Blue Tilapia (*Oreochromis aureus*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, April 2011
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Photo: Howard Jelks, USGS

1 Native Range and Status in the United States

Native Range

From Froese and Pauly (2017):

"Africa and Eurasia: Jordan Valley, Lower Nile, Chad Basin, Benue, middle and upper Niger, Senegal River [Wohlfarth and Hulata 1983]."

GISD (2018) reports the following countries as part of the native range of *Oreochromis aureus*: Cameroon, Chad, Egypt, Israel, Jordan, Mali, Niger, Nigeria, Saudi Arabia, and Senegal.

Status in the United States

From Nico et al. (2018):

"**Status:** Established or possibly established in ten states. Established in parts of Arizona, California, Florida, Nevada, North Carolina, and Texas. Possibly established in Colorado, Idaho, Oklahoma, and Pennsylvania. Reported from Alabama, Georgia, and Kansas. For more than a decade it has been considered the most widespread foreign fish in Florida (Hale et al. 1995)."

"**Nonindigenous Occurrences**: This species (often identified as *Tilapia nilotica*) was stocked annually by the Alabama Department of Conservation and Auburn University in lakes and farm ponds in **Alabama** during the late 1950s, 1960s, and 1970s (Rogers 1961; Smith-Vaniz 1968; Habel 1975). There are a few records of populations surviving mild winters, such as an account for Crenshaw County Public Lake, a southern Alabama public fishing lake, between 1971 and 1972 (Habel 1975). One recent record is of 25 specimens taken from Saugahatchee Creek in the Tallapoosa drainage, Mobile Basin, near Loachapoka, Lee County, on 2 October 1980 (museum specimens). The species reportedly is reproducing in experimental ponds associated with Auburn University, but there is no evidence of established populations in open waters of the state. It has been established in **Arizona** since about 1975 (Courtenay and Hensley [1979]). This species (and perhaps a hybrid with *O. niloticus*) is established and locally common in various parts of the lower Colorado River in the southwestern part of the state (Grabowski et al. 1984; Courtenay et al. 1984, 1986). Specimens of this species or a possible hybrid were collected from Alamo Reservoir on the Bill Williams River in the Colorado River drainage, Mojave and Yuma counties, ca. 1968 (Grabowski et al. 1984, Courtenay et al. 1986); the likely source of Alamo Lake tilapia was a population stocked in Francis Creek in 1968 that later moved downstream during flood periods (Grabowski et al. 1984). The species apparently is established as far north in the Colorado as Lake Havasu, above Parker Dam (Courtenay et al. 1986). It has been documented as being stocked in Dankworth ponds in Graham County, and in Randolph Park in Tucson, Pima County; many unrecorded stockings, official and unofficial, probably have occurred in various other parts of the state (Grabowski et al. 1984). The species is established in the Gila River north of Yuma (Courtenay et al. 1984, 1986). It was stocked in an irrigation district near Gila Bend in the early 1980s (Courtenay and Hensley [1979]; Courtenay et al. 1986). Several specimens were collected from the Arkansas River near Pine Bluff, **Arkansas**, in 1998 (T. Buchanan, personal communication). It is established and locally common in several areas of the lower Colorado River in the southeastern part of **California**, near the Arizona border (Grabowski et al. 1984; Courtenay et al. 1986, 1991; Swift et al. 1993). The species is apparently established as far north in the Colorado as Lake Havasu, above Parker Dam (Courtenay et al. 1986). It also has been reported and taken from the Salton Sea and vicinity (Courtenay et al. 1986, 1991; Swift et al. 1993), although some tilapia taken from the Salton Sea appeared to be hybrids between *O. aureus* and *O. mossambicus* (Swift et al. 1993). Some populations introduced into the lower Colorado River were possibly hybrids between *O. aureus* and *O. niloticus* (Courtenay et al. 1986, 1991). This, or a closely related tilapia, reportedly was raised commercially for food in high-altitude geothermal waters and ponds in the San Luis Valley, part of the Upper Rio Grande River system, near Alamosa, Conejos County, **Colorado** (Courtenay and Hensley [1979]; Courtenay et al. 1984, 1986; Zuckerman and Behnke 1986); it was reported that tilapia escaped and established self-maintaining populations in two earthen ponds in 1977 (Zuckerman and Behnke 1986). This species was listed as not established by Courtenay et al.

