

Exotic Fishes in Florida

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Introduction

Florida is well-known as an exotic vacation destination for people from all over the world. Many



enjoy the warm winters and decide to make Florida their permanent home. Florida is also attractive to other organisms besides people. One only needs to look outside

for a few moments to see some of the many established exotic plants, both aquatic and terrestrial. In southern Florida especially, exotic plants, amphibians, birds, and reptiles are often very common and visible. Less visible to the general public, but nevertheless common, are exotic fishes. In fact, Florida is home to more exotic fish species than any other state.

In this article, I am using the term “exotic” in its strict sense, referring to foreign fishes exclusively. Fishes from outside of Florida, but native to the U.S. are “transplants”. Florida has relatively few transplants, unlike California, for example, which has numerous eastern USA species introduced into its waters. Although some would argue that the distinction is artificial, the foreign origin of Florida’s nonindigenous fishes interacts with climate, geography, and history to produce a unique and interesting distributional and ecological mix of fishes.

Faunal origins, limiting factors, and distribution have been the main focus of research about Florida’s exotic fishes since the modern introductions began in the 1950s. The effects of exotic fishes in Florida are less well-understood.

Although efforts have been made all along to document effects on native fishes, attempts at quantitative analyses of fish population and community effects are recent and few. Indeed, there is a growing debate concerning the extent to which exotic fishes are changing Florida’s aquatic systems and what those changes mean ecologically and economically. Basic economic effects on commercial and recreational fisheries have been investigated for many species and systems. Therefore, the economic effects are better understood than are the ecological effects.

Exotic Fish Species in Florida

There are 104 exotic fish species that have been found in Florida fresh waters (Table 1). For over half (58) of these species, there was no evidence of reproduction and they are considered only as reported in Florida. Indeed, most of these species are represented by one or a few scattered individuals (e.g., pacu). Others are considered as formerly reproducing, reproducing but not yet established, or established. To be categorized as established, a population of an exotic fish must be reproducing, have survived one or more critical periods (e.g., cold winters), and be widespread or expanding such that a local natural event or human intervention is unlikely to result in eradication. Some refer to small but persistent

populations as locally established. There is some disagreement over exact placement among categories for certain species and category definitions are not completely standardized. This may lead to confusion among citizens, managers, politicians, and researchers. Also, introductions of exotic fishes are still occurring and the status of known introductions may change with time. Therefore, species lists such as Table 1 are dynamic. Given this, I estimate that 25 exotic fish species are presently established in the state.

A few of Florida’s exotic fishes are widely known. Grass carp, walking catfish, blue tilapia, oscar, and peacock cichlid (i.e., peacock bass) are a few commonly encountered species. The infamous piranhas have been collected several times as lone individuals and once as a reproducing population in a small sinkhole pond at a south Florida tourist attraction. Many, however, are relatively unfamiliar species. Of the established species, cichlids (Cichlidae) make up the vast majority. Catfishes of various families are next in number

Triploid grass carp (Ctenopharyngodon idella) are stocked to control aquatic macrophytes in Florida.





Blue tilapia (*Oreochromis aureus*) is one of the most abundant and widespread exotic fishes in Florida.



Peacock cichlids (i.e., peacock bass) (*Cichla ocellaris*) are common in canals and borrow lakes in extreme southeast Florida.

(e.g., suckermouth catfish or plecos Loricariidae). Interestingly, although several minnows (Cyprinidae) and tetras (Characidae) have been reported in open waters in Florida, only the common carp has become established. Even this species is uncommon to rare, and reproducing populations are generally found only in rivers of the Florida Panhandle.

Several characteristics have been shared by exotic fishes that have successfully invaded Florida waters. Most have some form of parental care for the offspring, either mouthbrooding or otherwise defending eggs and larvae (e.g., cichlids) or live birth (e.g., pike killifish). Some are very adaptable to different environmental conditions (e.g., low dissolved oxygen, desiccation). Another characteristic shared by nearly all established species is a tropical origin. Only a few established species of Asian origin are not naturally confined to the tropics. The Asian swamp eel, for example, occurs over a wide climatic range in Asia. The only temperate species established is the common carp.

