Mozambique Tilapia (*Oreochromis mossambicus*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, April 2011
Revised, August 2014 and July 2015

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1 Native Range, and Status in the United States

Native Range

From Froese and Pauly (2015):

"Africa: Lower Zambezi, Lower Shiré and coastal plains from Zambezi delta to Algoa Bay. Occurs southwards to the Brak River in the eastern Cape and in the Transvaal in the Limpopo system [de Moor and Bruton 1988]."

Status in the United States

From Nico and Neilson (2015):

"Established or locally established in seven states including Arizona, California, Colorado, Florida, Hawaii, Idaho, and Texas. Formerly considered locally established but no longer extant in Georgia, Montana, and North Carolina. Reported from Alabama, Illinois, and New York."

Means of Introductions in the United States

From Nico and Neilson (2015):

"Similar to *O. aureus*, this species has been introduced for a wide variety of reasons. Most introductions have been the result of intentional stockings for aquatic plant control by state and federal agencies and private companies, but introductions have also come about from stockings for potential use of the species as an insect control agent (e.g., to control mosquitoes and chironomids), as a sport fish, as a bait fish, and as a food or commercial fish, and through aquarium releases; the species also has been introduced through releases or escapes from fish farms, hatcheries, and zoos (Shapovalov et al. 1981; Dial and Wainright 1983; Courtenay et al. 1984, 1986; Grabowski et al. 1984; Courtenay and Stauffer 1990). This species was brought to Hawaii from Singapore in a small shipment of fish in 1951 (Brock 1960; Maciolek 1984; Randall 1987). The Mozambique tilapia was introduced with the expectation that it would be useful for aquatic plant control in irrigation systems, as a food fish, as a sport fish, and as live bait for tuna fishing (Brock 1960); results were only partially successful (Randall 1987). In California, introductions resulted from escapes or releases from fish farms and from intentional stocking by the state (Shapovalov et al. 1981). The Mozambique tilapia's initial introduction into Dade County, Florida, is believed to have been the result of escapes or releases from aquarium fish farms that cultured the species in the 1960s (Courtenay and Stauffer 1990). In some areas of Florida, this species may have been introduced by local anglers to create a commercial fishery (Dial and Wainright 1983), or intentionally stocked by aquarists (Courtenay and Stauffer 1990). In New York, introduction was probably due to aquarium release (Briggs, personal communication). In Texas, this species was introduced as a result of escapes from the San Antonio Zoo in 1956 and also from state and federal hatcheries during the late 1950s and early 1960s (Brown 1961; Courtenay and McCann 1981). Sources and reasons for many of the introductions have been reviewed by Courtenay and McCann (1981), Wieland et al. (1982), and Courtenay and Stauffer (1990)."

Remarks

From Nico and Neilson (2015):

"Some records of this species apparently are based on incorrect identifications. For instance, recent electrophoretic evidence indicated that populations in the San Marcos River and in Canyon Reservoir were *O. mossambicus* x *O. aureus* hybrids (Howells 1991, [1992]). With the aid of W. Smith-Vaniz, we examined preserved juveniles catalogued as *O. mossambicus* from the San Marcos River (TCWC 2073.01) and determined them to be *O. aureus* based on their caudal fin patterns and scale and gill raker counts. Some California records of this species may actually be those of *O. urolepis* (= *O. hornorum*) or of hybrids between *O. mossambicus* and *O. urolepis* (Swift et al. 1993). The occurrence of *O. mossambicus* in the United States was reviewed by Courtenay and McCann (1981), Wieland et al. (1982), and Courtenay et al. (1986). The history of this species introduction into the southwestern United States was reviewed by Hoover (1971), Courtenay and Robins (1989), Shapovalov et al. (1981), and Swift et al. (1993). *Oreochromis mossambicus* has largely replaced redbelly tilapia *Tilapia zillii* in the Salton Sea and possibly other areas in southern California (Swift et al. 1993). Collection sites and reported localities are mapped for the United States (Courtenay and Hensley 1979; Lee et al. 1980 et seq.), and for the states of Arizona (Minckley 1973; Grabowski et al. 1984) and Florida

(Courtenay et al. 1974; Hogg [1976]; Courtenay and Hensley 1979; Kushlan 1986; Loftus and Kushlan 1987)."

"Because of its presence in Dade County, Florida, Courtenay (1989) indicated that the Mozambique tilapia may eventually enter Everglades National Park."

"Electrofishing was an effective way to remove adults from a population during a project in Australia, but the removal was met with questionable success because the number of juveniles greatly increased as the adult numbers decreased (Thuesen et al. 2011)."