(1991). The first record of this tilapia in **Florida** was of 3,000 fish stocked in a series of phosphate pits for aquatic plant control experiments at the Pleasant Grove Research Station in Hillsborough County in August 1961 (Crittenden 1965; Courtenay et al. 1974; Courtenay and Hensley [1979]). The tilapia later spread and reproduced, and subsequent attempts to eradicate it failed (Langford et al. 1978; Hale et al. 1995). The species is now considered the most widespread foreign species in Florida. It has been reported or collected in more than 20 Florida counties, and is established in most of these (Buntz and Manooch 1969; Courtenay et al. 1974, 1984, 1986, 1991; Burgess et al. 1977; Foote 1977; Langford et al. 1978; Courtenay and Hensley [1979]; Kushlan 1986; Loftus and Kushlan 1987; Zale 1987; museum specimens; Nico 2005; Charlotte Harbor NEP; International Game Fishing Association 2000). The northernmost established population in Florida is in Lake Alice in Gainesville, Alachua County, where the fish has been present since about 1969 or perhaps earlier (Burgess et al. 1977). This species also is reproducing in saline waters of Tampa Bay (Lee et al. 1980 et seq.; Courtenay et al. 1986). It has also been collected in Big Cypress National Preserve and Everglades National Park (Tilmant 1999; Loftus 2004). It was collected from a pond at Musgrove Plantation on St. Simons Island, Glynn County, **Georgia**, during 1980. Although no attempt was made to document reproduction, that population persisted several years but apparently did not survive the severe winter of 1989 (Gennings, personal communication). An unconfirmed report of this tilapia on St. Simons Island also was mentioned by Courtenay and Hensley ([1979]) and Courtenay et al. (1984, 1986). Over 35 juveniles were trapped in a Skidaway River tidal creek draining an aquaculture experimental area on Skidaway Island, Chatham County, in July and August 1989 (Hales 1989). Another unconfirmed report indicated that tilapia, possibly this species, had been stocked and presumably were established in golf course ponds at Sea Island, Glynn County (Courtenay and Hensley [1979]; Courtenay et al. 1984, 1986). In reference to the same population, Gennings (personal communication) reported that an unknown species of tilapia, reported from golf course ponds at the Sea Island Golf Club, possibly was present during the late 1970s or mid 1980s, and indicated that the population apparently was extirpated during or before the winter of 1989. As of 1992, state personnel had concluded that the species is no longer established in Georgia (Gennings, personal communication). Specimens of this species recently have been reported as being taken from Lake Seminole, a reservoir on the Florida border in the Apalachicola drainage (Gennings, personal communication); however, all available specimens and photographs of tilapia from that lake have thus far proven to be those of *O. niloticus* (Smith-Vaniz, personal communication). This species has been cultured in **Idaho** in the Hagerman Valley, Twin Falls County, and may have become established following its escape into the Snake River near natural thermal outflows (Courtenay et al. 1987; V. Moore, personal communication). It has been taken in **Kansas** from a farm pond in Hodgeman County in 1967 and from a lake in Pratt County in 1990 (museum specimens). This species is known from the Muddy River system, Clark County, **Nevada** (Scoppettone et al. 1998), as well as from Lake Mead (USFWS 2002). It was purposefully introduced into Skyland Lake (now Julian Reservoir), **North Carolina**, a cooling reservoir of the Carolina Power and Light Company located in the French Broad-Tennessee drainage, south of Asheville, Buncombe County, in 1965 (Courtenay and Hensley [1979]; Courtenay et al. 1986). Although some information suggested that it had been replaced by *O. mossambicus* by the late 1970s (Courtenay and Hensley [1979]), recent reports indicated that *O. aureus* has continued to maintain an established population in Julian Reservoir (Menhinick 1991; D. Herlong, personal communication). The species was introduced into Hyco Reservoir in the Roanoke River drainage, Person and Caswell counties, in 1984, where it is established (McGowan 1988;

Crutchfield 1995). In a distribution map for this species, Menhinick (1991) indicated this species had been found in the Tennessee River drainage (i.e., Julian Reservoir), the Roanoke River drainage (i.e., Hyco Reservoir), and possibly a lake site in the lower Cape Fear drainage in or near New Hanover County. In his table of fishes introduced into the state, Menhinick (1991) listed this species as having been introduced into the Neuse River drainage but not in the Cape Fear drainage. This tilapia is known from **Oklahoma** in the North Canadian River since 1977, where it was reported as having a confirmed range of 383 km, from Lake Overholser to Lake Eufaula (Pigg 1978). This population has been somewhat unstable. For instance, the species was reported to have died out during cold weather in late 1977 and early 1978 (Courtenay and Hensley [1979]; Lee et al. 1980 et seq.), but specimens were taken there again in 1979 (Courtenay et al. 1986; Courtenay and Williams 1992). Pigg et al. (1992) discovered large numbers in the North Canadian River in 1987, but they have found no additional specimens in the river since. This species has been taken from the Arkansas River in Tulsa (Pigg et al. 1992). It also has been reported from and may have been established in Sooner Lake (Arkansas River drainage), a power plant reservoir about 20 miles north of Stillwater in Noble and Pawnee counties, since the middle or late 1980s (A. V. Zale, personal communication). It was listed as established in Oklahoma by Courtenay et al. (1991). The species became established in **Pennsylvania**, in warmwater effluents of a power plant on the Susquehanna River, after escaping from Pennsylvania Power and Light's Brunner Island Aquaculture Facility sometime after October 1982, possibly in 1984 (Skinner 1984, 1986; Stauffer et al. 1988; Courtenay and Williams 1992). Populations in the vicinity of Brunner Island were eradicated in February 1986, when condenser cooling water was deliberately and temporarily released at lethal, lower temperatures (Skinner 1987; Stauffer et al. 1988; Courtenay and Williams 1992); however, Stauffer et al. (1988) postulated that *O. aureus* may still survive farther downstream based on an earlier report by Skinner (1984) that tilapia had been collected as far downstream as 78 km from the Brunner Island site. This species first appeared in **Texas** open waters in reservoirs during the 1960s, apparently as a result of fish farm and bait bucket releases (Howells 1992a). Muoneke (1988) reported that its general distribution included all but the northern- and westernmost parts of the state. This species is most common in warmwater reservoirs and has been reported or is established in more than 30 Texas counties (Whiteside 1975; Hubbs et al. 1978, 1991; Courtenay and Hensley [1979]; Lee et al. 1980 et seq.; Muoneke 1988; Courtenay et al. 1991; Edwards and Contreras-Balderas 1991; Howells [1991], 1992a, 1992b; Red River Authority of Texas 2001; Texas Parks and Wildlife Department 1993, 2001). It is established in the Rio Grande, Trinity (USFWS 2000), San Antonio, and Guadalupe drainages, and in parts of the Colorado River drainage; this tilapia is most abundant in areas with warmer water temperatures (e.g., in the lower Rio Grande Basin and in power plant reservoirs) (Hubbs et al. 1991). Reservoirs known to contain established populations include Calaveras, Victor Braunig, Fairfield, Tradinghouse Creek, Canyon, Casa Blanca, Nasworthy, Falcon, Walter E. Long, Fayette County, Gibbons Creek, Colorado City, and Amistad (Muoneke 1988; Anonymous 1992; Texas Parks and Wildlife Department 2001). The species was established in Trinidad Lake, Henderson County, during the late 1960s and early 1970s (Noble and Germany 1986), but has since been extirpated (Hubbs et al. 1978; Noble and Germany 1986). Hybrids with *O. mossambicus* are present in the San Marcos River, and in Canyon and Gibbons Creek reservoirs (Howells 1992b). Listings of this tilapia's distribution in Texas, both before and after 1979, were given by Muoneke (1988). Blue tilapia were collected in non-specific locations in **Puerto Rico** (Lee et all 1983)."