Table 1. Exotic Fish Species Documented from Fresh Waters of Florida

A question mark (“?”) preceding the name indicates uncertainty about the identification. A question mark (“?”) following the status indicates (1) uncertainty in assigning a status category or (2) a questionable record. “Reported” means collected or observed without evidence of reproduction. “Formerly reproducing” refers to localized populations that have been extirpated by human intervention or natural events. “Reproducing” populations may be established, but are generally recent or little-studied introductions. These are often found in small areas where extirpation may be possible. “Established” species are reproducing, persistent over time, occur over a wide range, and extirpation is unlikely. Table adapted from list provided by P. L. Fuller, Florida Caribbean Science Center, USGS, Gainesville, Florida (see: <<http://nas.er.usgs.gov/fishes/>>).

Family	Scientific name	Common name	Status	
Anabantidae	<u>Anabas testudineus</u>	Climbing perch	formerly reproducing	
	<u>Ctenopoma nigropanosum</u>	Twospot climbing perch	formerly reproducing	
Anostomidae	<u>Leporinus fasciatus</u>	Banded leporinus	reported	
Belontiidae	<u>Betta splendens</u>	Siamese fighting fish	formerly reproducing	
	? <u>Colisa fasciata</u>	Giant gourami	reported	
	<u>Colisa labiosa</u>	Thicklipped gourami	reported	
	<u>Colisa lalia</u>	Dwarf gourami	reported	
	<u>Macropodus opercularis</u>	Paradisefish	reported	
	<u>Trichogaster leerii</u>	Pearl gourami	reported	
	<u>Trichogaster trichopterus</u>	Threespot gourami	reported	
	<u>Trichopsis vittata</u>	Croaking gourami	reproducing	
	Callichthyidae	<u>Callichthys callichthys</u>	Mailed catfish	reported
		<u>Corydoras</u> sp.	Corydoras catfish	reported
<u>Hoplosternum littorale</u>		Brown hoplo	established	
<u>Channa argus</u>		Snakehead	reported	
Channidae	<u>Channa maurulius</u>	Mottled snakehead	reproducing	
Characidae	<u>Aphyocharax anisitsi</u>	Bloodfin tetra	reported	
	<u>Colossoma macropomum</u>	Black pacu	reported	
	<u>Gymnocorymbus ternetzi</u>	Black tetra	reported	
	<u>Hyphessobrycon serpae</u>	Serpae tetra	reported	
	<u>Metynnis</u> sp.	Spotted metynnis	reported	
	<u>Moenkhausia sanctaefilomenae</u>	Redeye tetra	reported	
	<u>Piaractus brachypomus</u>	Red pacu	reported	
	? <u>Piaractus mesopotamicus</u>	Small-scaled pacu	reported	
	<u>Pygocentrus nattereri</u>	Redbelly piranha	reported	
	<u>Serrasalmus rhombeus</u>	Redeye piranha	formerly reproducing ^a	
		Unidentified pacu		
		(<u>Colossoma</u> , <u>Piaractus</u>)	pacu	reported
		Unidentified piranha		
		(<u>Pygocentrus</u> , <u>Serrasalmus</u>)	piranha	reported
	Cichlidae	<u>Aequidens pulcher</u>	Blue acara	reported
		<u>Astronotus ocellatus</u>	Oscar	established
		<u>Cichla ocellaris</u>	Peacock cichlid	established
<u>Cichla temensis</u>		Speckled peacock cichlid	reported	
<u>Cichlasoma bimaculatum</u>		Black acara	established	
<u>Cichlasoma citrinellum</u>		Midas cichlid	established	
<u>Cichlasoma cyanoguttatum</u> ^b		Rio Grande cichlid	established	
<u>Cichlasoma managuense</u>		Jaguar guapote	established	
<u>Cichlasoma meeki</u>		Firemouth cichlid	established	
<u>Cichlasoma nigrofasciatum</u>		Convict cichlid	formerly reproducing	
<u>Cichlasoma octofasciatum</u>		Jack Dempsey	reproducing	
<u>Cichlasoma salvini</u>		Yellowbelly cichlid	reproducing	
<u>Cichlasoma trimaculatum</u>		Threespot cichlid	formerly reproducing	
<u>Cichlasoma urophthalmus</u>		Mayan cichlid	established	
<u>Geophagus brasiliensis</u>		Pearl eartheater	reported	
<u>Geophagus surinamensis</u>		Redstriped eartheater	established	
<u>Haplochromis (Astatotilapia) callipterus</u>		Eastern happy	reproducing	
<u>Hemichromis letourneauxi</u>		African jewel cichlid	established	
<u>Heros severus</u>		Banded severum	established	
<u>Labeotropheus</u> sp.		Scrapemouth cichlid	reported	
<u>Oreochromis aureus</u>	Blue tilapia	established		
<u>Oreochromis mossambicus</u>	Mozambique tilapia	established		
<u>Oreochromis niloticus</u>	Nile tilapia	reproducing		
<u>Pterophyllum scalare</u>	Angelfish	reported?		
<u>Pterophyllum</u> sp.	Freshwater angelfish	reported		

