infestation 6, Parasitic infestations"

Threat to Humans

From Froese and Pauly (2016):

"Potential pest"

3 Impacts of Introductions

From Nico et al. (2014):

"According to Courtenay and Meffe (1989), mosquitofish have had the greatest ecological impact by far of any of the introduced poeciliids. Although widely introduced as mosquito control agents, recent critical reviews of the world literature on mosquito control have not supported the view that *Gambusia* are particularly effective in reducing mosquito populations or in reducing the incidence of mosquito-borne diseases (Courtenay and Meffe 1989; Arthington and Lloyd 1989). Because of their aggressive and predatory behavior, mosquitofish may negatively affect populations of small fish through predation and competition (Myers 1967; Courtenay and Meffe 1989), and benefit mosquitos by decreasing competitive pressure from zoooplantion and predation pressure from predatory invertebrates (Blaustein and Karban 1990). In some habitats, introduced mosquitofish reportedly displaced select native fish species regarded as better or more efficient mosquito control agents (Danielsen 1968; Courtenay and Meffe 1989)."

"Introduced mosquitofish have been particularly destructive in the American West where they have contributed to the elimination or decline of populations of federally endangered and threatened species (Courtenay and Meffe 1989). Specific examples of their negative effects include a habitat shift and a reduction in numbers of the threatened Railroad Valley springfish *Crenichthys baileyi* in springs in Nevada (Deacon et al. 1964) and the local elimination of the endangered Sonoran topminnow *Poeciliopsis occidentalis* in Arizona (Moyle 1976a; Meffe et al. 1983, Meffe 1985). Western mosquitofish use the same habitat as the plains topminnow *Fundulus sciadicus* and have displaced these topminnows and other species with their aggressive behavior (Whitmore 1997). The mosquitofish is also responsible for the elimination of the least chub *Iotichthys phlegethontis* in several areas of Utah (Whitmore 1997). Meffe (1983, 1985) found that mosquitofish are very aggressive, even toward larger fish. They often attack, shred fins, and sometimes kill other species. Mosquitofish are known to prey on eggs, larvae, and juveniles of various fishes, including those of largemouth bass and common carp; they are also known to prey on adults of smaller species (Meffe 1985; Courtenay and Meffe 1989). Courtenay and Meffe (1989) listed impacts on a variety of native fishes."

"Introducing mosquitofish also can precipitate algal blooms when the fish eat the zooplankton grazers (Hurlbert et al. 1972), or in an increase in the number of mosquitoes if the fish eat the invertebrate predators (Hoy et al. 1972, Bence 1988). Introduced fishes, including mosquitofish, are likely at least partially responsible for the decline of the Chiricahua leopard frog *Rana chiricahuensis* in southeastern Arizona (Rosen et al. 1995). In California, *Gambusia affinis* has been documented to prey heavily on California newt *Taricha torosa* larvae (Gamradt and Kats 1996) and Pacific treefrog *Hyla regilla* tadpoles (Goodsell and Kats 1999)."

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

"Introductions of western mosquitofish have been implicated in the current restricted distribution of plains topminnow in Nebraska and may be affecting populations in Wyoming (Rahel and Thel 2004; Wyoming Fish and Game Department 2010)."

"Galat and Robertson (1992) found that the Yaqui topminnow *Poeciliopsis occidentalis sonoriensis* occurring in some sites increased their fecundity in response to the presence of introduced *Gambusia*; however, the researchers noted that such habitats must also have certain environmental conditions (e.g., uniform temperatures) for maintenance of vigourous *P. o. sonoriensis* populations. Galat and Robertson concluded that conservation of some extant populations of *P. occidentalis* depends primarily on control of *Gambusia*."

From Nico et al. (2016):

"Schumann et al. (2015) examined the impacts of mosquitofish on populations of plains topminnow and plains killifish (*Fundulus kansae*) in Nebraska using mesocosm trials, finding increased fundulid mortailty [sic] through direct predation on larval fishes and aggression towards juveniles, as well as alteration in activity patterns and microhabitat use by the native species in the presence of mosquitofish."

From GISD (2016):

"Adult *Gambusia affinis* are extremely aggressive and attack other fish, shredding fins and sometimes killing them. Controversy has followed the introduction of mosquito fish, as they have been accused of being little better at destroying mosquitoes than native fish species, as well as being responsible for eliminating many of these same species (Myers, 1965; Haas et al., 2003). Selective predation by mosquito fish has also been shown to alter zooplankton, insect and crustacean communities (McDowall, 1990). Mosquito fish are potential hosts of helminth parasites, which have been transmitted to native fishes (FishBase, 2003)."