Means of Introduction into the United States

From Nico et al. (2015):

"This species has been introduced through a combination of means, including stocking and experimental work by states and private companies (e.g., the electric power industry), and release by individuals seeking to use the species as a sport fish, as forage for warmwater predatory fish, as a food source, and as a means of aquatic plant control. Introductions and spread have resulted by way of escapes or releases from aquaculture facilities and experimental control areas, and from various other holding sites (e.g., zoological parks); through aquarium and bait bucket releases; and by intentional transport by anglers and private individuals (Courtenay and Hensley [1979]; Lee et al. 1980 et seq.; Courtenay et al. 1984, 1986; Muoneke 1988; Courtenay and Williams 1992). The exact reasons for and sources of some introductions are uncertain (e.g., Texas) (Hubbs et al. 1978; Courtenay and Hensley [1979]). Apparently, power companies became interested in using so-called "tropical fishes" for food or sport in heated effluent ponds used to cool effluents from both fossil fuel fired and nuclear generating plants, where temperatures often became too high to support populations of native fishes (Courtenay and Hensley [1979]). Blue tilapia and redbelly tilapia were inadvertently introduced into Hyco Reservoir in North Carolina in 1984 after a small number of fish escaped from a holding cage located in the heated discharge area during an on-site agricultural study (Crutchfield 1995)."

Remarks

From Nico et al. (2018):

"The origin of the U.S. stocks of *O. aureus*, imported as *Tilapia nilotica*, was Israel (Courtenay and Hensley [1979]). Voucher specimens taken from the lower Colorado river system, Arizona, in 1980 were initially reported as mango tilapia *Tilapia* (= *Sarotherodon*) *galilaea*; but these were later determined by D. Thys van den Audenaerde to be *O. aureus*. Some lower Colorado River populations in California and Arizona may be hybrids with *O. niloticus* (Courtenay et al. 1984, 1986). Although all species from the genus *Oreochromis* readily hybridize (D'Amato et al. 2007), electrophoretic studies on tilapia sampled from 12 Texas reservoirs indicated that most populations were *O. aureus* without indicating genetic introgression with other tilapia species (Howells [1991]). There is a 1971 record of Alabama fish overwintering in outdoor ponds at Auburn University (Courtenay and Hensley [1979], Courtenay et al. 1986); however, tilapia introduced into that state typically begin to die each fall when water temperatures reach about 10°C (Smith-Vaniz 1968). This species was stocked in aquaculture ponds in Iowa to test growth potential; although it reproduced there, it did not overwinter (Pelgren and Carlander 1971; Courtenay and Hensley [1979]). In the southwestern United States, the Central Arizona Project canal system is proving to be a major dispersal route for blue tilapia (Courtenay, personal communication)."

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 Perciformes
Suborder Labroidei
Family Cichlidae
Genus *Oreochromis*
Species *Oreochromis aureus* (Steindachner, 1864)"

"Current Standing: valid"

Size, Weight, and Age Range

From Froese and Pauly (2017):

"Maturity: L_m ?, range 13 - 20 cm
Max length : 45.7 cm TL male/unsexed; [IGFA 2001]; common length : 16.0 cm TL male/unsexed; [Hugg 1996]; max. published weight: 2.0 kg [IGFA 2001]"

Environment

From Froese and Pauly (2017):

"Freshwater; brackish; benthopelagic; potamodromous [Riede 2004]; depth range 5 - ? m. "

From CABI (2018):

"Juveniles are less tolerant of cold temperatures than adults (McBay, 1961). A minimum temperature of 20-22°C is required for breeding (McBay, 1961; Trew[a]vas, 1983)."

Climate/Range

From Froese and Pauly (2017):

"Tropical; […] 35°N - 10°N"

Distribution Outside the United States

Native

From Froese and Pauly (2017):

"Africa and Eurasia: Jordan Valley, Lower Nile, Chad Basin, Benue, middle and upper Niger, Senegal River [Wohlfarth and Hulata 1983]."

GISD (2018) reports the following countries as part of the native range of *Oreochromis aureus*: Cameroon, Chad, Egypt, Israel, Jordan, Mali, Niger, Nigeria, Saudi Arabia, and Senegal.

Introduced

GISD (2018) reports distribution records for *Oreochromis aureus* in the following countries: Antigua and Barbuda, Bahamas, Brazil, China, Costa Rica, Cote d'Ivoire, Cuba, Cyprus, Dominica, Dominican Republic, El Salvador, French Polynesia, Guatemala, Haiti, Japan, Kuwait, Mexico, Myanmar, Netherlands Antilles, Nicaragua, Pakistan, Panama, Peru, Philippines, Russian Federation, Singapore, South Africa, Syrian Arab Republic, Taiwan, Thailand, Turkey, Uganda, United Arab Emirates, and Zambia.

Froese and Pauly (2017) report attempted introduction of *Oreochromis aureus* to Colombia, although establishment is noted as "unknown".

