U.S. Fish & Wildlife Service

Nile Tilapia (*Oreochromis niloticus*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, April 2011
Revised, August 2014, July 2015, January 2018
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Photo: Pam Fuller, USGS

1 Native Range and Status in the United States

Native Range

From Nico et al. (2018):

"Tropical and subtropical Africa, Middle East. Widely distributed in Nile and Niger river basins and in lakes Tanganyika, Albert, Edward, and George, as well as in many smaller drainages and lakes in western and eastern Africa; also in Middle East in Yarkon River, Israel (Trewavas 1983)."

Status in the United States

From Nico et al. (2018):

"Established in Mississippi. Possibly established in a large reservoir bordering Florida and Georgia. Established locally (Alachua County) in Florida. Reported from Alabama and Arizona."

"A single fish in cold distress was taken from the Saugahatchee Creek portion of Yates Reservoir, in the Tallapoosa drainage of Mobile Basin, Lee County, Alabama, on 12 January 1986 (Hornsby, personal communication; Boschung 1992). Probably in reference to Yates Reservoir, Courtenay and Williams (1992) reported that a reservoir on the Tallapoosa River, where this species has been recorded, receives drainage from the aquaculture ponds of Auburn University. This species reportedly was being reared in fish farms in Arizona and apparently was introduced experimentally into the southern part of the state (Minckley 1973; Grabowski et al. 1984); however, the identification of those fish has come into question (Courtenay and Hensley 1979; Courtenay et al. 1984, 1986). Specific sites of introduction are not mentioned in the literature and there are no recent reports of this species in the state. The species is established in Orange Lake (Alachua County), Florida (FWC). Anglers have taken this species from Lake Seminole in the Apalachicola drainage, Seminole County, on both sides of the Florida and Georgia border, since about 1991; it is possibly established in the reservoir (Smith-Vaniz, personal communication). In 2004/2005 it was reported from Chicago Sanitary and Ship Canal at the Crawford Generation Plant, the South Fork of the South Branch of the Chicago River, and in 1999 from the North Shore Channel of the Chicago River at Dempster, Illinois (Wozniak, pers. comm.; Wasik, pers. comm.) A breeding population of Nile tilapia has inhabited Robinson Bayou in the Pascagoula River drainage, Mississippi since the late 1990s (Peterson et al. 2004). Recent collection sites include Crane Creek near Melbourne, Florida (T. Angradi, pers. comm.) and tidal bayous of Galveston Bay in Texas (J. Culbertson, pers. comm.) both in 2006, and Charles River in Boston, Massachusetts in 2007 (K. Hartel, pers. comm.). Specimens have been reported in non-specific locations in Puerto Rico (Lee et al. 1983)."

Means of Introduction into the United States

From Nico et al. (2018):

"This species was introduced for aquaculture purposes. It was introduced into open waters, likely through escape or release from fish farms."

Remarks

From Nico et al. (2018):

"This species closely resembles *Oreochromis aureus*. Before the two species were shown to be distinct, many or most accounts of "*Tilapia nilotica*" in U.S. ponds probably referred to *O. aureus,* likely imported from Israel (Trewavas 1983)."

"In the U.S. and other regions where they have been introduced, tilapias have hybridized and introgressed in aquaculture settings and subsequently escaped into the wild. Reproductively viable hybrids have resulted from these various crosses and thus, for most tilapia populations in the U.S., the use of meristics and traditional systematics to assign species names to specimens is not useful (see: Costa-Pierce 2003)."

"A specimen taken from Lake Seminole on the Georgia side of the lake near Saunder's Slough in 1991 was originally reported as *O. aureus* (Gennings, personal communication); however, all available specimens and photographs of tilapia from that lake have thus far proven to be *O. niloticus* (Smith-Vaniz, personal communication). Although *O. niloticus* has been reported from Texas, these reports were based on erroneous identifications of other tilapia species (Hubbs 1982, cited by Muoneke 1988). Reports of this species in Arizona also may be based on a misidentification. Minckley's (1973) figure 122, labeled as "*Tilapia nilotica*," and his description of their young, more closely match *T. mariae* (Courtenay and Hensley 1979; Courtenay et al. 1984, 1986)."

"Grammer et al. (2012) found that introduced Nile tilapia in Mississippi live to ~4 years, confirming multi-year survival and establishment of this population."

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 niloticus* (Linnaeus, 1758)"

"Taxonomic Status: valid"

From Froese and Pauly (2017):

"The following subspecies were previously recognized: *Oreochromis niloticus baringoensis*, *Oreochromis niloticus cancellatus*, *Oreochromis niloticus eduardianus*, *Oreochromis niloticus filoa*, *Oreochromis niloticus niloticus*, *Oreochromis niloticus sugutae*, *Oreohromis niloticus tana* and *Oreohromis* [*sic*] *niloticus vulcani*."