“Location Specific Impacts:

North Kaipara Peninsula (New Zealand)
Predation: Recent work has found mosquito fish are likely responsible for the decline of the 'Vulnerable (VU)' dwarf inanga (see *Galaxias gracilis* in IUCN Red List of Threatened Species) in Northland dune lakes.
United States (USA)
Other: *Gambusia affinis* have been found to often attack, shred fins, and sometimes kill other species. Mosquito fish are known to prey on eggs, larvae, and juveniles of various fishes, including those of largemouth bass and common carp; they are also known to prey on adults of smaller species. Introduced fishe [sic], including mosquito fish, are likely at least partially responsible for the decline of the 'Vulnerable (VU)' Chiricahua leopard frog (see *Rana chiricahuensis* in IUCN Red List of Threatened Species) in southeastern Arizona.
Threat to endangered species: Courtenay and Meffe (1989) state that mosquito fish have contributed to the elimination or decline of populations of federally endangered and threatened species; mosquito fish are known to prey on eggs, larvae, and juveniles of various fishe [sic], including those of largemouth bass and common carp; they are also known to prey on adults of smaller species. Several studies have shown that introduced mosquito fish impact negativly [sic] on native species, Nico and Fuller (2005) catalogue these impacts. Specific examples of their negative effects include a habitat shift and a reduction in numbers of the 'Vulnerable (VU)' Railroad Valley springfish (see *Crenichthys baileyi* in IUCN Red List of Threatened Species) in springs in Nevada and the local elimination of the 'Near Threatened (NT)' Sonoran topminnow (see *Poeciliopsis occidentalis* in IUCN Red List of Threatened Species) in Arizona. Western mosquito fish use the same habitat as the plains topminnow *Fundulus sciadicus* and have displaced these topminnows and other species with their aggressive behavior. The mosquito fish is also responsible for the elimination of the 'Vulnerable (VU)' least chub (see *Iotichthys phlegethontis* in IUCN Red List of Threatened Species) in several areas of Utah. Mosquito fish have been founf [sic] to be very aggressive, even toward larger fish.

Hawaii (United States (USA))
Predation: Mosquito fish, and other introduced poeciliids, have been implicated in the decline of native damselflies *Megalagrion spp*. including the ' Vulnerable (VU)' (see *Megalagrion oahuense* in IUCN Red List of Threatened Species) on Oahu, Hawaii. Often the distributions of the damselflies and introduced fishes were found to be mutually exclusive, probably resulting from predation of the fish on the insects (Englund, 1999).”

From CABI (2014):

“*G. affinis* has been introduced throughout the world as a mosquito-control agent. It has become a pest in many waterways following initial introductions in the early 1900s. *G. affinis* is a highly predatory fish, that as well as controlling mosquitoes also eats the eggs of economically important fish, and preys on rare indigenous fish and invertebrate species (ISSG, 2010).”

“G. affinis has been regarded as a controversial species as it has created ecological problems of various kinds but is, at the same time, perceived as being extremely useful in controlling

unwanted organisms (Welcomme, 1988). According to Courtenay and Meffe (1989), mosquitofish have had the greatest ecological impact by far of any of the introduced poeciliids. Although widely introduced as mosquito control agents, recent critical reviews of the world literature on mosquito control have not supported the view that *Gambusia* are particularly effective in reducing mosquito populations or in reducing the incidence of mosquito-borne diseases (Courtenay and Meffe, 1989)."

"Because of the aggressive and predatory behaviour of *G. affinis*, it is reported that native fish species and populations of small fish tend to decline, or are eliminated in areas where it has become established. In some habitats, introduced *G. affinis* reportedly displaced select native fish species regarded as better or more efficient mosquito control agents. They have been particularly destructive in the American West where they have contributed to the elimination or decline of populations of federally endangered and threatened species (Courtenay and Meffe, 1989). Mosquitofish, and other introduced poeciliids, have been implicated in the decline of native damselflies on Oahu, Hawaii. Often the distributions of the damselflies and introduced fishes were found to be mutually exclusive, probably resulting from predation of the fish on the insects (Englund, 1999)."

From Lowe et al. (2000):

"The mosquito fish is a small, harmless-looking fish native to the fresh waters of the eastern and southern United States. It has become a pest in many waterways around the world following initial introductions early last century as a biological control of mosquito. In general, it is considered to be no more effective than native predators of mosquitoes. The highly predatory mosquito fish eats the eggs of economically desirable fish and preys on and endangers rare indigenous fish and invertebrate species. Mosquito fish are difficult to eliminate once established, so the best way to reduce their effects is to control their further spread. One of the main avenues of spread is continued, intentional release by mosquito-control agencies."