From Cambray and Swartz (2007):

"Threatened by hybridization with the rapidly spreading *Oreochromis niloticus*. *Oreochromis niloticus* is being spread by anglers and for aquaculture. Hybridization is already occurring throughout the northern part of the species' range, with most of the evidence coming from the Limpopo River system. In terms of locations the threat of *Oreochromis niloticus* is widespread, but probably more than 50% of the locations are not yet affected. Given the rapid spread of *O. niloticus* it is anticipated that this species will qualify as threatened under Criterion A due to rapid population decline through hybridization. The species is therefore assessed as Near Threatened."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2015):

"Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Osteichthyes
Class Actinopterygii
Subclass Neopterygii
Infraclass Teleostei
Superorder Acanthopterygii
Order Perciformes
Suborder Labroidei
Family Cichlidae
Genus Oreochromis
Species *Oreochromis mossambicus* (Peters, 1852) – Mozambique mouth-breeder, Mozambique mouthbrooder, Mozambique tilapia, tilapia mosambica"

"Taxonomic Status: valid"

Size, Weight, and Age Range

From Froese and Pauly (2015):

"Maturity: Lm 15.4, range 6 - 28 cm
Max length : 39.0 cm SL male/unsexed; [Wohlfarth and Hulata 1983]; common length : 35.0 cm TL male/unsexed; [Frimodt 1995]; max. published weight: 1.1 kg [IGFA 2001]; max. reported age: 11 years [Noakes and Balon 1982]"

Environment

From Froese and Pauly (2015):

"Freshwater; brackish; benthopelagic; amphidromous [Riede 2004]; depth range 1 - 12 m [Bruton and Boltt 1975]."

Climate/Range

From Froese and Pauly (2015):

"Tropical; 17°C - 35°C [Philippart and Ruwet 1982]; 13°S - 35°S, 180°W - 180°E"

Distribution Outside the United States

Native

From Froese and Pauly (2015):

"Africa: Lower Zambezi, Lower Shiré and coastal plains from Zambezi delta to Algoa Bay. Occurs southwards to the Brak River in the eastern Cape and in the Transvaal in the Limpopo system [de Moor and Bruton 1988]."

Introduced

From CABI (2015):

"Mozambique tilapia have been introduced into more than 50 countries on all the continents except Antarctica (Pullin et al., 1997)."

Means of Introduction Outside the United States

From CABI (2015):

"Introductions of Mozambique tilapia were for farming, insect and weed control, and tuna bait purposes."

"The Mozambique tilapia was the first tilapia to be widely distributed as a farmed fish. It was transferred to the Island of Java in the 1930s. Its rapid spread and adoption as a popular food across Indonesia led to the common name of Java tilapia as many did not realize it was not native."

“Dispersal of the Mozambique tilapia accelerated in the 1940s and 1950s with Japanese occupiers and later post-war reconstruction efforts spreading the fish to several countries in Asia. Sixty individuals were sent from Singapore to Hawaii in 1951. Progeny of these fish were later sent to public aquariums in California and New York, who later shared further progeny with universities and resource agencies in Alabama, Arizona and California. Tilapias are important to aquaculture because of the ease with which they can be bred in captivity and the wide variety of water conditions in which the fish will grow.”

From GISD (2006):

“Mozambique tilapia (*Oreochromis mossambicus*) are hardy and can easily establish in natural waters near aquaculture ponds or cages, from which they may escape during loading-harvesting or via containment failures.”

From Froese and Pauly (2015):

“Translocated and introduced for aquaculture, sport fishing, stocking man-made lakes and biological control of nuisance plants and animals [de Moor and Bruton 1988].”

Short description

From Froese and Pauly (2015):

“Dorsal spines (total): 15 - 18; Dorsal soft rays (total): 10-13; Anal spines: 3; Anal soft rays: 7 - 12; Vertebrae: 28 - 31. Diagnosis: snout long; forehead with relatively large scales, starting with 2 scales between the eyes followed by 9 scales up to the dorsal fin [Pfeffer 1893, 1894]. Adult males develop a pointed, duckbill-like snout [Lamboj 2004] due to enlarged jaws, often causing the upper profile to become concave [Bell-Cross 1976; Trewavas 1983; Bell-Cross and Minshull 1988; Skelton 1993; Lamboj 2004], but upper profile convex in smaller specimens [Boulenger 1899; Weber 1897]. Pharyngeal teeth very fine, the dentigerous area with narrow lobes, the blade in adults longer than dentigerous area; 28-31 vertebrae; 3 anal spines; 14-20 lower gill-rakers; genital papilla of males simple or with a shallow distal notch; caudal fin not densely scaled; female and non-breeding male silvery with 2-5 mid-lateral blotches and some of a more dorsal series; breeding male black with white lower parts of head and red margins to dorsal and caudal fins [Trewavas 1983].”