Size, Weight, and Age Range

From Froese and Pauly (2017):

"Maturity: L_m 18.6, range 6 - 28 cm
Max length : 60.0 cm SL male/unsexed; [Eccles 1992]; max. published weight: 4.3 kg [IGFA 2001]; max. reported age: 9 years [Noakes and Balon 1982]"

Environment

From Froese and Pauly (2017):

"Freshwater; brackish; benthopelagic; potamodromous [Riede 2004]; depth range 0 - 20 m [Wudneh 1998], usually ? - 20 m [van Oijen 1995]."

"Extended temperature range 8-42 °C, natural temperature range 13.5 - 33 °C [Philippart and Ruwet 1982]."

Climate/Range

From Froese and Pauly (2017):

"Tropical; […] 32°N - 10°N"

Distribution Outside the United States

Native

From Nico et al. (2018):

"Tropical and subtropical Africa, Middle East. Widely distributed in Nile and Niger river basins and in lakes Tanganyika, Albert, Edward, and George, as well as in many smaller drainages and lakes in western and eastern Africa; also in Middle East in Yarkon River, Israel (Trewavas 1983)."

Introduced

From CABI (2018):

"It has been introduced […] into more than 50 countries on all the continents except Antarctica (Pullin et al., 1997), and is now found in virtually every country within the tropics."

From Froese and Pauly (2017):

Year / Period	From	To	Established	Ecol. effects
1950-1974	Unknown	Iraq	probably not established	unknown
1975-1999	Unknown	Jamaica	unknown	
unknown	unknown	Mozambique	unknown	unknown
unknown	Unknown	Malta	not established	

Year / Period	From	To	Established	Ecol. effects
unknown	unknown	Liberia	unknown	unknown
unknown	Unknown	Kiribati	unknown	
unknown	Unknown	Jordan River	unknown	
unknown	Unknown	Iran	probably established	unknown
unknown	Unknown	Guyana	unknown	
unknown	Unknown	Gabon	unknown	
unknown	Unknown	France	not established	
unknown	Unknown	Ecuador	established	
unknown	Central African Republic	Zaire	unknown	
unknown	Unknown	Comoros	unknown	
unknown	Unknown	Brunei Darussalam	probably established	
unknown	Not specified	Botswana	established	no data
unknown	Unknown	Scotland	not established	
unknown	Unknown	Neth Antilles	unknown	
unknown	unknown	Qatar	probably established	no data
unknown	unknown	Sierra Leone	unknown	unknown
unknown	Unknown	Syria	unknown	
unknown	Unknown	UK	unknown	
unknown	Unknown	England	not established	
unknown	Unknown	Saudi Arabia	unknown	
unknown	Thailand	Laos	established	some
unknown	Gabon	Sao Tome and Principe	unknown	
unknown	Unknown	Russia	not established	
unknown	Unknown	Slovakia	probably not established	
1927 - 1930	Unknown	Lake Bunyoni	established	probably some
1940 - 1949	Unknown	Argentina	not established	
1970 - 1979	Unknown	Singapore	established	probably some
1970 - 1979	Unknown	Turkey	probably not established	unknown
1954 - 1962	Unknown	Kenya	established	some
1960 - 1969	Brazil	Bolivia	established	probably none
1950 - 1969	Unknown	Tanzania	established	some
1970 - 1979	Jamaica	Saint Lucia	probably established	probably some
1990 - 1999	unknown	Libyan Arab Jamahiriya	unknown	unknown
1980 - 1985	Jamaica	Trinidad	unknown	unknown
1935	Lake Bunyoni	Lakes Bulera and Luhondo	established	probably some

Year / Period	**From**	**To**	**Established**	**Ecol. effects**
1950	Madagascar	Mauritius	established	unknown
1950	Tanzania	Mauritius	established	unknown
1951	Congo, Dem. Rep. of the	Rwanda	established	no data
1951	Congo	Burundi	established	unknown
1953	Sudan	Congo	established	some
1954	Thailand	Bangladesh	established	some
1955	Israel	South Africa	probably not established	probably some
1956	Egypt	Madagascar	established	some
1956	Unknown	Sri Lanka	established	some
1957	Unknown	Germany	not established	
1957	Israel	Belgium	probably established	unknown
1957	Madagascar	Réunion	established	
1957	Congo	Central African Republic	unknown	
1962	Egypt	Japan	established	unknown
1964	El Salvador	Nicaragua	established	
1964	Costa Rica	Mexico	established	some
1964	Africa	Mexico	established	some
1965	Japan	Thailand	established	some
1966	Japan	Taiwan	established	probably none
1966	Unknown	Tunisia	established	probably some
1967	Peru	Cuba	established	
1968	Israel	Viti Levu, Fiji	established	
1969	Kenya	Israel	not established	unknown
1969	Taiwan	Indonesia	probably established	some
1970	Thailand	Philippines	established	some
1971	unknown	Indonesia (Irian Jaya)	unknown	unknown
1971	Côte d'Ivoire	Brazil	established	
1972	Taiwan	Hong Kong	established	some
1973	Thailand	Viet Nam	established	some
1973	Philippines	Viet Nam	established	some
1973	Taiwan Island	Viet Nam	established	some
1974	Pentecoste, northeast Brazil	USA	unknown	unknown
1974	Brazil	Puerto Rico	established	
1974	Costa Rica	Guatemala	established	unknown
1974	El Salvador	Guatemala	established	unknown
1975	Taiwan	South Korea	established	