Table 1. Exotic Fish Species Documented from Fresh Waters of Florida (cont'd)

<i>Family</i>	<i>Scientific name</i>	<i>Common name</i>	<i>Status</i>
	<u>Sarotherodon melanotheron</u>	Blackchin tilapia	established
	<u>Telmatochromis bifrenatus</u>	Tanganyikan dwarf cichlid	reported
	<u>Tilapia mariae</u>	Spotted tilapia	established
	<u>Tilapia sparrmani</u>	Banded tilapia	reported
	<u>Tilapia zillii</u>	Redbelly tilapia	formerly reproducing
	Unidentified tilapia (<u>Oreochromis</u> , <u>Sarotherodon</u> , <u>Tilapia</u>)		reported
Clariidae	<u>Clarias batrachus</u>	Walking catfish	established
Cobitidae	<u>Misgurnus anguillicaudatus</u>	Oriental weatherfish	reproducing
	<u>Pangio kuhlii</u>	Coolie loach	reported
Cyprinidae	<u>Brachydanio rerio</u>	Zebra danio	reported
	<u>Carassius auratus</u>	Goldfish	reported?
	<u>Ctenopharyngodon idella</u>	Grass carp	reported ^c
	<u>Cyprinus carpio</u>	Common carp (koi)	established
	<u>Danio malabaricus</u>	Malabar (giant) danio	reported
	<u>Hypophthalmichthys molitrix</u>	Silver carp	reported
	<u>Hypophthalmichthys nobilis</u>	Bighead carp	reported
	<u>Morulus chrysophekadion</u>	Black shark	reported
	<u>Puntius conchonius</u>	Rosy barb	reported
	<u>Puntius gelius</u>	Gold barb	reported
	<u>Puntius schwanefeldii</u>	Tinfoil barb	reported
	<u>Puntius tetrazona</u>	Tiger barb	reported
	<u>Tinca tinca</u>	Tench	reported?
Doradidae	<u>Oxydoras niger</u>	Ripsaw catfish	reported
	<u>Platydoras costatus</u>	Raphael catfish	reported
	<u>Pterodoras</u> sp.	Thorny catfish	reported
Erythrinidae	<u>Hoplias malabaricus</u>	Trahira	formerly reproducing
Helostomatidae	<u>Helostoma temminckii</u>	Kissing gourami	reported
Loricariidae	<u>Hypostomus</u> sp.	Suckermouth catfish	established
	<u>Pterygoplichthys disjunctivus</u>	Vermiculated sailfin catfish	established
	<u>Pterygoplichthys multiradiatus</u>	Orinoco sailfin catfish	established
	<u>Pterygoplichthys</u> sp.	Sailfin catfish	established
Notopteridae	<u>Chitala ornata</u>	Clown knife fish	reproducing
Osteoglossidae	<u>Osteoglossum bicirrhosum</u>	Silver arrowana	reported
Pangasiidae	<u>Pangasius sutchi</u>	Siamese shark	reported
Pimelodidae	<u>Phractocephalus hemiliopterus</u>	Redtail catfish	reported
	<u>Rhamdia quelen</u>	Bagre	reported
Poeciliidae	<u>Belonesox belizanus</u>	Pike killifish	established
	<u>Poecilia latipinna</u> x <u>P. velifera</u>	Black molly	established
	<u>Poecilia latipunctata</u>	Broadspotted molly	reported
	<u>Poecilia petenensis</u>	Swordtail molly	reported
	<u>Poecilia reticulata</u>	Guppy	formerly reproducing
	<u>Poecilia shenops</u>	Mexican molly	reproducing?
	<u>Xiphophorus hellerii</u>	Green swordtail	reproducing
	<u>Xiphophorus hellerii</u> x <u>X. maculatus</u>	Red swordtail	reported
	<u>Xiphophorus hellerii</u> x <u>X. variatus</u>	Swordtail variatus	reported
	<u>Xiphophorus maculatus</u>	Platyfish	reproducing
	<u>Xiphophorus maculatus</u> x <u>X. variatus</u>	Hybrid platyfish	reported
	<u>Xiphophorus variatus</u>	Variable platyfish	reproducing
Polypteridae	<u>Polypterus dehlhezi</u>	Bichir	reported
Salmonidae	<u>Salmo trutta</u>	Brown trout	reported
Synbranchidae	<u>Monopterus albus</u>	Asian swamp eel	established