Biology

From Froese and Pauly (2015):

“Adults thrive in standing waters [Crass 1964; Skelton 1993]. Inhabit reservoirs, rivers, creeks, drains, swamps and tidal creeks; commonly over mud bottoms, often in well-vegetated areas [Allen et al. 2002]. Also found in warm weedy pools of sluggish streams, canals, and ponds [Page and Burr 1991]. Most common in blind estuaries and coastal lakes [Blaber 1997], but usually absent from permanently open estuaries and open sea [de Moor and Bruton 1988] and from fast-flowing waters [Crass 1964; Skelton 1993]. Normally not found at high altitudes [de Moor and Bruton 1988]. Able to survive extreme reduction of temporary water bodies [Trewavas 1983; Lévêque 1997]. Highly euryhaline [Crass 1964; Bell-Cross 1976; Pienaar 1978; Balarin

1979; Chervinski 1982; Philippart and Ruwet 1982; Trewavas 1983; Bell-Cross and Minshull 1988; de Moor and Bruton 1988; Thys van den Audenaerde 1988; Lévêque 1997; Gupta and Acosta 2004]. Grow and reproduce in fresh-, brackish and seawater [Bardach et al. 1972; Balarin 1979; Bruton et al. 1982; Chervinski 1982; Trewavas 1983; Wohlfarth and Hulata 1983; Suresh and Lin 1992; Lévêque 1997]. Can be reared under hyper-saline conditions [Robins et al. 1991; Allen et al. 2002; Lamboj 2004]. Tolerate low dissolved oxygen levels [Chervinski 1982, Philippart and Ruwet 1982; de Moor and Bruton 1988] and can utilise atmospheric oxygen when water oxygen levels drop [Balarin 1979; de Moor and Bruton 1988]. Mainly diurnal. May form schools [Philippart and Ruwet 1982; Robins et al. 1991; Allen et al. 2002]. Omnivorous [Bell-Cross 1976; Wohlfarth and Hulata 1983], feed mainly on algae and phytoplankton [Crass 1964; Bardach et al. 1972; Bell-Cross 1976; Pienaar 1978; Bell-Cross and Minshull 1988; Robins et al. 1991; Skelton 1993; Allen et al. 2002; Lamboj 2004] but also take some zooplankton, small insects and their larvae [Bell-Cross 1976; Bell-Cross and Minshull 1988; Robins et al. 1991; Skelton 1993; Allen et al. 2002; Lamboj 2004], shrimps [Bell-Cross 1976; Bell-Cross and Minshull 1988], earthworms [Crass 1964] and aquatic macrophytes [de Moor and Bruton 1988]. Juveniles carnivorous/omnivorous, adults tend to be herbivorous or detritus feeders [Trewavas 1983; Otto-Infante 1985; de Moor and Bruton 1988]. Large individuals have been reported to prey on small fishes [Crass 1964; Pienaar 1978; Trewavas 1983; de Moor and Bruton 1988], and occasionally cannibalise their own young [Trewavas 1983; de Moor and Bruton 1988]. Exhibit considerable plasticity in their feeding habits [Maitipe and De Silva 1985; de Moor and Bruton 1988] as well as in their reproductive biology [Maitipe and De Silva 1985]. Polygamous [Bell-Cross 1976; Bell-Cross and Minshull 1988], maternal mouthbrooder [Bell-Cross 1976; Bruton et al. 1982; Trewavas 1982; Bell-Cross and Minshull 1988]. Reach sexual maturity at 15 centimeter length [Allen et al. 2002], but stunted fish may breed at 6-7 centimeters and at an age of just over 2 months [Lamboj 2004]. Fecundity high [Gupta and Acosta 2004]. Extended temperature range 8-42 °C, natural temperature range 17-35°C [Philippart and Ruwet 1982], with salinity-dependent difference in temperature tolerance [Chervinski 1982; Trewavas 1983]. Somewhat aggressive toward other species [Bardach et al. 1972]. … Eurytopic; a most successful and vagile invader [de Moor and Bruton 1988]."

"Spawns at the edge of the littoral terrace of lakes [Lowe-McConnell 1982; Trewavas 1982, 1983; de Moor and Bruton 1988], in sandy or muddy bottoms [Oliveira et al. 2005]. Displays a lek mating system; territorial males establish breeding territories where they dig spawning pits, assume a dark coloration, defend a breeding territory and actively court females; sneaking males intrude into nests during a spawning episode, exhibiting quivering behavior which is usually an indicator of sperm release; sneaking is predominantly performed by subordinate males, which may adopt pseudo-female behavior [Oliveira et al. 2005]. Only territorial males produce sounds, during all phases of courtship but especially during the late stages, including spawning [Amorim et al. 2003]. Territorial male excavates and defends a basin-shaped pit in the center of his territory, where female deposits 100-1700(1800) eggs [Allen et al. 2002; Lamboj 2004]. Eggs and milt are sucked up by the female [Trewavas 1983; Allen et al. 2002]. Fertilization is reported to sometimes occur in the mouth of the female [Pethiyagoda 1991]. Females incubate eggs alone [Crass 1964; Lamboj 2004]. It is possible, albeit rare, that males take up some eggs after spawning [Bruton and Boltt 1975; Trewavas 1983; Arthington and Milton 1986; Lamboj 2004], but they almost always eat them soon after [Lamboj 2004]. Females school together while mouthbrooding [Holden and Bruton 1994], they cease to feed and subsist on food reserves stored