Means of Introduction Outside the United States

From CABI (2018):

"*O. aureus* has mainly been introduced into ponds, reservoirs, lakes and rivers through stocking, but also via aquaculture and biological control. It is stocked as a forage species for warm water predatory fish and to control aquatic plants. A very popular aquaculture species, *O. aureus* is reared widely all over the world, and escapes or releases from aquaculture facilities, zoological parks and aquariums are common (Canonico et al., 2005). It has also been intentionally released as bait by anglers and as a food species worldwide (Courtenay and Hensley, 1979; Lee et al., 1980; Courtenay et al., 1984; 1986; Muoneke, 1988; Courtenay and Williams, 1992; [Nico] 2007)."

Short Description

From Froese and Pauly (2017):

"Dorsal spines (total): 14 - 17; Dorsal soft rays (total): 11-15; Anal spines: 3; Anal soft rays: 8 - 11; Vertebrae: 28 - 31. Diagnosis: Adults: narrow preorbital bone (depth max. 21.5% of head length in fishes up to 21.3cm SL); lower pharyngeal jaw with short blade; no enlargement of the jaws in mature fish (lower jaw not exceeding and usually less than 36.8% head length) [Trewavas 1983]. Caudal without regular dark vertical stripes [Trewavas 1965, 1983; Teugels and Thys van den Audenaerde 2003], but with a broad pink to bright red distal margin [Trewavas 1983]. Breeding males assume an intense bright metallic blue on the head, a vermilion edge to the dorsal fin and a more intense pink on the caudal margin [Trewavas 1965, 1983]. Breeding females with the edges of dorsal and caudal fins in a paler more orange color [Trewavas 1983].

Juveniles: upper line of head profile running upward from snout at sharp angle; lower pharyngeal bone nearly triangular, teeth numerous but not densely crowded; dorsal and anal fin striped, with stripes running obliquely on the soft dorsal and longitudinally on the caudal fin; black Tilapia-mark on soft dorsal present; body dark; lower lip developed from beneath [Chervinski 1977]."

Biology

From Froese and Pauly (2017):

"Cold tolerant [Balarin 1979; Chervinski 1982; Gupta and Acosta 2004], occuring at temperatures ranging from 8°-30°C [Trewavas 1983], tolerating up to 41 °C [Chervinski 1982]. Tolerates fairly brackish conditions [Balarin 1979; Chervinski 1982; Philippart and Ruwet 1982; Wohlfarth and Hulata 1983; de Moor and Bruton 1988; Suresh and Lin 1992]. Forms schools; is sometimes territorial; inhabits warm ponds and impoundments as well as lakes and streams [Goren 1974; Page and Burr 1991], in open water as well as among stones and vegetation [Goren 1974]. Feeds on phytoplankton and small quantities of zooplankton [Balarin 1979; Philippart and Ruwet 1982; de Moor and Bruton 1988; Lamboj 2004]. Young fish have a more varied diet which includes large quantities of copepods and cladocerans [Balarin 1979; Trewavas 1983; de Moor and Bruton 1988], but they also take pieces of small invertebrates [Lamboj 2004]. Ovophilic, agamous [Lamboj 2004], maternal mouthbrooder [Fryer and Iles 1972; Lamboj 2004]. Sexual maturity in ponds reached at age of 5-6 months [Gupta and Acosta 2004]. Reproduces in both fresh and brackish water [Balarin 1979; Page and Burr 1991]."

"Nesting usually in shallow water weedy areas [Payne and Collinson 1983]. Males establish territory and dig a spawning pit [Ben-Tuvia 1978; Trewavas 1983; de Moor and Bruton 1988], using mouth and fins [Trewavas 1983], up to 60cm deep and 4-6m in diameter; a number of territories can often be found clustered together [Lamboj 2004]. Territories are defended by means of agressive [*sic*] behaviour [de Moor and Bruton 1988], including lateral display, lateral biting and mouth-to-mouth combat [Trewavas 1983]. Reproduction is stimulated by long photoperiods and inhibited by short daylengths [Baroiller et al. 1997]. Reproduction requires a minimum temperature of about 20°C [Trewavas 1983]. Males visit schools of females and attempt to attract a female spawning partner [Trewavas 1983; Lamboj 2004]. Courting behaviour in the nest consists of lateral display by both sexes with nipping and tail-flapping [Trewavas 1983]. Eggs are deposited in single clutches, from several dozen to 100 eggs [Lamboj 2004], and are taken into the females mouth as soon as they are fertilized [Trewavas 1983; de Moor and Bruton 1988; Lamboj 2004], with a peak spawning frequency around the 9-11th hour of light [Marshall and Bielic 1996; Baroiller et al. 1997]. One female may hold up to 2000 eggs in her mouth [Trewavas 1983]. The female swims away to deeper water with the brood after spawning is complete [Trewavas 1983; Lamboj 2004], while the male renews spawning activities with another female. Hatching occurs about 3 days after oviposition [Trewavas 1983]. Incubation time varies with temperature, 13-14 days at 25-27°C [Trewavas 1983; Lamboj 2004] or 8-10 days at 29°C [Dadzie 1970], and juveniles leave the mother's mouth when they are about 1.1cm in length [Ben-Tuvia 1978]. The young school near parent's head for a few days, reentering the mouth at any sign of danger or at a gesture of the female; parent-offspring relationship ceases after 5 days [Trewavas 1983]."