From NatureServe (2016):

"Outside their native range, mosquitofish play a role in decreasing populations of native fishes (Miller 1961, Myers 1965, Minckley and Deacon 1968). Due to the number of introductions and corresponding decreases in native fish populations, there can be no doubt of the destructive nature of such introductions. Myers (1965) wrote that almost everywhere introductions have been made, mosquitofish have gradually eliminated or reduced populations of small native fishes. For example, mosquitofish have been instrumental in eliminating native populations of *Poeciliopsis occidentalis* in the southwestern U.S. (Sublette et al. 1990); *P. occidentalis* may be effectively eliminated in 1-3 years (Meffe 1984). Evermann and Clark (1931) reported that mosquitofish in the Salton Sea, California, drove out *Cyprinodon macularius* less than 10 years after introduction to the state. The mechanism for many of these reductions is believed to be predation (Meffe 1985, Courtenay and Meffe 1989). Myers (1965) reported that mosquitofish have even reduced largemouth bass (*Micropterus salmoides*) and carp (*Cyprinus carpio*) populations due to predation on larvae. Another problem is caused when mosquitofish hybridize with other *Gambusia* species (Yardley and Hubbs 1976, Rutherford 1980). Intergradation then corrupts the genome of the native species."

“Introduced mosquitofish also prey heavily on amphibian larvae (Goodsell and Kats 1999) and potentially negatively impact salamander and frog populations (Lawler et al. 1999).”

From NIES (2016):

“Competition with Medaka (*Oryzias latipes*). Predation on juvenile Medaka.
Affected organism: Medaka *Oryzias latipes*”

“Import, transport and keeping are prohibited by the Invasive Alien Species Act [of Japan].”

4 Global Distribution

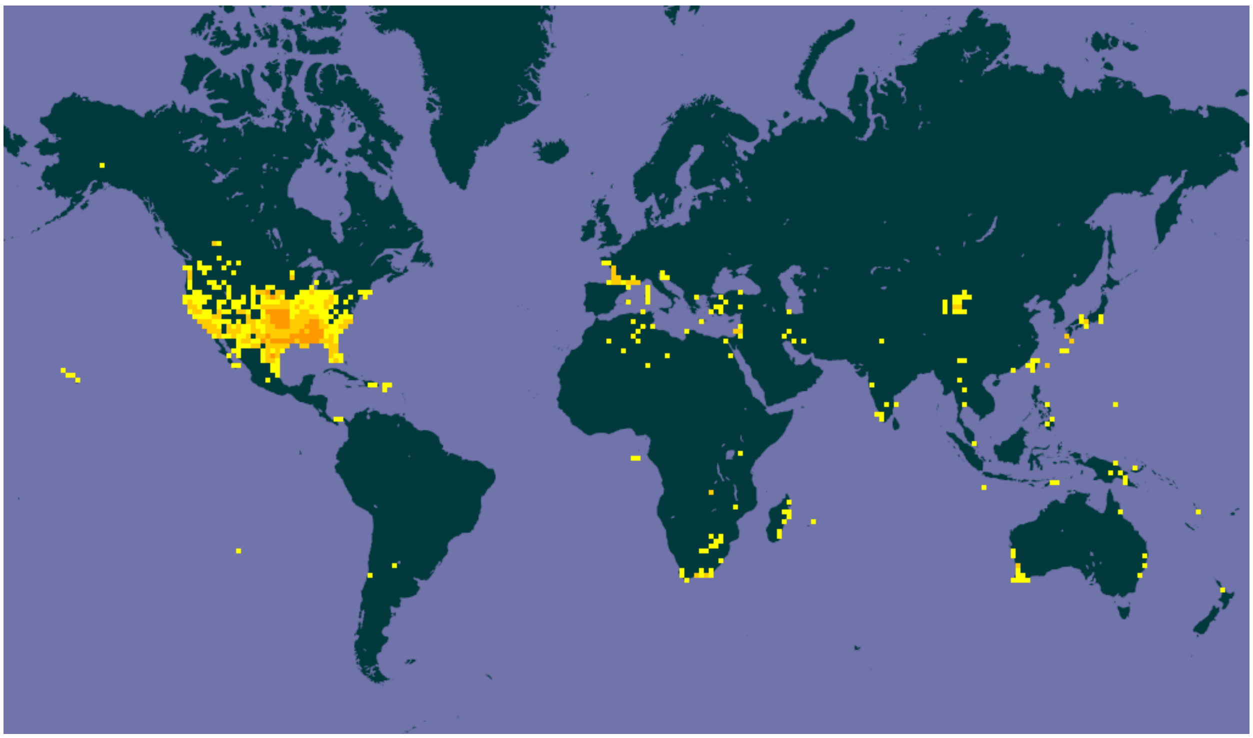

Figure 1. Known global distribution of *Gambusia affinis*. Map from GBIF Secretariat (2016).