in their body [Trewavas 1982]. Females may spawn a full clutch with just one male, or may spawn with several different males in a series [Lamboj 2004]. Water is circulated over the eggs by chewing movements of the jaws [Crass 1964; Pienaar 1978]. Fry hatch in the female's mouth after 3-5 days [Crass 1964; Pienaar 1978; Trewavas 1983; Allen et al. 2002; Lamboj 2004], depending on the temperature [Lamboj 2004]. The young are released from the mouth in 10-14 days, but remain near the female and enter the mouth if threatened until about 3 weeks old [Trewavas 1983; Allen et al. 2002; Lamboj 2004]. Fry and juveniles shoal in shallow water [Bruton and Boltt 1975; de Moor and Bruton 1988; Skelton 1993] where they feed during the day, and retreat to deep water at night [Lowe-McConnell 1982; de Moor and Bruton 1988]. Females raise multiple broods during a season [Bruton and Boltt 1975; Skelton 1993]."

Human uses

From Froese and Pauly (2015):

"Fisheries: highly commercial; aquaculture: commercial; gamefish: yes; aquarium: commercial"

"Used extensively in biological, physiological and behavioural research [Skelton 1993]."

Diseases

From Froese and Pauly (2015):

"Ambiphyra Infestation 2, Parasitic infestations (protozoa, worms, etc.)"
"Amyloodinium Infestation, Parasitic infestations (protozoa, worms, etc.)"
"Cichlidogyrus Infestation, Parasitic infestations (protozoa, worms, etc.)"
"Cichlidogyrus Infestation 4, Parasitic infestations (protozoa, worms, etc.)"
"Contracaecum Disease (larvae), Parasitic infestations (protozoa, worms, etc.)"
"Cryptobia Infestation, Parasitic infestations (protozoa, worms, etc.)"
"Dactylogyrus Gill Flukes Disease, Parasitic infestations (protozoa, worms, etc.)"
"Diplostomum Infection, Parasitic infestations (protozoa, worms, etc.)"
"Dolops Infestation, Parasitic infestations (protozoa, worms, etc.)"
"Edwardsiellosis, Bacterial diseases"
"Epitheliocystis, Bacterial diseases"
"Euclinostomum Infestation 2, Parasitic infestations (protozoa, worms, etc.)"
"False Fungal Infection (*Epistylis* sp.), Parasitic infestations (protozoa, worms, etc.)"
"Fish louse Infestation 1, Parasitic infestations (protozoa, worms, etc.)"
"Fish Louse Infestation 3, Parasitic infestations (protozoa, worms, etc.)"
"Fish Tuberculosis 2, Parasitic infestations (protozoa, worms, etc.)"
"Gnathostoma Disease (larvae), Parasitic infestations (protozoa, worms, etc.)"
"Gnathostoma Infestation 2, Parasitic infestations (protozoa, worms, etc.)"
"Goezia Disease 2, Parasitic infestations (protozoa, worms, etc.)"
"HTRLO Disease, Parasitic infestations (protozoa, worms, etc.)"
"Ichthyobodo Infection, Parasitic infestations (protozoa, worms, etc.)"
"Ichthyophthirius Disease, Parasitic infestations (protozoa, worms, etc.)"
"Lernaea Infestation, Parasitic infestations (protozoa, worms, etc.)"
"Orientocreadium Disease, Parasitic infestations (protozoa, worms, etc.)"
"Pentastoma Infection 2, Parasitic infestations (protozoa, worms, etc.)"

“Rhabdochona Infestation 6, Parasitic infestations (protozoa, worms, etc.)”
“Saccocoelioides Infection, Parasitic infestations (protozoa, worms, etc.)”
“Spinning Tilapia Syndrome, Viral diseases”
“Transversotrema Infestation, Parasitic infestations (protozoa, worms, etc.)”
“Trichodina Infection 1, Parasitic infestations (protozoa, worms, etc.)”
“Trichodina Infection 5, Parasitic infestations (protozoa, worms, etc.)”
“Trichodinella Infection 1, Parasitic infestations (protozoa, worms, etc.)”
“Trichodinosis, Parasitic infestations (protozoa, worms, etc.)”
“Turbidity of the Skin (Freshwater fish), Parasitic infestations (protozoa, worms, etc.)”
“Velvet Disease 2 (*Piscinoodinium* sp.), Parasitic infestations (protozoa, worms, etc.)”
“White spot Disease, Parasitic infestations (protozoa, worms, etc.)”

No OIE-listed diseases have been reported for this species.