^a - The Redeye piranha was formerly established in a pond in a tourist attraction, plus other specimens reported.

^b - The Rio Grande cichlid is technically not an exotic species, but a transplant, because it is native to Texas.

^c - Triploid grass carp are stocked into open waters of the region and may live several years.

History and Distribution of Exotic Fishes in Florida

History, climate, and geography play major roles in determining the distribution of Florida's exotic fishes. Prior to the 1950s and 1960s, introduced fishes in Florida were few and were either transplants from more northern areas or were temperate species from the Old World (e.g., common carp, tench). This followed the typical pattern for the rest of the U.S. Around the middle of the 20th century, however, tropical species began to appear in Florida. Some of the earliest introductions were of suckermouth catfish, pike killifish, black acara, and blackchin mouthbrooder in the 1950s. Blue tilapia came early in the 1960s and walking catfish were introduced by the middle of the decade. The trend has continued to the present with several new species and new introductions of established species being discovered through 2001. One of the recent introductions (i.e., 1990s or later) includes the Asian swamp eel, a species that has drawn a great deal of attention from agencies, environmentalists, managers, and the national press.

The origin of most exotic fish introductions is unknown. A few are well-documented and several can be easily inferred. Circumstantial evidence links the growth of the aquarium industry with the increase in exotic fish introductions into Florida. Many species are found in the pet trade and some introductions are documented as releases or escapes from fish farms. On the other hand, it is generally not known if the introduction of these species is from the farm, the intermediate

Suckermouth catfish (Hypostomus sp.) and similar pleco catfish may be found throughout much of peninsular Florida in canals, lakes, and streams.



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wholesaler or retailer, or from the aquarium owner. Some ornamental species are also found in the live food fish trade. It is clear, however, that the point source for many introductions coincides with historic centers of tropical fish production and high human population density (i.e., Miami-Ft. Lauderdale and Tampa areas). Another interesting trend is the occurrence of several localized populations of exotic fishes over the years at tourist attractions and academic institutions.

Most exotic species are found in the southern one half of Florida. Most are also near the coast and relatively few species live in the central portions of the peninsula. This corresponds to the tropical nature of the fish and the subtropical climate of much of Florida. Only in extreme southern Florida does the climate become mostly tropical (e.g., it has snowed in Miami). Many species occur in the canals of south Florida or the coastal plain streams of southwest and west central Florida. Given this coastal distribution, however, relatively few exotic fishes are common in lakes. Grass carp, suckermouth catfish, walking catfish, and blue tilapia are the most common lake species. Lake Okeechobee has perhaps the largest number of lake-dwelling exotics, with some southern species such as Mayan cichlids and oscars entering the system. In Florida, exotic fishes also tend to be more abundant in disturbed habitats (e.g., canals) than in natural habitats (e.g., lake, marsh). For example, canals are artificial habitats that provide deep water that acts as a refuge for exotic fishes during cold periods or drought.