5 Distribution Within the United States

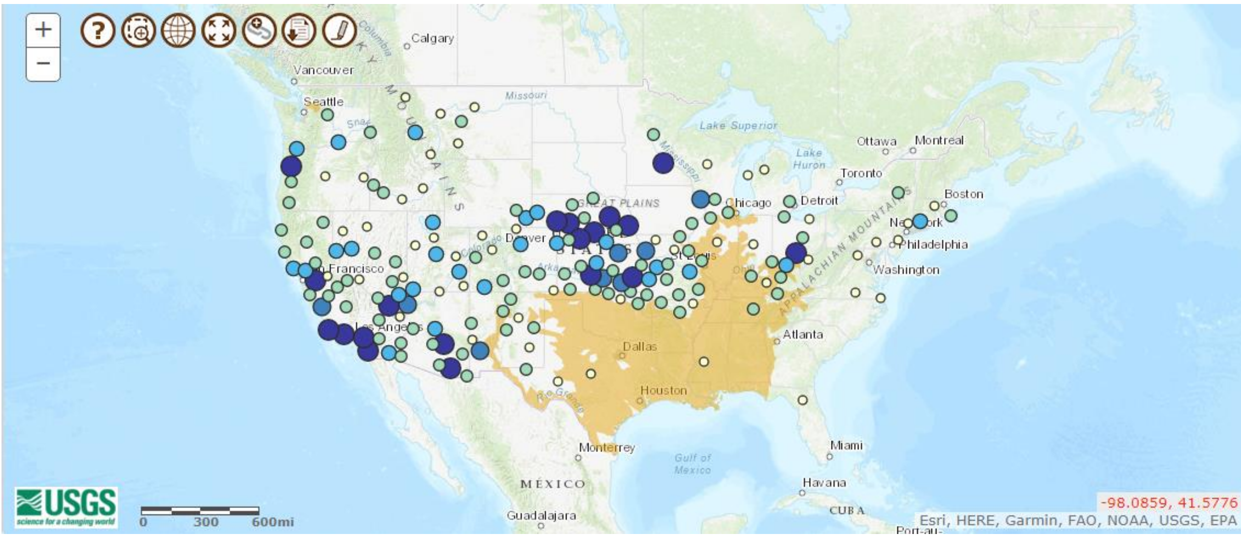

Figure 2. Known distribution of *Gambusia affinis* in the continental United States. Map from Nico et al. (2014).

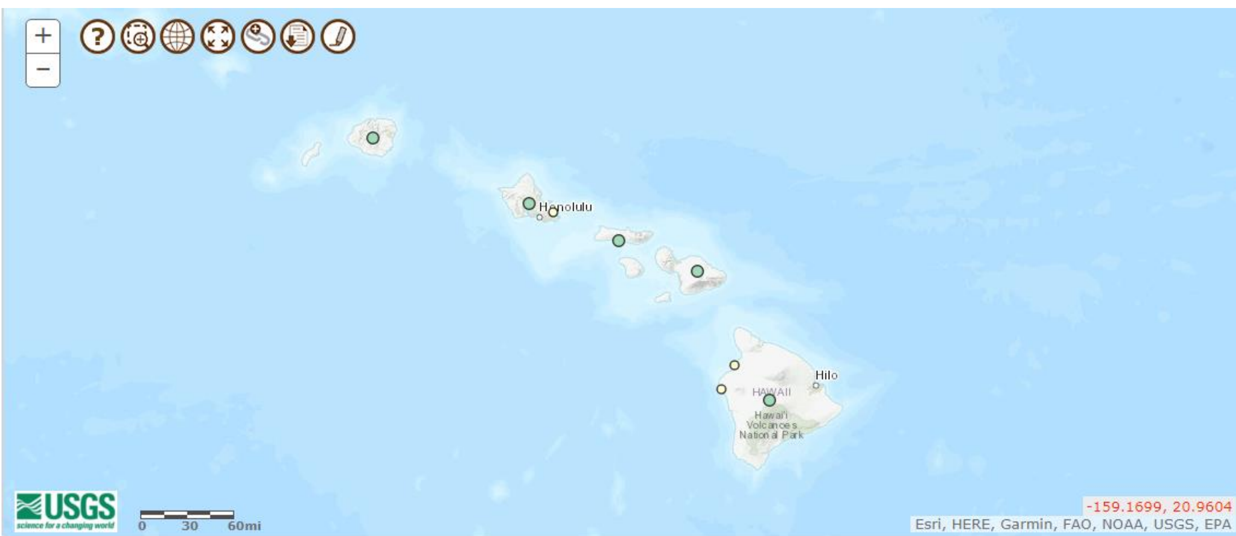

Figure 3. Known distribution of *Gambusia affinis* in the state of Hawai'i. Map from Nico et al. (2014).