Threat to humans

From Froese and Pauly (2015):

“Potential pest”

3 Impacts of Introductions

From Russell et al. (2012):

“There is considerable evidence that invasive *O. mossambicus* populations are impacting on native fauna at many locations where they have been introduced around the world. *Oreochromis mossambicus* was directly or indirectly responsible for the disappearance of native species in Venezuela (Pérez et al. [2006]). In Central America, *O. mossambicus* and other tilapia species have been implicated in the decline of native cichlid populations in Lake Nicaragua, probably as a result of competitive displacement (McKaye et al. 1995) and their presence has been related to damage to indigenous fauna in Florida and Columbia (Philippart and Ruwet 1982). The introduction of *O. mossambicus* into Laguna Chichancanab in Mexico negatively impacted on a species flock of endemic pupfish (*Cyprinodon* spp.) (Fuselier 2001) by competitively excluding them from optimal habitats, resulting in declines in the abundance in four out of the five flock members. These results were supported by both field and laboratory experiments that suggested agonistic behaviour of *O. mossambicus* towards pupfish had caused major microhabitat shifts. Fuselier (2001) also cautioned that the introduction of *O. mossambicus* may have disrupted the evolutionary mechanisms that led to the sympatric speciation of the pupfish flocks. This potentially could result in the breakdown of reproductive barriers between the recently diverged species, resulting in introgression and loss of rare phenotypes.”

“Doupé et al. (2010) reported that herbivory from *O. mossambicus* significantly reduced macrophyte biomass of three native Australian species (*Hydrilla verticillata*, *Ceratophyllum demersum* and *Vallisneria nana*) in controlled microcosm experiments. However, within Australia, the impact of *O. mossambicus* on macrophytes at a community scale has not been assessed. In a small South African lagoon, Cooper and Harrison (1992) observed that nest building activities close to shore caused the collapse of an overlying bank and its binding

vegetation into the main channel but suggested that overall, changes in estuarine morphology resulting from nest construction were unlikely to be a major factor in estuarine degradation."

"International studies suggest that tilapia species are also vectors of Helminthid parasites, which can potentially switch hosts and infect native species. There is also evidence of monogenean transfer from African cichlids to American cichlids and vice versa (Jiménez-García et al. 2001)."

From GISD (2006):

"**Location Specific Impacts:**"

"Bahamas
Competition: Mozambique tilapia (*Oreochromis mossambicus*) compete with the threatened native Bahama pupfish (*Cyprinodon laciniatus*) resulting in declining abundance of these fish (Barton, 1999)."

"Morelos (Mexico)
Competition: Stocking of Mozambique tilapia (*Oreochromis mossambicus*) in ponds has resulted in displacement of other fish species.
Economic/Livelihoods: Stocking of Mozambique tilapia (*Oreochromis mossambicus*) in ponds has resulted in a net decrease in fisheries production, due to competition with other fish species."

"Crater Lakes (Mexico)
Threat to endangered species: Mozambique tilapia (*Oreochromis mossambicus*) compete with the vulnerable silverside fish charal de la caldera (see *Chirostoma bartoni* in IUCN Red List of Threatened Species) that is endemic to La Alberca crater-lake."

"Laguna Chichancanab (Mexico)
Competition: Mozambique tilapia (*Oreochromis mossambicus*) compete with the native Cyprinodon species for habitat, resulting in declining abundance of these fish."

"Buada Lagoon (Nauru)
Economic/Livelihoods: Mozambique tilapia (*Oreochromis mossambicus*) have caused the collapse of milkfish aquaculture."

"New Caledonia (Nouvelle Caledonie)
Threat to endangered species: The introduction of two tilapia species (*Oreochromis mossambicus* and *Sarotherodon occidentalis*) in 1955, followed by that of the largemouth bass (*Micropterus salmoides*) in 1960, has led to a decrease in numbers of galaxias (*Galaxias neocaledonicus*). These introduced species preyed on the different stages of *G. neocaledonicus* (Keith 2002)."

"Malakal Is. (Palau)
Competition: Mozambique tilapia (*Oreochromis mossambicus*) can build large populations that often disrupt or eliminate populations of native species, usually due to their high numbers reached via reproduction (Courtenay, W., pers. comm., 2004).

Predation: There is recent evidence that Mozambique tilapia (*Oreochromis mossambicus*), many of which feed on detritus or algae, will also eat small fishes (Courtenay, W., pers. comm., 2004)."

From CABI (2015):

"Tilapia introductions were often associated with severe environmental change, especially construction of reservoirs and large-scale irrigation projects. Tilapia are often described as 'pioneer' species, meaning they thrive in disturbed habitats, opportunistically migrating and reproducing. Often they were introduced into areas that have severe environmental damage where natives were already at risk. The tilapia are better able to adapt to the new conditions and the natives have been forced to contend with environmental changes and competition from exotic species."

