

Orinoco Sailfin Catfish (*Pterygoplichthys multiradiatus*) Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, May 2013,
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Available: http://eol.org/data_objects/31643792. (May 10, 2013).

1 Native Range and Status in the United States

Native Range

From Froese and Pauly (2017):

“South America: Orinoco River basin. Reported from Argentina [Lopez et al. 1987].”

From Nico et al. (2011):

“Native Range: Tropical America. Orinoco River basin in northern South America.”

From GISD (2017):

“*Pterygoplichthys multiradiatus* is native to Venezuela (FishBase, 2010d).”

From NatureServe (2017):

“Native to Bolivia, Paraguay, Brazil, and Peru; [...]”

Status in the United States

From Froese and Pauly (2017):

“In Hawaii it was first observed in January 1987 in Wahiawa Reservoir and within two years has become one of the most abundant fishes in the reservoir; also found in Kaukunahua Stream and the various ditches and lower-elevation reservoirs which convey irrigation water to sugar cane fields in Waialua and Hale'iwa; [...] Known from O'ahu [Mundy 2005].”

Pterygoplichthys multiradiatus has been introduced in Puerto Rico (Froese and Pauly 2017).

From Nico et al. (2017):

“This catfish is known from various canals and water bodies in south Florida within Dade, Palm Beach, Martin, and Broward counties (Courtenay and Stauffer 1990; Page 1994; Nico, unpublished data). It is established in Florida Panther National Wildlife Refuge (USFWS 2005). The species was first reported from Hawaii in Wahiawa Reservoir, Oahu, in January 1986; it had become one of the most abundant fish in the reservoir by 1989; it also is established in Kaukonahua Stream, Oahu (Devick 1988, 1991). The fish is widely distributed in lower elevation reservoirs and streams on northern Oahu (Devick 1988, 1989; Mundy 2005; Hoover 2004).”

“Status: Established in Florida and Hawaii. Recent surveys in Florida indicate its range may be expanding (Nico, unpublished data).”

From GISD (2017):

“*Pterygoplichthys multiradiatus* was first recorded in Puerto Rico in 1990 and has become established atleast [sic] eight rivers and two reservoirs. Known locations include Dos Bocas Lake, Loiza Reservoir, Bayamon River, Rio Piedras, Rio Loco, Guanajibo River, Loiza River, Loiza Reservoir, and Rio Grande Loiza.”

“*Pterygoplichthys multiradiatus* and *P. disjunctivus* were found abundantly in Peace River, Florida in an electrofishing survey during 2005-2006 (Champeau et al, 2009). [...] *Pterygoplichthys* spp. are common throughout much of peninsular Florida and have invaded streams, canals, and lakes. [...] *P. multiradiatus* was first collected in Florida in 1971 and is established within various canals and water bodies in south Florida in Dade, Palm Beach, Martin, and Broward counties, as well as, in the Florida Panther National Wildlife Refuge (Nico, 2006). Over the past 20 years *Pterygoplichthys* spp. has invaded most inland drainages in the central and southern parts of the Florida peninsula. In certain rivers, canals, and lakes, they are widespread and abundant, accounting for a large proportion of the total fish biomass (Nico et al, 2009b). At the mouth of the Peace River and upper Charlotte Harbor, native fish abundance decreased dramatically after Hurricane Charley in 2004 and typical estuarine fish assemblages

were replaced by a few nonindigenous fish including *Pterygoplichthys* spp. (Stevens et al, 2006).”

“*Pterygoplichthys multiradiatus*, *P. disjunctivus*, and *P. anisitsi* have all been recorded in Texas. Established populations of one or more of these species exist in the Buffalo Bayou drainage, Harris County; in the headwaters of the San Marcos, Comal, and San Antonio rivers; and in irrigation canals in Hidalgo County (Hubbs et al, 2008). *Pterygoplichthys* spp. have also been reported from Bexar and Hays Counties (Lopez-Fernandez & Winemiller, 2005).”

Means of Introductions in the United States

From Nico et al. (2017):

“This armored catfish has been collected in southeastern Florida since about 1971 (Courtenay et al. 1984). Its presence is most likely the result of escapes or releases from aquarium fish farms (Courtenay and Stauffer 1990). In Hawaii, introductions are presumably the result of aquarium releases that occurred in the 1980s, possibly as early as 1982 (Devick 1991).”

From GISD (2017):

“It is believed introduced [to Puerto Rico] by aquarium hobbyist release (Bunkley-Williams et al, 1994).”

Remarks

From Nico et al. (2017):

“Many early reports of *Hypostomus* from south Florida, and some from the Tampa area, may have been based on misidentifications of *Pterygoplichthys* (Loftus and Kushlan 1987; Ludlow and Walsh 1991).”

From Bijukumar et al. (2015):

“The species delineation within the genus *Pterygoplichthys* remains in chaos primarily because the four closely related species such as *P. anisitsi*, *P. multiradiatus*, *P. pardalis* and *P. disjunctivus* are separated only based on the nature of their abdominal patterns (Nico et al. 2012).”