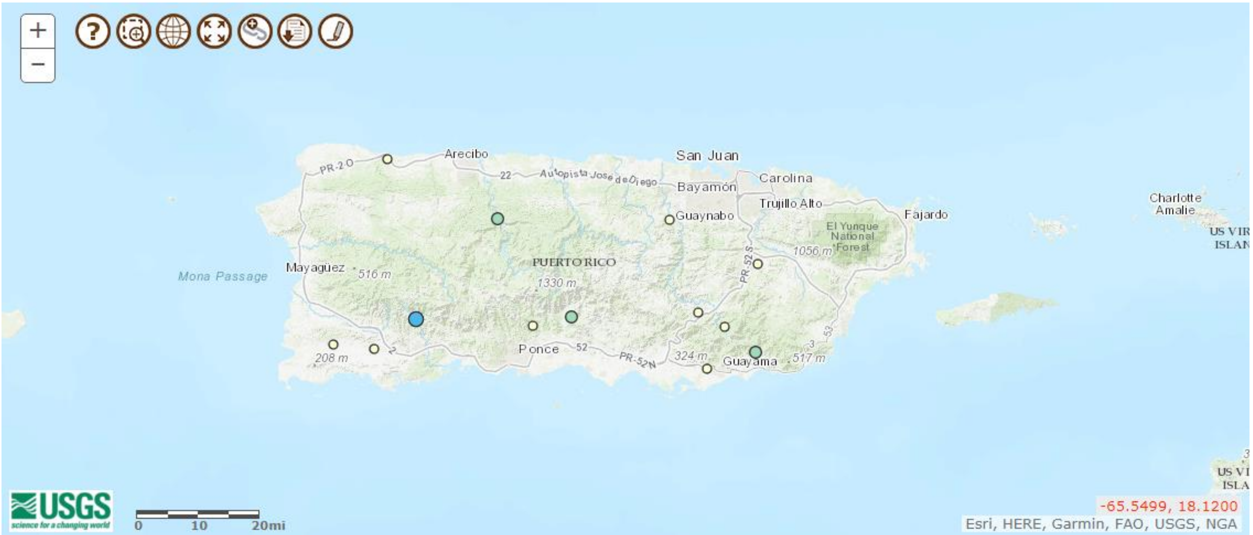

Figure 4. Known distribution of *Gambusia affinis* in the U.S. territory of Puerto Rico. Map from Nico et al. (2014).