4 Global Distribution

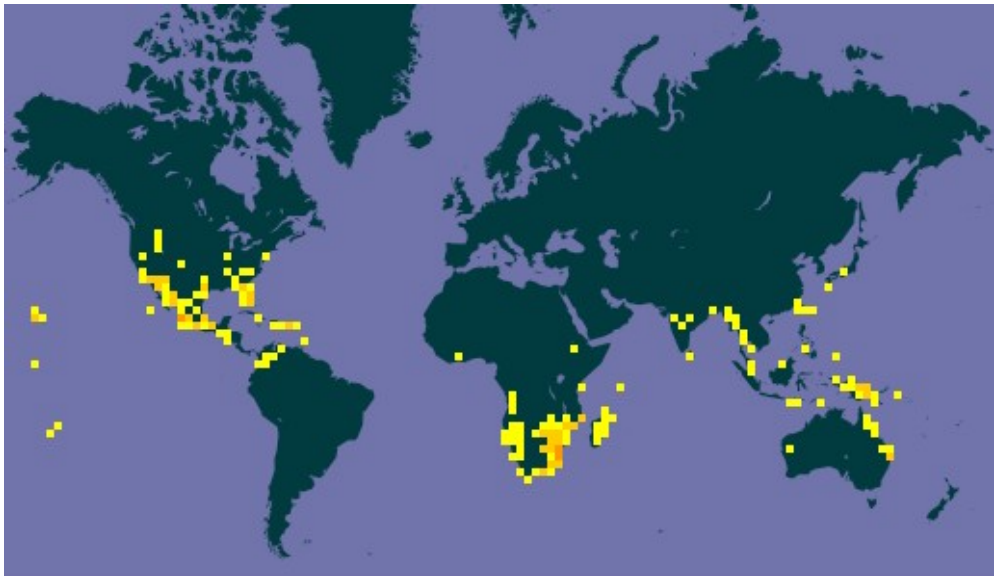

Figure 1. Global distribution of *Oreochromis mossambicus*. Map from GBIF (2015). Points in Ethiopia, Côte d'Ivoire, Kenya, and central Angola were not included in climate matching (Sec. 6) because they did not represent extant populations.

5 Distribution within the United States

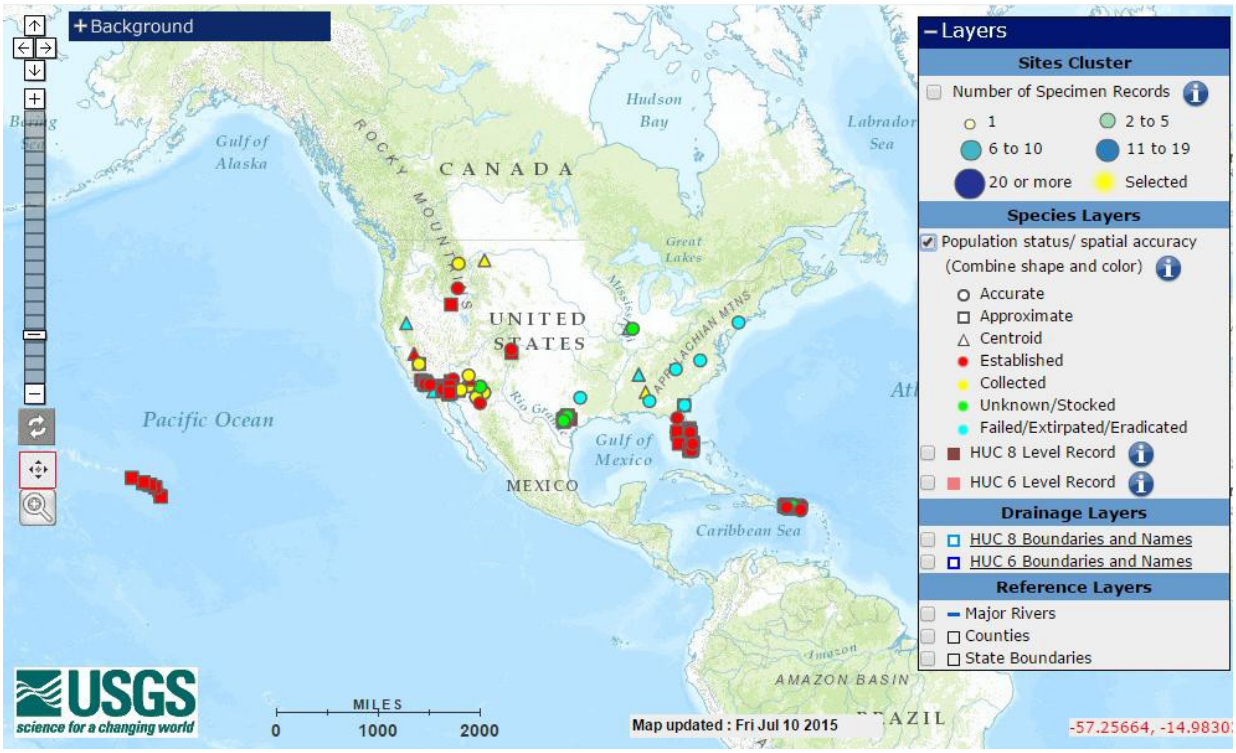

Figure 2. U.S. distribution of *Oreochromis mossambicus*. Map from Nico and Neilson (2015).