Human Uses

From Froese and Pauly (2017):

"Fisheries: highly commercial; aquaculture: commercial; aquarium: commercial; bait: usually"

From GISD (2018):

"*Oreochromis aureus* is a prolific and tolerant species introduced worldwide for aquaculture, angling, and the control of aquatic vegetation. They are popularly used for hybridization in producing all male populations (FishBase, 2007). Power companies have introduced *O. aureus* for food and sport, as well as vegetation control, in heated effluent ponds used to cool effluents from plants which are too warm to support native fish (Nico, 2007)."

Diseases

From Froese and Pauly (2017):

"Sanguinicola Disease, Parasitic infestations (protozoa, worms, etc.)
Centrocestus Disease, Parasitic infestations (protozoa, worms, etc.)
Ichthyobodo Infection 2, Parasitic infestations (protozoa, worms, etc.)
Whirling Viral Disease of Tilapia Larvae, Viral diseases
Saccocoelioides Infection, Parasitic infestations (protozoa, worms, etc.)
Goezia Disease 2, Parasitic infestations (protozoa, worms, etc.)
Gnathostoma Disease (larvae), Parasitic infestations (protozoa, worms, etc.)"

From CABI (2018):

"*O. aureus* can be infected a wide range of diseases and parasites, including *Flexibacter columnaris* (Bacteria), *Apiosoma piscicolum*, *Epistylis colisarum*, *Trichodina* sp., *Trypanoplasma* sp. (Protozoa), *Cichlidogyrus tilapiae*, *Gyrodactylus cichlidarum* and *Neobedenia melleni* (Monogenea) (Bunkley-Williams and Williams, 1994)."

From Shlapobersky et al. (2010):

"We report here an outbreak of a novel disease characterized by a whirling syndrome and high mortality rates in laboratory-reared tilapia larvae."

"The disease was initially observed in inbred gynogenetic line of blue tilapia larvae (*Oreochromis aureus*) and could be transmitted to larvae of other tilapia species. […] The disease-associated DNA virus is described and accordingly designated tilapia larvae encephalitis virus (TLEV). […] Phylogenetic analysis […] places TLEV within the family of Herpesviridae and distantly from the families Alloherpesviridae and Iridoviridae."

From AlYahya et al. (2017):

"*Aeromonas hydrophila* is a bacterial pathogen that results in high economic losses causing a disease known as motile septicemia or hemorrhagic septicemia. *A. hydrophila*, as a food-borne pathogen, causes zoonotic diseases (Guz and Kozinska, 2004)."

"Blue tilapia, *Oreochromis aureus*, was experimentally infected with *Aeromonas hydrophila*, a bacterium that damages the gills, liver, and intestine, resulting in histopathological changes in the infected organs. Our histopathological study showed an aggregation of hemocytes with cell necrosis in gills; a massive aggregation of hemocytes and pyknotic nuclei in the hepatopancreas; and a lower rate of hemocyte aggregation in the digestive system of the infected fish."

No OIE-reportable diseases have been documented for this species.

Threat to Humans

From Froese and Pauly (2017):

"Potential pest [de Moor and Bruton 1988]"

3 Impacts of Introductions

From Nico et al. (2018):

"The blue tilapia is considered a competitor with native species for spawning areas, food, and space (Buntz and Manooch 1969; Noble and Germany 1986; Muoneke 1988; Zale and Gregory 1990). Courtenay and Robins (1973) reported that certain streams where this species is abundant have lost most vegetation and nearly all native fishes. It has invaded the Taylor Slough portion of Everglades National Park where it is considered a major management problem for the National Park Service (Courtenay 1989; Courtenay and Williams 1992). The blue tilapia's local abundance and high densities in certain areas have resulted in marked changes in fish community structure (Muoneke 1988, and citations therein). A dramatic reduction in native fishes in the Warm Springs area of Nevada coincided with invasion of this species (Scoppettone et al. 1998, 2005)."

"Blue tilapia have also been implicated as the cause for unionid mussel declines in two Texas water bodies, Tradinghouse Creek and Fairfield reservoirs (Howells 1995)."

From GISD (2018):

"*Oreochromis aureus* is believed to displace native cichlids such as *Cichlasoma nicaraguense*, *Cichlasoma longimanus*, *Cichlasoma rostratum* and *Cichlasoma citrinelluml* [*sic*] in Lake Nicaragua since their populations have been dramatically [*sic*] reduced following the introduction of *O. aureus* and catches are inversely associated (McKaye *et al*. 1995; McCrary *et al*. 2007). Introduced tilapias, including *Oreochromis aureus* compete for breeding and/or feeding resources directly with *Hypsophrys nicaraguensis*, *Parachromis dovii* and some forms of *Amphilophus citrinellus* (McCrary *et al*. 2007)."

“The invasion of *Oreochromis aureus* to the Taylor Slough portion the Everglades National Park has caused a major management problem for the National Park Service (Nico, 2007). Young *Oreochromis aureus* exhibit considerable trophic overlap with *Dorosoma* spp. in early life stages indicating exploitative competition in Florida, which may explain decline in *Dorosoma* spp. shad abundance (McDonald, 1987; Zale & Gregory, 1990).”

“High densities of *Oreochromis aureus* in Lake Trinidad, Texas were believed to inhibit reproduction of largemouth bass (GSMFC, 2003).”

From Froese and Pauly (2017):

“May hybridize with the indigenous *O. mossambicus* of the Wewe catchment [in South Africa] [de Moor and Bruton 1988].”