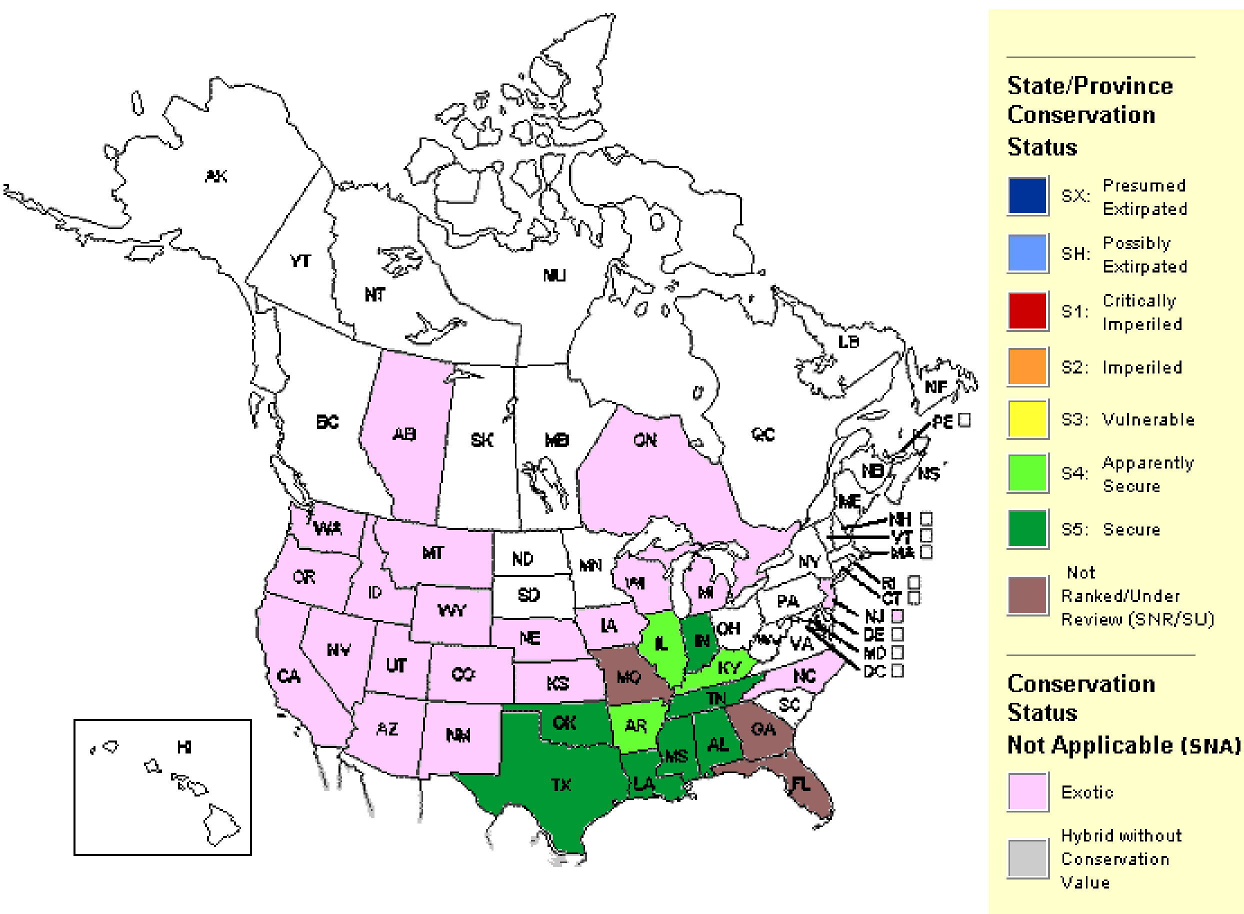

Figure 5. Known distribution and status of *Gambusia affinis* in the United States and Canada. Map from NatureServe (2016).

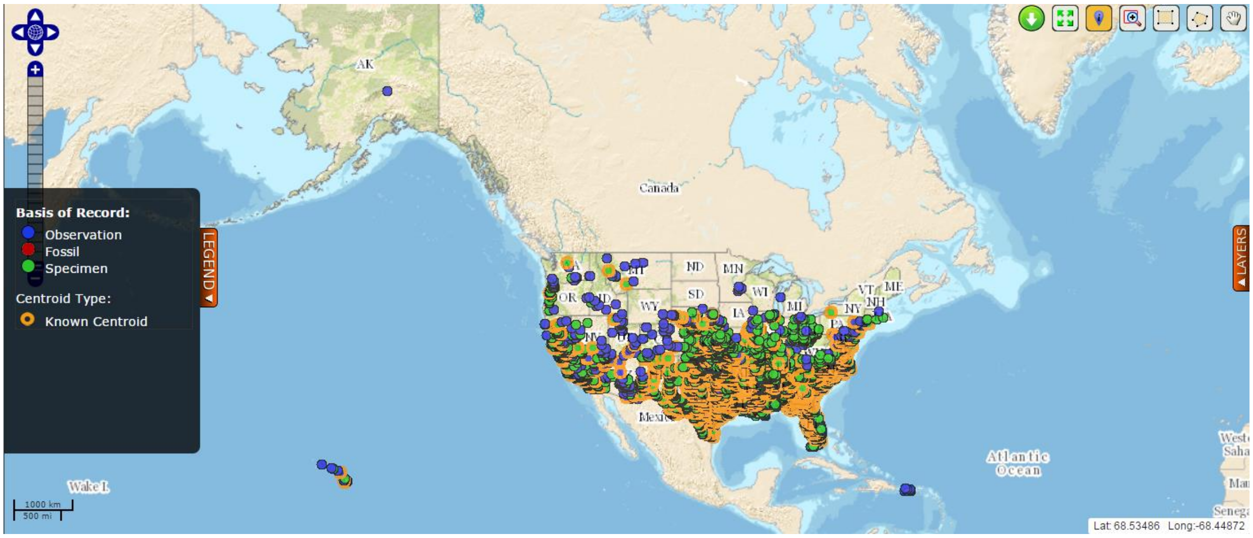

Figure 6. Known distribution of *Gambusia affinis* in the United States as reported by BISON (2016).