Year / Period	From	To	Established	Ecol. effects
1976	Brazil	Panama	established	
1976	Israel	South Africa	probably established	unknown
1976	Israel	Cyprus	probably not established	
1977	Thailand	Myanmar	established	
1977	Unknown	Haiti	probably established	
1978	Nile River	China	probably established	probably none
1978	USA	Honduras	established	unknown
1979	United States of America	Haiti	probably established	no data
1979	USA	El Salvador	established	
1979	Unknown	Dominican Republic	established	
1979	Brazil	Peru	established	
1979	Panama	Costa Rica	established	
1979	Brazil	Colombia	established	unknown
1979	Thailand	Malaysia	established	
1980	Viet Nam	Cambodia	probably established	
1980	Panama	Colombia	established	
1982	Unknown	Grenada	unknown	
1983	Dominica	St. Vincent	unknown	
1983	UK Scotland	Zambia	established	unknown
1985	Sudan	Czech Republic	not established	none
1985	Unknown	Bhutan	unknown	
1985	Thailand	Nepal	unknown	unknown
1985	Unknown	Czechoslovakia	probably not established	
1985	Egypt	Pakistan	established	probably none
1985	unknown	Nepal	unknown	unknown
1986	UK Scotland	Zimbabwe	established	some
1987	Jamaica	Haiti	unknown	no data
1989	Ethiopia	Eritrea	probably established	
1989	Czechoslovakia	Poland	not established	none
1990	Egypt	Colombia	unknown	unknown
1990	Kenya	Zimbabwe (Lake Kariba)	unknown	unknown
1990	Thailand	India	probably not established	probably none
1991	Fiji	Samoa	unknown	
1991	Germany	Zambia	unknown	unknown
1993	Fiji	Rarotonga, Cook Is.	probably not established	
1993	Jamaica	Cayman Is.	established	unknown

Year / Period	From	To	Established	Ecol. effects
2000	unknown	Italy	established	probably some
2002	Egypt	Dams, agricultural farms	not established	
2003	Unknown	Galapagos Is.	established	

Means of Introduction Outside the United States

From CABI (2018):

"Nile tilapia has been widely introduced for aquaculture, augmentation of capture fisheries, and sport fishing (Trewavas, 1983; Welcomme, 1988)."

"Nile tilapia has repeatedly reached new areas after escaping from nearby fish farms, such as in the Middle Zambezi, Nata (Makgadikgadi/Okavango), Runde-Save, Buzi and Limpopo River systems (Schwank, 1995; van der Waal and Bills 1997; 2000; Tweddle and Wise, 2007; Weyl, 2008; Zengeya and Marshall, 2008)."

Short Description

From Froese and Pauly (2017):

"Dorsal spines (total): 15 - 18; Dorsal soft rays (total): 11-13; Anal spines: 3; Anal soft rays: 9 - 11; Vertebrae: 30 - 32. Diagnosis: jaws of mature male not greatly enlarged (length of lower jaw 29-37 % of head length); genital papilla of breeding male not tassellated [Trewavas 1983]. Most distinguishing characteristic is the presence of regular vertical stripes throughout depth of caudal fin [Eccles 1992; Teugels and Thys van den Audenaerde 2003]."

Biology

From Froese and Pauly (2017):

"Occur in a wide variety of freshwater habitats like rivers, lakes, sewage canals and irrigation channels [Bailey 1994]. Mainly diurnal. Feed mainly on phytoplankton or benthic algae. Oviparous [Breder and Rosen 1966]. Mouthbrooding by females [Trewavas 1983]."

"Sexual maturity is reached at 3-6 months depending on temperature, reaching about 30 g. Reproduction occurs only when temperatures are over 20°C. Several yearly spawnings every 30 days. Females incubate eggs inside their mouths (approximately for a week) where larvae hatch and remain until the vitellus is reabsorved [*sic*]. Egg size 1.5 mm, larval length at hatching 4 mm. Spawns in firm sand in water from 0.6 to 2 m deep of lakes [Trewavas 1983] and inshore waters [Worthington 1932]. Males set up and defend territory which are visited by the females. Courtship lasts several hours. A single male probably fertilises the eggs of more than one female [Worthington 1932]. Eggs are shed in batches in shallow nest and fertilized by male. Each batch of eggs is picked up into oral cavity by female. Females solely involved in broodcare. Female carries up to 200 eggs in her mouth where the larvae hatch and remain until after the yolk-sac is absorbed."

Human Uses

From Froese and Pauly (2017):

"Fisheries: highly commercial; aquaculture: commercial"

From CABI (2018):

"Tilapias are the third most farmed fish in the world after carps and salmonids, accounting for 4% of global aquaculture production (FAO, 2010). Aquaculture is perceived as a means of protein security, poverty alleviation and economic development in many developing countries (NEPAD, 2005)."