Effects of Exotic Fishes in Florida

Theoretically, exotic fishes may have numerous adverse effects for native fishes and aquatic systems. Habitat alterations (e.g., loss of aquatic macrophytes, water quality degradation), introduction of parasites



A lateral canal of Snapper Creek Canal, Miami-Dade County, Florida. This is a typical setting for exotic fishes in Florida.

or disease, competition, predation, hybridization, and social inhibition are some of the most common ecological effects attributed to introduced fishes. Although well-supported theoretically, there is little direct evidence for most of these effects in Florida. No native fish have become extinct in Florida due to the introduction of exotic fish. Florida's native fish fauna is made up of robust, widespread species that have themselves invaded Florida over a recent geological timescale.

A good deal of research has documented the changes that grass carp can cause to aquatic macrophytes, water characteristics, and fish assemblage structure. At high stocking rates, for example, grass carp can reduce macrophyte abundance to the point where small, vegetation-associated fish species become rare (e.g., blue-spotted sunfish *Enneacanthus gloriosus*).

There is relatively little evidence that predation by exotic fishes has significantly altered fish assemblage characteristics, except over short time periods (e.g., pike killifish predation on native killifish and livebearers). Blue tilapia may inhibit largemouth bass reproduction in a few systems, but this is not well-documented for Florida. Also, there is a negative correlation between blue tilapia and gizzard shad density in some central Florida lakes. Exotic fishes may reach high density in certain Florida systems, especially canals. In lakes, however, usually suckermouth catfish and blue tilapia are the only species to reach high density.

Exotic fishes may also serve beneficial purposes. In Florida, a few species are important recreational sport fish. The only exotic fish legally established in Florida is the peacock cichlid (i.e., peacock bass). It was stocked by the then-Florida Game and Fresh Water Fish Commission in 1984 as a sport fish and for biological control of other exotic fishes. It now supports a fishery with an economic value greater than \$8 million. Jaguar guapote, Mayan cichlids, and oscars are also regularly caught and

consumed by south Florida anglers. Blue tilapia supports a modest commercial fishery in central Florida lakes. Triploid grass carp are extensively used as an alternative to chemical or mechanical methods for aquatic macrophyte management. The ecological benefits of exotic fishes are less-investigated, although many serve as forage species for native fishes and introductions increase species richness, at least over the short term.

Legal and Regulatory Issues

Florida law prohibits the introduction of nonindigenous fishes into open waters of the state, except by permit from the Florida Fish and Wildlife Conservation Commission (FWC). Florida also maintains a list of regulated species, some being restricted, others being prohibited. Possession of regulated species requires a permit, and those on the prohibited list may only be maintained for scientific research or public display. Piranhas may not be maintained for any purpose. General policy of the FWC is to prevent exotic fish introductions, to eradicate those populations that are vulnerable, and to attempt to manage widespread established species to obtain benefits, if possible, and to reduce adverse environmental effects.

Florida has a large aquaculture industry that farms and imports exotic fishes for the ornamental aquarium trade. About 200 farms produce fish in



Some exotic fishes are important sport fish. The author holds a peacock cichlid (i.e., peacock bass) (Cichla ocellaris) caught in Cutler Drain Canal, Miami-Dade County, Florida. Thousands of angler-hours are directed at largemouth bass (Micropterus salmoides) and peacock cichlids each year in southeast Florida.

ponds, flow-through tanks, and in recirculating systems. Other firms import fishes from Africa, Asia, and South America. This industry is valued between \$75-100 million annually. The Florida Department of Agriculture and Consumer Services (FLDACS) is the lead agency in permitting and regulating the industry and has established Best Management Practices (BMPs) for tropical ornamental aquaculture. This agency and the FWC have various enforcement responsibilities relative to exotic fishes—FLDACS on the farm and FWC off the farm.

Future Considerations

The trend of increasing numbers of fish introductions into Florida that began in the 1950s will likely continue. The challenges for managers and researchers are several. It is important to monitor systems that are prone to introductions so that early intervention might be possible or, failing eradication, that baseline ecological data will be present to evaluate effects of the species introduction. Quantitative analysis of current and future data sets is needed to determine effects of exotic fishes on native species and system functioning. Careful investigations of proposed mechanisms of impact are also desirable to link these mechanisms with changes in native fish populations. It is clear from the current data that exotic fishes

have not caused catastrophic harm to Florida's aquatic systems. Yet, the potential dangers of exotic fishes and the management difficulties they represent are important challenges to Florida's fisheries managers in the 21st century.

Further Reading

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