The location in Alaska does not represent an established population (BISON 2016) and was not used as a source location in the climate match.

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Gambusia affinis* was high for almost the entire continental United States. The only location where it was not high was a small portion of the Pacific Northwest coast. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean Distance) was 0.989, high. All 48 continental states had an individually high match. This was expected as almost all of the continental United States was used as source locations for the climate match.

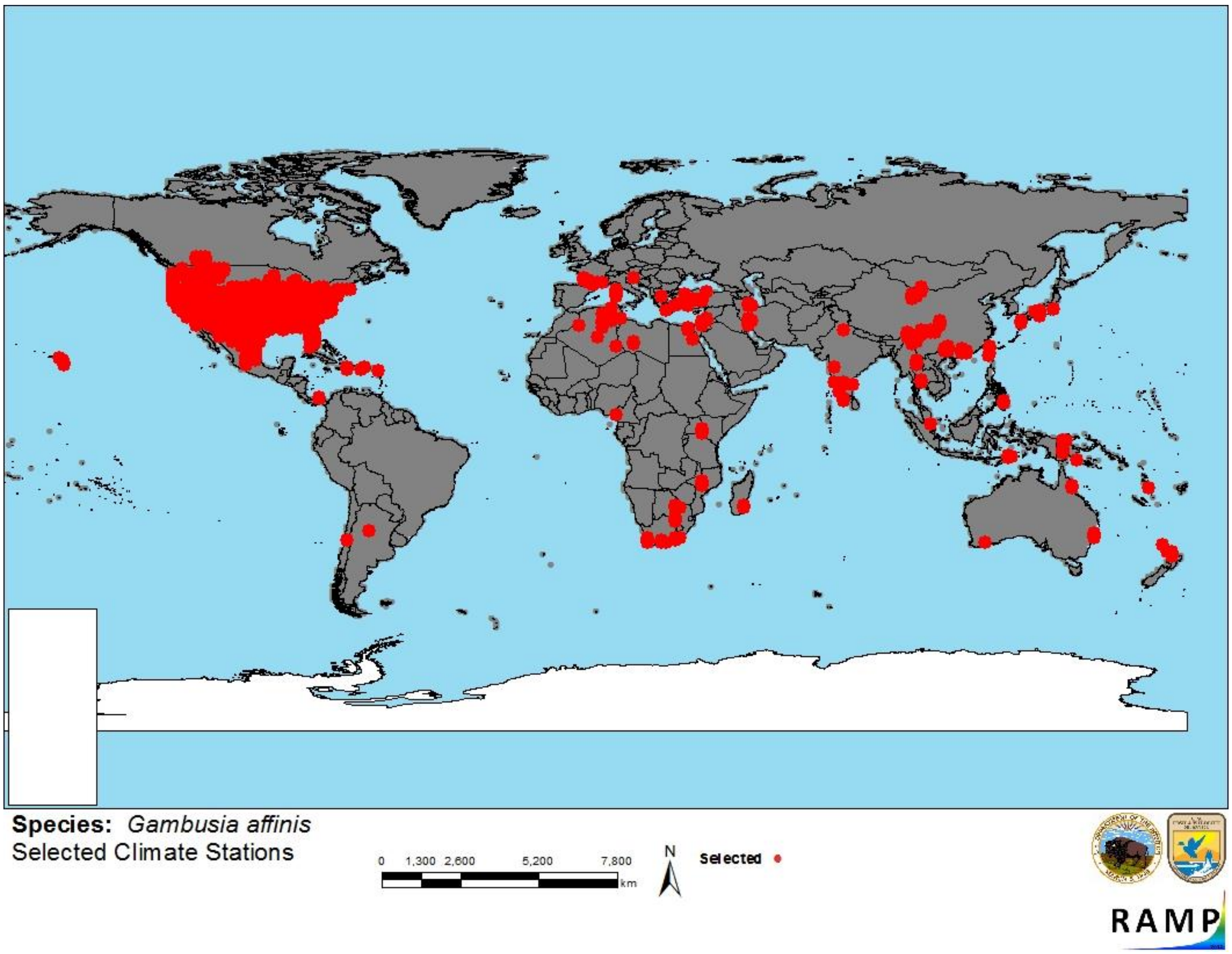

Figure 7. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (grey) for *Gambusia affinis* climate matching. Source locations from BISON (2016), GBIF Secretariat (2016), and Nico et al. (2016).