"The Nile tilapia is well-suited for aquaculture because of its wide range of trophic and ecological adaptations, as well as its adaptive life history characteristics that enable it to occupy many different tropical and sub-tropical freshwater niches (Trewavas, 1983)."

"Along with the Mozambique tilapia, *Oreochromis mossambicus*, the Nile tilapia is the most important tilapia in aquaculture. They are among the ten most introduced fish species in the world, and together they account for 99.5% of global tilapia production (FAO 2010). Since the mid-1980s, there has been a shift in producer preference away from the Mozambique tilapia towards culturing Nile tilapia, as the latter has a higher growth rate and a reduced tendency to stunt. Nile tilapia now dominates global tilapia aquaculture production, accounting for 72%, or 474 000 tons, in 1995 (FAO, 2010)."

"Tilapia's major social impact is as an important source of protein in many developing countries. A second important impact is as a source of employment producing tilapia for export. In Brazil, tilapia also support the fee fishing recreational activities. One important social impact of tilapia aquaculture is the increase in household incomes from small farms and eateries associated with farms. Another impact is the benefit to women involved with tilapia farming. Hatcheries and genetic improvement programs employ many highly educated women in developing countries. These positions are especially important in locations where women with advanced degrees in biology have a difficult time finding employment commensurate with their education. Processing plants also hire large numbers of unskilled women for the processing line and skilled women for quality assurance. Finally, Nile tilapia, also known as Egyptian Mouth Breeders, are a popular aquarium fish."

Diseases

From Froese and Pauly (2017):

"Yellow Grub, Parasitic infestations (protozoa, worms, etc.)
Fish tuberculosis (FishMB) [mycobacteriosis], Bacterial diseases
Dactylogyrus Gill Flukes Disease, Parasitic infestations (protozoa, worms, etc.)
Trichodinosis, Parasitic infestations (protozoa, worms, etc.)

Aeromonasis in Tilapia, Bacterial diseases
Dactylogyrus Gill Flukes Disease, Parasitic infestations (protozoa, worms, etc.)
Trichodinosis, Parasitic infestations (protozoa, worms, etc.)
Skin Flukes, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Disease, Parasitic infestations (protozoa, worms, etc.)
Cryptobia Infestation, Parasitic infestations (protozoa, worms, etc.)
False Fungal Infection (*Apiosoma* sp.), Parasitic infestations (protozoa, worms, etc.)
False Fungal Infection (*Epistylis* sp.), Parasitic infestations (protozoa, worms, etc.)
Transversotrema Infestation, Parasitic infestations (protozoa, worms, etc.)
Caligus Infestation 3, Parasitic infestations (protozoa, worms, etc.)
Alitropus Infestation, Parasitic infestations (protozoa, worms, etc.)
Trichodina Infection 1, Parasitic infestations (protozoa, worms, etc.)
Tripartiella Infestation, Parasitic infestations (protozoa, worms, etc.)
Trichodina Infection 5, Parasitic infestations (protozoa, worms, etc.)
Cristaria Infestation, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation, Parasitic infestations (protozoa, worms, etc.)
Ichthyophthirius Disease, Parasitic infestations (protozoa, worms, etc.)
Tripartiella Infestation 2, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation 2, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation 3, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation 4, Parasitic infestations (protozoa, worms, etc.)
Trichodina Infestation 8, Parasitic infestations (protozoa, worms, etc.)
Trichodina Infestation 9, Parasitic infestations (protozoa, worms, etc.)
Trichodina Infestation 10, Parasitic infestations (protozoa, worms, etc.)
Enterogyrus Infestation, Parasitic infestations (protozoa, worms, etc.)
Gyrodactylus Infestation 1, Parasitic infestations (protozoa, worms, etc.)
Gyrodactylus Infestation 2, Parasitic infestations (protozoa, worms, etc.)
Lamproglena Infestation, Parasitic infestations (protozoa, worms, etc.)
Fish louse Infestation 1, Parasitic infestations (protozoa, worms, etc.)
Turbidity of the Skin (Freshwater fish), Parasitic infestations (protozoa, worms, etc.)
Ergasilus Disease 3, Parasitic infestations (protozoa, worms, etc.)
Aeromonosis, Bacterial diseases
Trypanosoma Infection, Parasitic infestations (protozoa, worms, etc.)
Sporozoa-infection (*Myxobolus* sp.), Parasitic infestations (protozoa, worms, etc.)
Contracaecum Disease (larvae), Parasitic infestations (protozoa, worms, etc.)
Fish Tuberculosis 2, Parasitic infestations (protozoa, worms, etc.)
Myxobacterial Infections, Bacterial diseases
Myxobacterial Infections, Bacterial diseases
Amplicaecum Infection (Larvae), Parasitic infestations (protozoa, worms, etc.)
Whirling Viral Disease of Tilapia Larvae, Viral diseases
Iridovirosis, Viral diseases
Aeromonosis, Bacterial diseases
Edwardsiellosis, Bacterial diseases
Epitheliocystis, Bacterial diseases
Cichlidogyrus Infestation, Parasitic infestations (protozoa, worms, etc.)
Gnathostoma Disease (larvae), Parasitic infestations (protozoa, worms, etc.)