From Traxler and Murphy (1995):

“The potential for feeding competition between largemouth bass, *Micropterus salmoides*, and blue tilapia, *Oreochromis areus* [*sic*], in Lake Fairfield, Texas was evaluated experimentally. Largemouth bass and blue tilapia were grown in cages alone and in combination with each other. The fish were allowed to feed on the natural food within the lake. Largemouth bass grown in combination with blue tilapia were significantly shorter and weighed less than largemouth bass grown alone. Blue tilapia grown in combination with largemouth bass were statistically significantly longer and heavier than blue tilapia grown alone. Largemouth bass grown alone had diets (volume and number of food items) significantly different than the largemouth bass grown with the blue tilapia. Largemouth bass fed primarily on chironomid larvae and pupae, and odonates, whereas blue tilapia consumed vegetable matter, detritus, and chironomid larvae. Length and weight differences between largemouth bass grown alone and in combination with blue tilapia, in conjunction with the largemouth bass diet shift, support the theory that these two species compete for food resources.”

From Scoppettone et al. (2005):

“Blue tilapia adjusts its feeding strategy to reflect the relative abundance and composition of available food (Gu et al. 1997), and we found this adjustment may include fish consumption. In the Apcar Spring outflow we assume that blue tilapia switched its diet from *Vallisneria*, after it was depleted, to fish. When blue tilapia were first observed in the Apcar Spring system in May 1997, over 400 were counted. At that time much of the stream was covered with *Vallisneria*, and the Moapa dace population was extensive (>500), similar to what had been counted in previous surveys (Scoppettone et al. 1992, 1998). In June 1997, seven blue tilapia (140–240 mm fork length) were captured and were full of *Vallisneria* (James Heinrich personal communication), suggesting it was their primary food source. By 9 December 1998, the Apcar outflow was denuded and the Moapa dace population had collapsed from >500 to <70 (James Harvey personal communication). We collected fish samples from Apcar Spring outflow at a time when blue tilapia had switched diet but native fishes had not yet been extirpated. We were thus able to implicate blue tilapia piscivory as a contributor to native fish decline.”

From Canonico et al. (2005):

"No tilapias were collected in Lake Nicaragua during the Soviet study in 1983 (McKaye et al., 1995), but by 1987–88, fishermen in the Granada region began reporting tilapia catches. The fishermen correlated these catches with a decline in native cichlid catches, and this correlation was confirmed with data collected by McKaye et al. (1995). By 1990, three species of introduced tilapias (*O. aureus*, *O. mossambicus*, and *O. niloticus*) were being caught throughout the coastal region, including in Lake Nicaragua's outlet on the San Juan River, the southern islands of Solentiname, and the northern shore (including *isletas*). In comparison with standing crop levels in the lake before tilapia introduction, and in locations where tilapias had not yet migrated, there was approximately 80% reduction of native cichlids and a 50% reduction in total cichlid biomass (including tilapias) wherever introduced tilapias were found in Lake Nicaragua (McKaye et al., 1995, [1998])."

"Lake Apoyo is the largest and deepest of Nicaragua's volcanic crater lakes; it is an endorheic lake in the Pacific region of Nicaragua, near Lake Nicaragua. Aquaculture of blue tilapia (*O. aureus*) was attempted in cages in Lake Apoyo in 1983; the project was abandoned a few years later due to economic problems. Escapees were documented, but the project had few observed effects in the lake."

"Blue tilapias (*O. aureus*) were discovered in Muddy River, southern Nevada, in 1992 as a result of an illegal introduction. By 1996, they had dispersed throughout the river. In 1994, they were found in two basins of Lake Mead, and have since been found throughout the lake. By 2001 it was determined that they had spawned in the Virgin River (USFWS, 2002). The decline in the number of endangered Moapa dace (*Moapa coriacea*) and Moapa White River springfish (*Crenichthys baileyi moapae*) have been correlated with the presence of tilapia. Tilapias are believed to prey on, or compete with, other native fish such as the federally endangered woundfin (*Plagopterus argentissimus*) and Virgin River chub (*Gila seminude*) (USFWS, 2002). Stomach content analyses of blue tilapias in this region obtained by the US Geological Survey indicate that they are omnivorous, feeding on a range of vegetable and animal material, including fish (USFWS, 2002)."

From Trexler et al. (2000):

"We found little evidence of ecological effects of introduced fishes on native freshwater fish communities in southern Florida, especially in wet prairies. While consistent with Shafland's [1996a, 1996b] conclusions, this does not negate Courtenay's (1997) observation that cryptic or delayed effects may have been overlooked. Negative results from field sampling data should not be used to infer the absence of negative biotic interactions. […] Many ecological effects that are not readily observed are possible, including a variety of interactions among introduced and native species that are negative for natives. For example, we have observed competitive interactions among substrate-spawning species (e.g., introduced blue tilapia, spotted tilapia, and Mayan cichlids interacting with native largemouth bass (*Micropterus salmoides*), warmouth (*Chaenobryttus gulosus*), and spotted sunfish (*Lepomis punctatus*) in the ENP [Everglades National Park].

4 Global Distribution

Figure 1. Reported global distribution of *Oreochromis aureus*. Map from GBIF Secretariat (2017). Points in Morocco, Guinea, Sudan, Eritrea, and the Seychelles were not used in climate matching because they do not represent known established populations. Not all points in the United States were used in climate matching; see Section 5 for details.