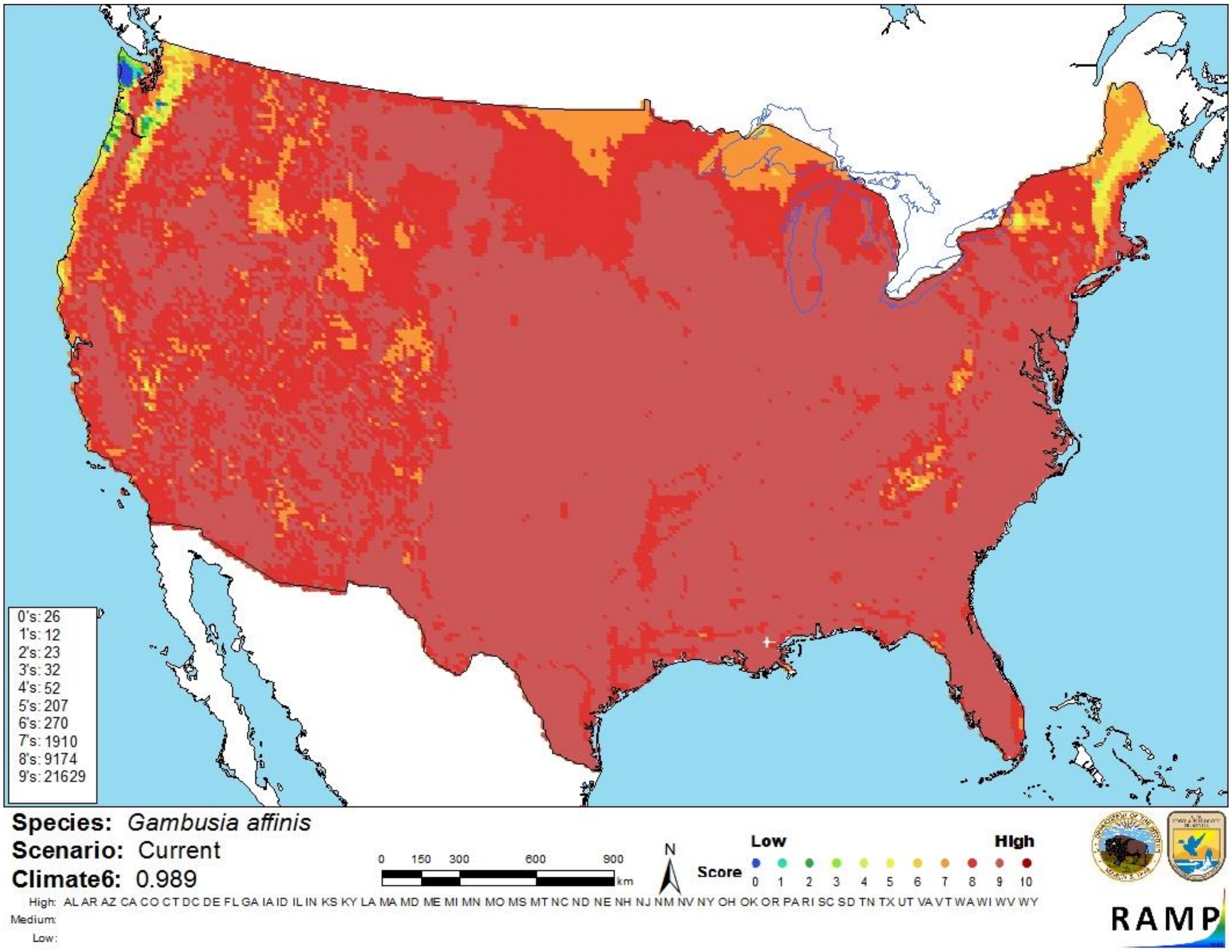

Figure 8. Map of RAMP (Sanders et al. 2014) climate matches for *Gambusia affinis* in the continental United States based on source locations reported by BISON (2016), GBIF Secretariat (2016), and Nico et al. (2016). 0 = Lowest match, 10 = Highest match.

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

Certainty of this assessment is high. *G. affinis* is a well-known and studied species. Negative impacts from introductions of this species are adequately documented in the scientific literature.

8 Risk Assessment

Summary of Risk to the Contiguous United States

The history of invasiveness for *Gambusia affinis* is high. It has been introduced with well documented negative impacts around the world. Invasion and establishment of the Western Mosquitofish is occurring in the United States. It is already established in much of the United States in areas outside of its native range. The climate match is high. There is no climate barrier to this species invading the rest of the United States. The certainty of the assessment is high. The overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information** It is difficult to determine if some early introduced populations belong to *Gambusia affinis* or *G. holbroki*.
- **Overall Risk Assessment Category: High**

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Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

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