Cichlidogyrus Infestation 5, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Disease, Parasitic infestations (protozoa, worms, etc.)
Acanthogyrus Infestation, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation 2, Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation 3, Parasitic infestations (protozoa, worms, etc.)
Dilepid Cestode larvae Infestation (general sp.), Parasitic infestations (protozoa, worms, etc.)
Cichlidogyrus Infestation 10, Parasitic infestations (protozoa, worms, etc.)
Trypanosoma Infestation 2, Parasitic infestations (protozoa, worms, etc.)
Dactylosoma Infection 1, Parasitic infestations (protozoa, worms, etc.)"

FAO (2018) reports that the following diseases have been documented in *O. niloticus*: Motile Aeromonas Septicaemia (MAS), Vibriosis, Edwardsiellosis, Streptococcosis, and Saprolegniosis. The disease agent for the last is fungal, and all the rest are bacterial. In addition, *O. niloticus* can be infected with ciliates and monogenetic trematodes, both protozoan parasites.

From Haenen et al. (2013):

"*Streptococcus iniae*, a Gram-positive bacterium, is a zoonotic pathogen in fresh water and marine fish, causing disease outbreaks in aquatic species [Agnew and Barnes 2007] and invasive disease in humans [Baiano and Barnes 2009]. This pathogen causes significant economic losses, particularly in the tilapia and hybrid striped bass aquaculture industries in the USA, Japan, Israel, South Africa, Australia, the Philippines, Taiwan, Bahrain and other countries."

From Soliman et al. (2008):

"[…] *Oreochromis niloticus* is more resistant to the SVCV [spring viraemia of carp virus] than the susceptible hosts (Family Cyprinidae), but due to the several stress conditions which are facing the cultured fish in our culture pond systems, which lead to immunosuppression (the same role played by cortisone injected to the examined fish during the experimental infection), the *Oreochromis niloticus* can catch the infection with the virus, with little or, in some times, no specific clinical signs or post mortem lesions and may serve as a carrier to the virus."

Spring viraemia of carp is an OIE-reportable disease.

Threat to Humans

From Froese and Pauly (2017):

"Potential pest"

3 Impacts of Introductions

From Nico et al. (2018):

"Nile tilapia exert competition pressures on native fish and are known to prey on amphibians and juveniles of other fish species (Zambrano et al. 2006). However, Peterson et al. (2006) found little overlap in the diets of Nile tilapia and three native centrarchids (bluegill *Lepomis macrochirus*, redear sunfish *L. microlophus*, and largemouth bass *Micropterus salmoides*), with tilapia foraging at a lower trophic level (e.g., higher proportion of small benthic invertebrates and detritus) than native centrarchids (primarily consuming fishes and larger invertebrates). In Nevada and Arizona, the introduction of *O. niloticus* has resulted in the decline of endangered Moapa dace and Moapa white river springfish (Wise et al. 2007). Martin et al. (2010) found that Nile tilapia displaced native redspotted sunfish (*L. miniatus*) from preferred habitat in laboratory experiments, exposing the sunfish to greater predation pressure."

Note that *O. niloticus* has not been confirmed as established in either Nevada or Arizona.

From Figueredo and Giani (2005):

"To measure the effects of tilapia on the phytoplankton community and on water conditions of a large tropical reservoir in south-eastern Brazil (Furnas Reservoir), we performed two in situ experiments using three controls (no fish) and three tilapia enclosures (high fish density). […] Fish presence increased nitrogen (N) and phosphorus (P) availability […] via excretion. Nutrient recycling by fish can thus be significant in the nutrient dynamics of the reservoir. The higher chlorophyll *a* concentration in the experimental fish tanks […] was the result of a positive bottom-up effect on the phytoplankton community. […] Because tilapia feed selectively on large algae (mainly cyanobacteria and diatoms), several small-sized or mucilaginous colonial chlorophyceans proliferated at the end of the experiments. Thus, the trophic cascade revealed strong influences on algal composition as well as on biomass. Tilapia can contribute to the eutrophication of a waterbody by both top-down and bottom-up forces. In particular, by supplying considerable amount of nutrients it promotes the increase of fast growing algae."

From Gu et al. (2015):

"Nile tilapia (*Oreochromis niloticus*) is one of the most widespread invasive fish species, and this species has successfully established populations in the major rivers of Guangdong Province, China. Field surveys and manipulative experiments were conducted to assess the impacts of Nile tilapia on fisheries. We determined that the increase of Nile tilapia in these rivers not only affects the CPUE (catch-per-unit-per-effort) of the fish community and native fish species but also reduces the income of fishermen. In the manipulative experiments, we observed that the growth of native mud carp decreased in the presence of Nile tilapia. Our results suggest that the invasion of Nile tilapia negatively affected the fishery economy and native fish species, and suitable control measurements should be taken."