6 Climate Match

Summary of Climate Matching Analysis

The climate match (Sanders et al. 2014; 16 climate variables; Euclidean Distance) is high in Florida, along the Atlantic coast in the Southeast, in southern and central Texas, and in much of the West. The eastern portion of the United States is predominantly low climate match, although portions of the Great Lakes are a medium match. Climate 6 match indicates that the contiguous U.S. has a high climate match. The range for a high climate match is 0.103 and greater; Climate 6 score of *Oreochromis mossambicus* is 0.587.

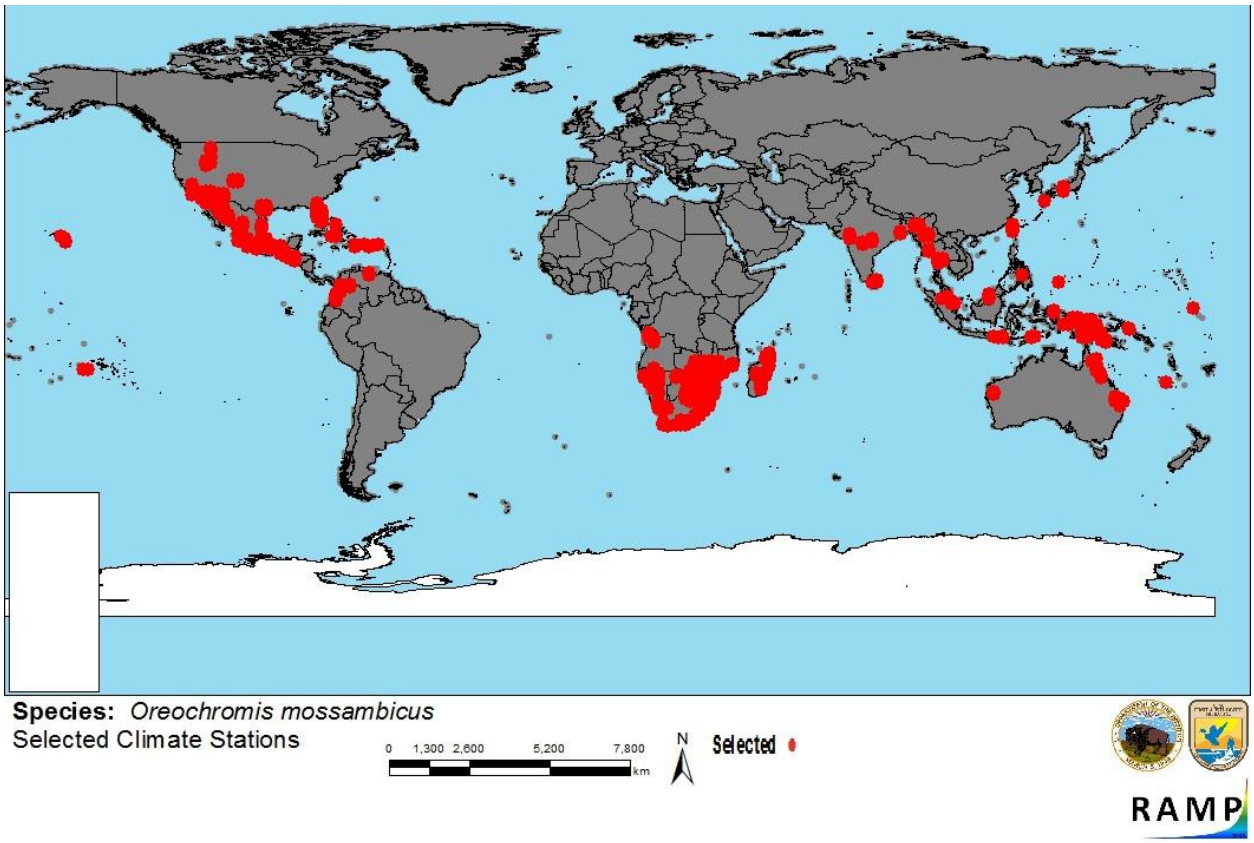

Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Oreochromis mossambicus* climate matching. Source locations from GISD (2006), GBIF (2015), and Nico and Neilson (2015).