5 Distribution within the United States

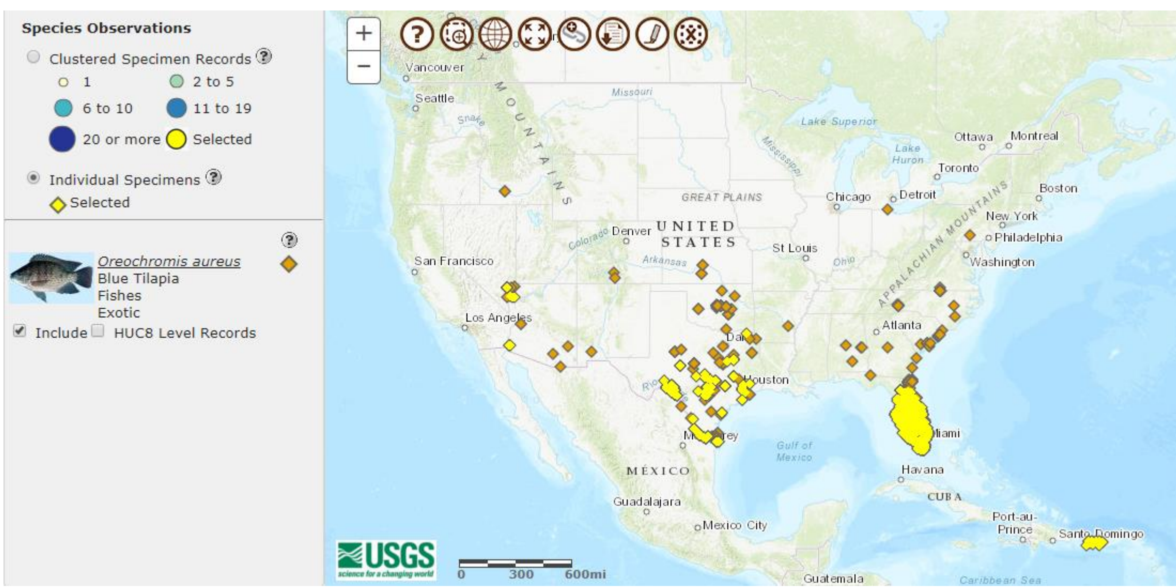

Figure 2. U.S. distribution of *Oreochromis aureus*. Map from Nico et al. (2018). Yellow points represent established populations, excluding those populations established in artificially heated waters such as power plant effluent ponds. Orange points represent collection locations where establishment has not occurred or has not been confirmed. Only established populations were used in the climate matching analysis.

6 Climate Match

Summary of Climate Matching Analysis

The climate match (Sanders et al. 2014; 16 climate variables; Euclidean Distance) was high in Florida, southeastern Georgia, Texas, southwestern Arizona, southwestern Utah, southern Nevada, and much of California. Small areas of high match also occurred in central Idaho, eastern Oregon, and northwestern Utah. The climate match was low in New England; along the spine of the Appalachian Mountains; Upper Midwest; parts of Colorado, Wyoming, and Montana; and the coastal Pacific Northwest. All other areas in the contiguous U.S. showed medium climate match. Climate 6 score indicates that the contiguous U.S. has a high climate match overall. The range of scores indicating a high climate match is 0.103 to 1.000, inclusive; the Climate 6 score of *Oreochromis aureus* was 0.362.