From Attayde et al. (2011):

"In this study, a 30-year time series of fisheries records from a tropical reservoir was divided into five equal periods of 6 years and compared. The introduction of Nile tilapia did not increase the total catch-per-unit-of-effort (CPUE), the number of fishers actively fishing or their per capita income. Conversely, a significant reduction in the CPUE of other commercially important species was observed after the introduction of Nile tilapia in the reservoir. Although other factors cannot be rule out as possible explanations of the observed changes in the reservoir fisheries, the results are consistent with the hypothesis that these changes may have been caused, at least partially, by the introduction of the Nile tilapia."

From Ellender and Weyl (2014):

"In South Africa, studies on the impact of *O. niloticus* introductions into the Limpopo River system indicate extensive hybridisation and introgression with native *O. mossambicus* (D'Amato et al. 2007; Moralee et al. 2000)."

"In the Limpopo River system, stomach content analysis revealed high levels of dietary overlap between invasive *O. niloticus* and native *O. mossambicus*, however, stable isotope analyses, which provides increased accuracy on long-term dietary carbon and nitrogen assimilation, indicated strong selective resource partitioning (Zengeya et al. 2011). It was therefore unclear whether *O. niloticus* would be a strong competitor in the Limpopo River system (Zengeya et al. 2011)."

From Martin et al. (2010):

"[…] we present results of laboratory experiments designed to assess the impacts of unintended aquaculture releases of the Nile tilapia (*Oreochromis niloticus*), in estuaries of the Gulf of Mexico, on the functionally similar redspotted sunfish (*Lepomis miniatus*). Laboratory choice tests showed that tilapia prefer the same structured habitat that native sunfish prefer. In subsequent interspecific competition experiments, agonistic tilapia displaced sunfish from their preferred structured habitats. When a piscivore (largemouth bass) was present in the tank with both species, the survival of sunfish decreased. Based on these findings, if left unchecked, we predict that the proliferation of tilapia (and perhaps other aggressive aquaculture fishes) will have important detrimental effects on the structure of native food webs in shallow, structured coastal habitats."

4 Global Distribution

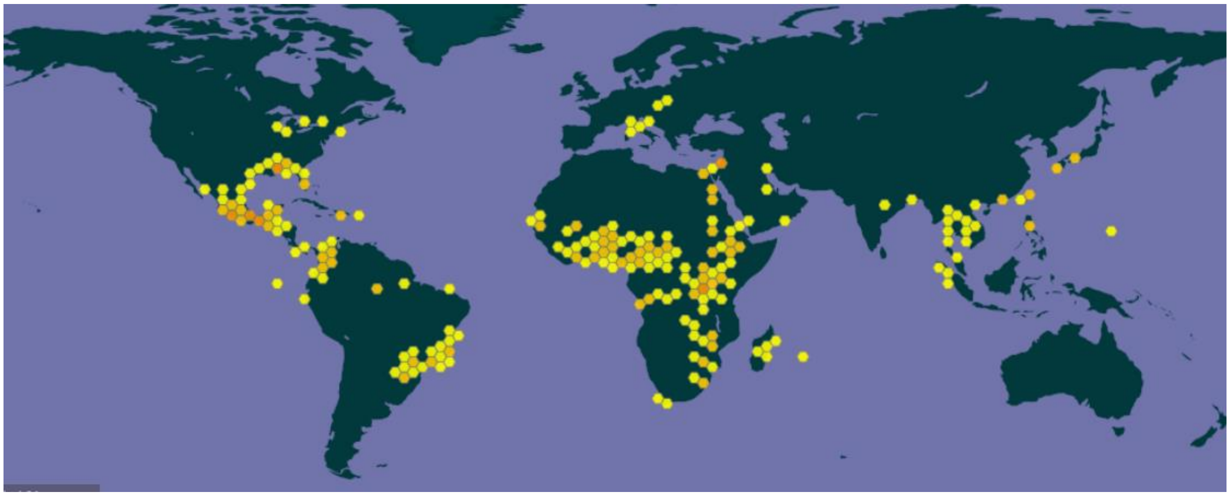

Figure 1. Reported global distribution of *Oreochromis niloticus*. Map from GBIF Secretariat (2017). Reported occurrences in the following countries were omitted from the climate matching analysis because they are not confirmed to represent established populations of *O. niloticus*: Canada, Poland, Iraq, Mozambique, Zambia, Central African Republic, Saudi Arabia, Oman, and India (Froese and Pauly 2017, CABI 2018). Within South Africa, reported occurrences in the Western Cape were not included in the climate matching analysis because they do not represent confirmed established populations (Ellender and Weyl 2014). Established populations in Italy occur in thermal streams (Bianco and Turin 2010) that do not reflect the local climate overall, so they were excluded from the climate matching analysis. Reported occurrences in the U.S. that do not represent established populations (Figure 2) were also excluded.