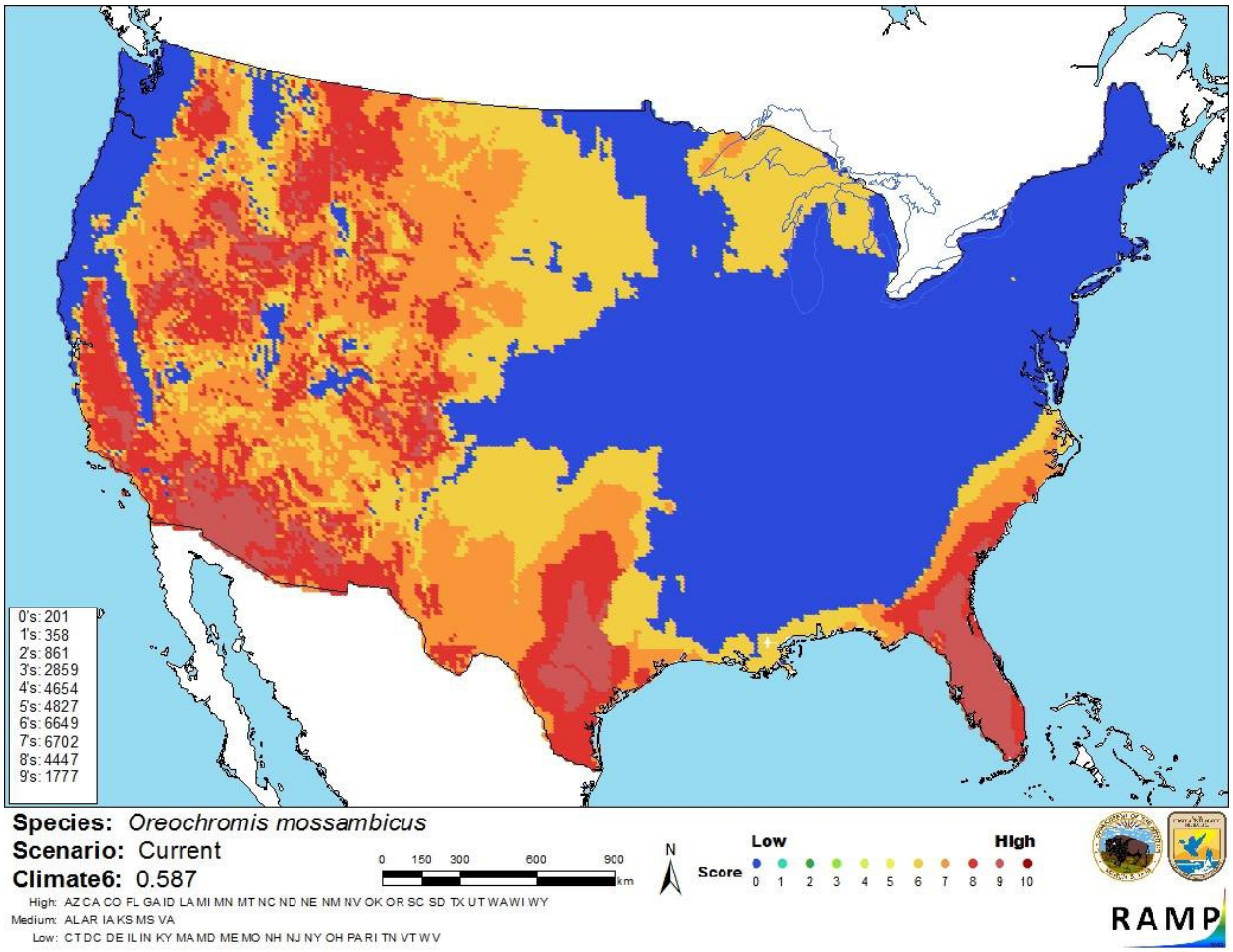

Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *Oreochromis mossambicus* in the continental United States based on source locations reported by GISD (2006), GBIF (2015), and Nico and Neilson (2015). 0= Lowest match, 10=Highest match. Climate match scores are tabulated on the left.

7 Certainty of Assessment

Information on the biology, distribution, and impacts of this species is readily available. Negative impacts from introductions of this species are adequately documented in the scientific literature. No further information is needed to evaluate the negative impacts the species is having where introduced. Certainty of assessment is high.

8 Risk Assessment

Summary of Risk to the Continental United States

O. mossambicus has a truly circumglobal distribution currently thanks to its high value to humans for commercial and recreational fishing, aquaculture, the aquarium trade, mosquito and macrophyte control, and biological research. Where *O. mossambicus* has been introduced outside its native range in southeastern Africa, numerous impacts have been documented on native fish and macrophytes. In addition to impacts of herbivory, competition, and predation, *O.*

mossambicus is susceptible to numerous parasitic, bacterial, and viral diseases which could be transmitted to native fish populations. Climate match to the contiguous U.S. is high. Overall risk of this species is high.

Assessment Elements

- **History of Invasiveness (Sec. 3):** High
- **Climate Match (Sec.6):** High
- **Certainty of Assessment (Sec. 7):** High
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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.

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