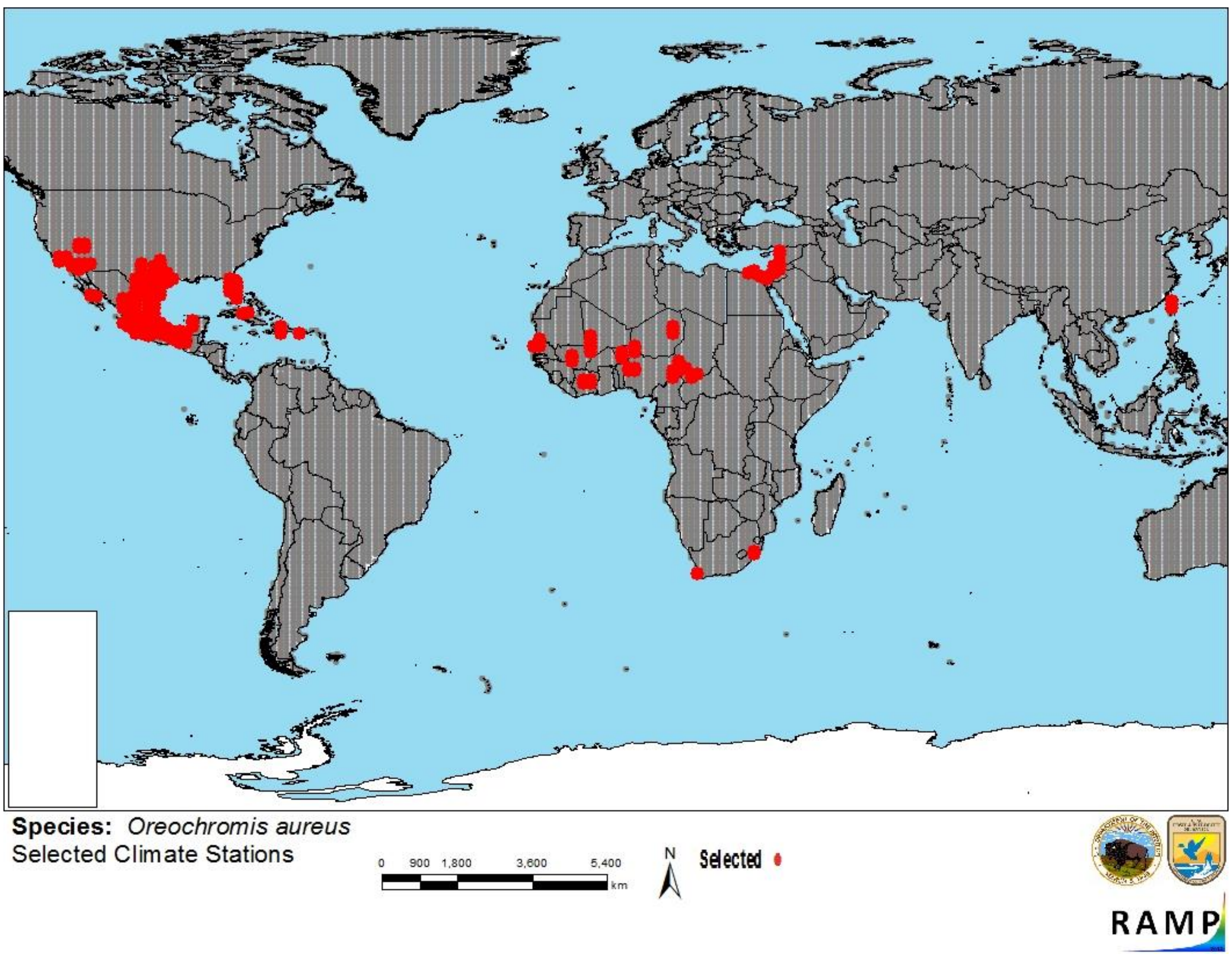

Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Oreochromis aureus* climate matching. Source locations from GBIF Secretariat (2017) and Nico et al. (2018).

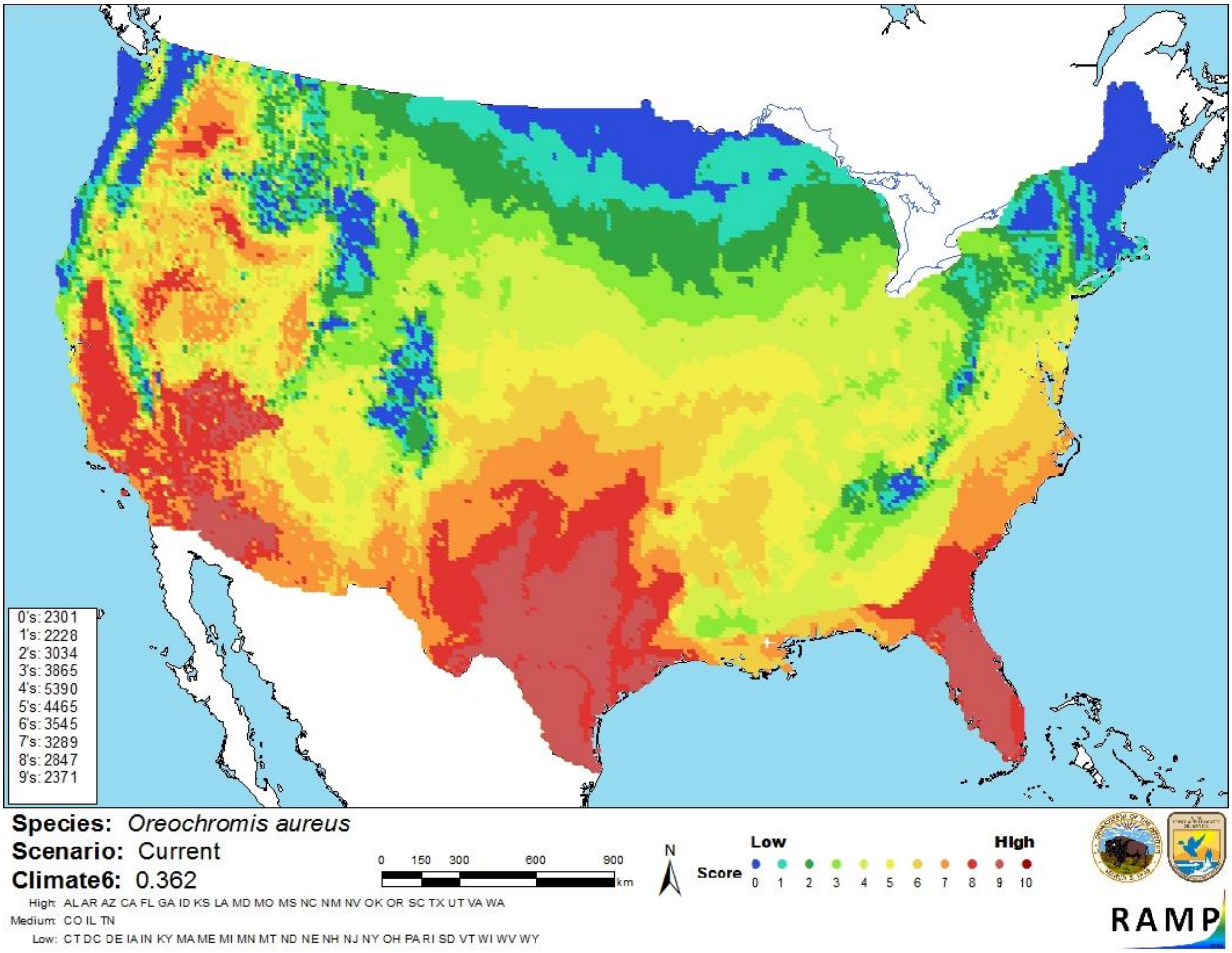

Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *Oreochromis aureus* in the contiguous United States based on source locations reported by GBIF Secretariat (2017) and Nico et al. (2018). 0= Lowest match, 10=Highest match. Counts of climate match scores are tabulated on the left.

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

Information on the biology, distribution, and impacts of *O. aureus* is readily available. Negative impacts from introductions of this species are adequately documented in the scientific literature, at least for certain locations. No further information is needed to assess the risk posed by this species to the contiguous United States. Certainty of this assessment is high.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Oreochromis aureus has been transported around the world because of its high value for fisheries and aquaculture. Climate match with the contiguous U.S. is high, reflected in the successful establishment of the species in Florida, Texas, Arizona, Nevada, and California. This species carries with it several potential threats to native species, including resource competition, hybridization, and disease, and it has been implicated in declines of native fish and mollusks. Overall risk posed by this species is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information: Host of several diseases and parasites. Considered a potential pest.**
- **Overall Risk Assessment Category: High**

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