5 Distribution Within the United States

Figure 2. U.S. distribution of *Oreochromis niloticus*. Yellow dots indicate established populations while orange dots represent collection locations where establishment was not confirmed. Map from Nico et al. (2018). Only established locations were used to inform source locations in the climate matching analysis. Furthermore, the Illinois population was located at a power generation plant that may have produced warmer water temperatures than expected for the local climate, so this location was not included 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) is high in the Southeast, southern Texas, and localized areas of southern and central California. Medium match is found in the southern Midwest region, the Mid-Atlantic region, Texas, California, and the Desert Southwest. Low match occurs in the Northeast, Great Lakes, Plains states, Interior West, and Pacific Northwest. Climate6 score indicated that the contiguous U.S. has a high climate match overall. Scores classified as high climate match are those 0.103 or greater; Climate6 score of *Oreochromis niloticus* was 0.237. According to the climate matching analysis, suitable climates extend farther north in the United States than the observed distribution of established populations. This difference may reflect the establishment of *O. niloticus* in other temperate locations globally, such as in Japan and South Africa.

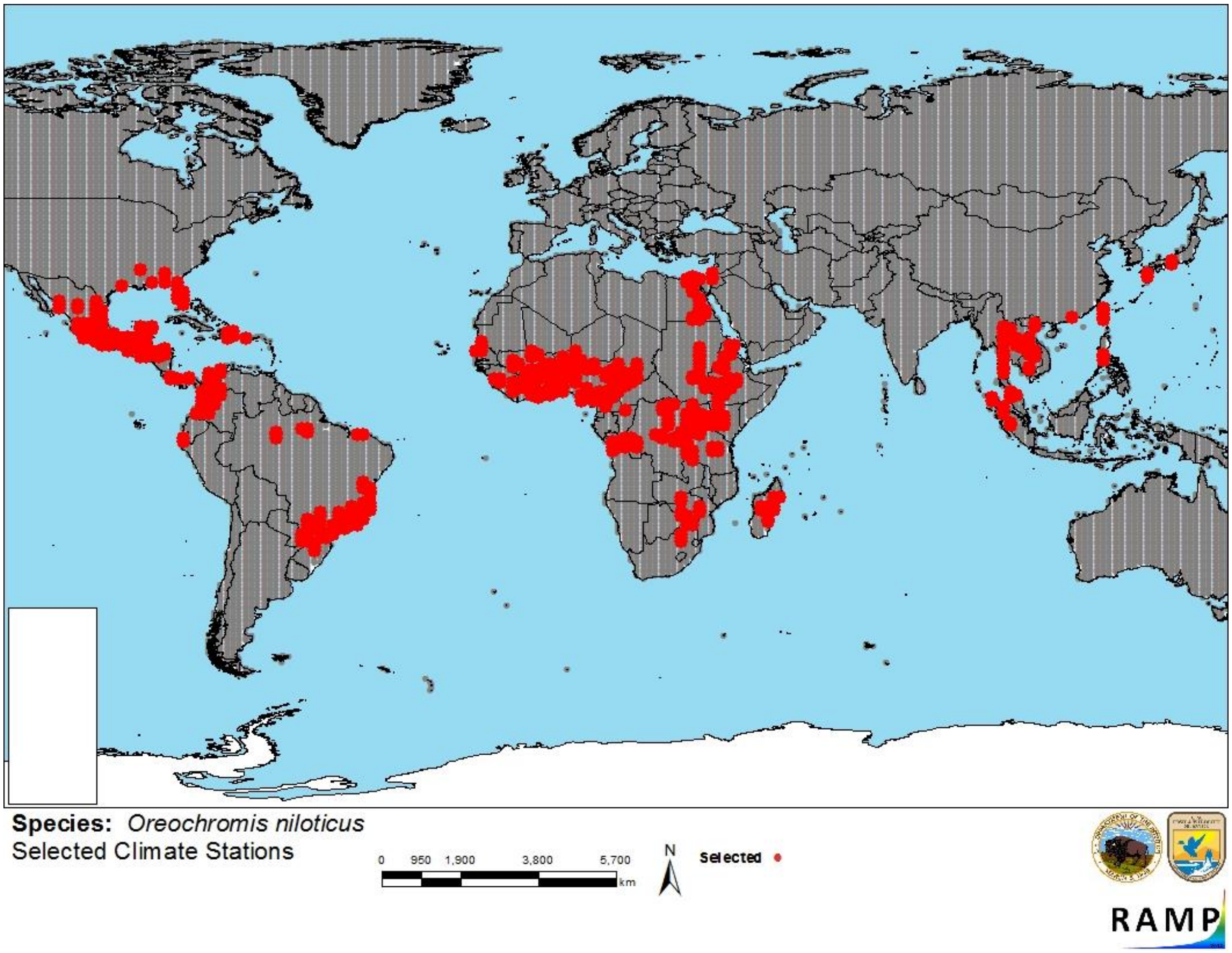

Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Oreochromis niloticus* climate matching. Source locations from GBIF Secretariat (2017) and Nico et al. (2018).

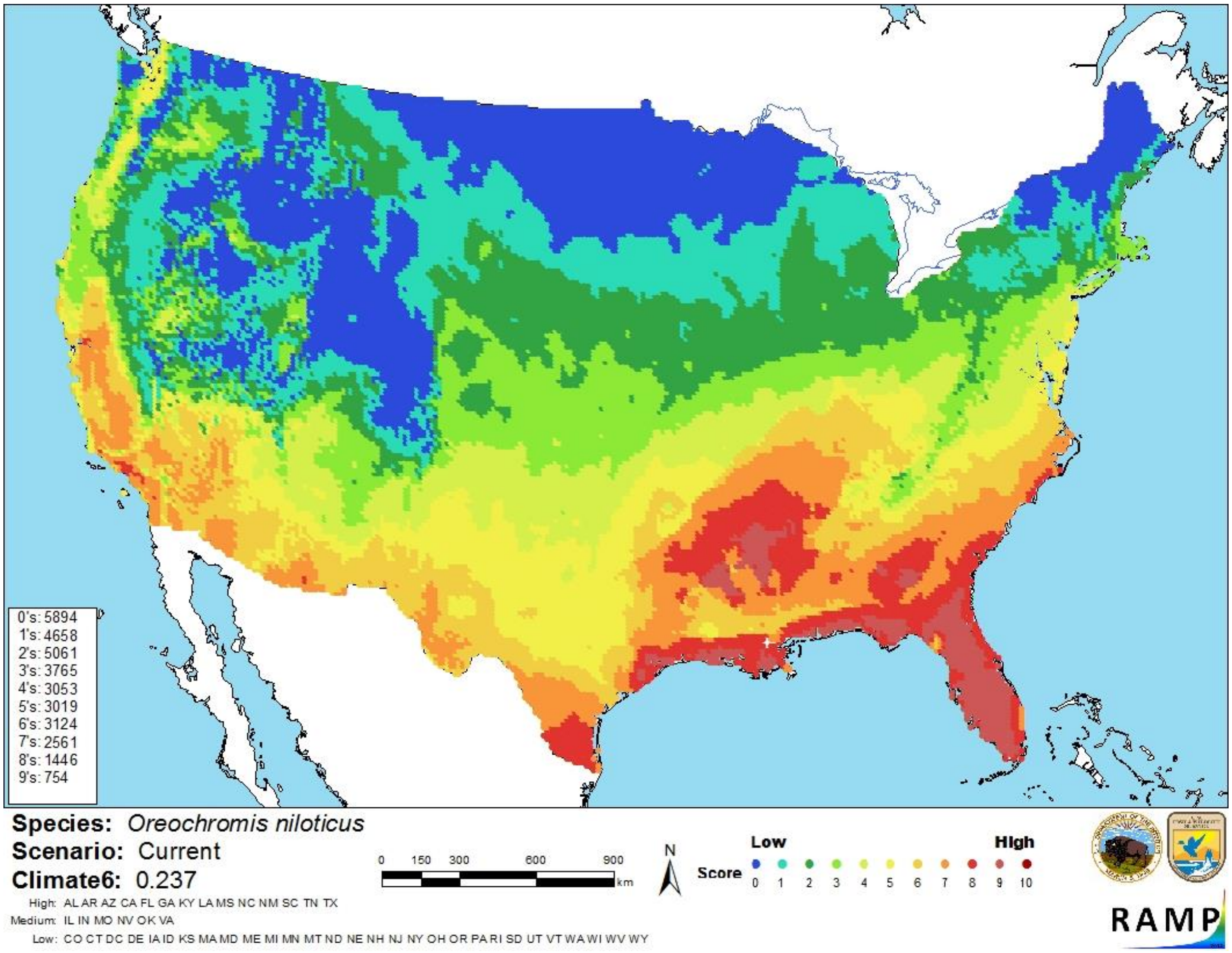

Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *Oreochromis niloticus* in the contiguous United States based on source locations reported by GBIF Secretariat (2017) and Nico et al. (2018). 0=Lowest match, 10=Highest match.

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
$0.000\leq X\leq 0.005$	Low
$0.005<X<0.103$	Medium
≥ 0.103	High

7 Certainty of Assessment

Information on the biology, distribution, and impacts of *O. niloticus* 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 this assessment is high.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Oreochromis niloticus has been transported around the world because of its high value for fisheries and aquaculture. Climate match to the contiguous U.S. is high. The species has already established wild populations in Florida, Alabama, and Mississippi, with the climate match suggesting highest risk of further establishment in the Southeast and California. Impacts of *O. niloticus* in its introduced range include eutrophication of waterbodies through its influences on the plankton community, competition with native fishes, hybridization with native fishes, and in some cases, reduced fishing success. 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: May serve as a carrier of the OIE-reportable disease Spring Viraemia of Carp.**
- **Overall Risk Assessment Category: High**

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