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2013):

“Kingdom Animalia
Phylum Chordata
Subphylum Vertebrata

Superclass Osteichthyes
Class Actinopterygii
Subclass Neopterygii
Infraclass Teleostei
Superorder Ostariophysi
Order Siluriformes
Family Loricariidae
Subfamily Hypostominae
Genus *Pterygoplichthys* Gill, 1858
Species *Pterygoplichthys multiradiatus* (Hanock, 1828)”

“Taxonomic Status:
Current Standing: valid”

From Eschmeyer et al. (2017):

“***multiradiatus***, *Hypostomus* Hancock [J.] 1828:246 [Zoological Journal, London v. 4; [...]
[Probably near Santa Catalina, Orinoco system], Demerara, Guyana. Holotype (unique): BMNH
1857.6.13.162 [ex Zool. Soc.] (stuffed). Type catalog: Ferraris 2007:291 [...]. •Valid as
Liposarcus multiradiatus (Hancock 1828) -- (Weber 1991:642 [...], Weber 1992:9, 27 [...],
Chang & Ortega 1995:7 [...], Burgess & Finley 1996:169 [...], Montoya-Burgos et al. 1998:367
[...], Fuller et al. 1999:225 [...], Isbrücker 2001:28, 29 [...], Isbrücker 2002:20 [...], Weber in
Reis et al. 2003:365 [...]). •Valid as *Pterygoplichthys multiradiatus* (Hancock 1828) --
(Isbrücker 1980:42 [...], Ortega & Vari 1986:18 [...], Burgess 1989:433 [...], López &
Miquelarena 1991:42 [...], Page & Burr 1991:211 [...], Nelson et al. 2004:84 [...], Menni
2004:81 [...] as *multiradiata*, Mundy 2005:156 [...], Page & Robins 2006:455 [...], Armbruster
& Page 2006:403 [...], Scharpf 2006:20 [...], Ferraris 2007:291 [...], Page & Burr 2011:371
[...], Page et al. 2013:82 [...]). **Current status:** Valid as *Pterygoplichthys multiradiatus*
(Hancock 1828). Loricariidae: Hypostominae.”

From Bijukumar et al. (2015):

“The species delineation within the genus *Pterygoplichthys* remains in chaos primarily because
the four closely related species such as *P. anisitsi*, *P. multiradiatus*, *P. pardalis* and *P.*
disjunctivus are separated only based on the nature of their abdominal patterns (Nico et al.
2012).”

Size, Weight, and Age Range

From Froese and Pauly (2017):

“Maturity: Lm ?, range 25 - 40 cm
Max length : 50.0 cm TL male/unsexed; [Baensch and Riehl 1991]”

From Nico et al. (2017):

“Size: 70 cm.”

Environment

From Froese and Pauly (2017):

“Freshwater; demersal; pH range: 6.5 - 7.8; dH range: 4 - 20. [...]; 23°C - 27°C [assumed to be recommended aquarium water temperature] [Riehl and Baensch 1991]; [...]”

From Nico et al. (2017):

“Sailfin suckermouth catfishes (*Pterygoplichthys* spp.) are capable of surviving mesohaline conditions (up to 10 ppt) for extended periods of time, allowing for the use of estuarine and coastal areas for dispersal (Capps et al. 2011).”

From GISD (2017):

“They can thrive in a range of acidic to alkaline waters in a range of about (pH 5.5.0 to 8.0) (Mendoza et al., 2009). They are often found in soft waters, but can adapt very quickly to hard waters.”

From Gestring et al. (2010):

“Orinoco Sailfin Catfish (n = 6, range = 318–382 mm TL) had a range of [water] temperatures associated with reduced feeding (19–24°C), but no feeding occurred below 15°C. The low water temperature at which death occurred was 9°C (range = 9–11°C).”

Climate/Range

From Froese and Pauly (2017):

“Tropical; [...]; 10°N - 1°N, 68°W - 61°W”

From GISD (2017):

“*Pterygoplichthys* spp. may be found in from lowlands to elevations of up to 3,000 m (Wakida-Kusun[o]ki, 2007).”

Distribution Outside the United States

Native

From Froese and Pauly (2017):

“South America: Orinoco River basin. Reported from Argentina [Lopez et al. 1987].”

From Nico et al. (2011):

“Native Range: Tropical America. Orinoco River basin in northern South America.”

From GISD (2017):

“*Pterygoplichthys multiradiatus* is native to Venezuela (FishBase, 2010d).”

From NatureServe (2017):

“Native to Bolivia, Paraguay, Brazil, and Peru; [...]”

Introduced

From Froese and Pauly (2017):

“Established in the Kaoping river in southern Taiwan [Page and Robins 2006].”

“Recorded from Akkulam Lake, Kerala, Canoli Canal, central Keralan and the Western Ghats [India] [Radhakrishnan et al. 2012].”

From GISD (2017):

“*Pterygoplichthys multiradiatus* is reported from Argentina where its biostatus is uncertain (FishBase, 2010c).”

“*Pterygoplichthys multiradiatus* is reported from Guyana where its biostatus remains uncertain (FishBase, 2010d).”

“Three specimens of *Pterygoplichthys multiradiatus* were captured in in June of 2007 in an irrigation channel beside the Railways of Kahalu Upazilla, Borga in northwestern Bangladesh. This represents the first record of *P. multiradiatus* in Bangladesh.”

“*Pterygoplichthys multiradiatus* has been reported from Java (Hossain et al, 2008).”

“*Pterygoplichthys multiradiatus* has been reported from Sumatra (Hossain et al, 2008); [...]”

“*Pterygoplichthys multiradiatus* has been reported from Malaysia (Hossain et al, 2008).”

“*P. multiradiatus* is established in Campeche, Chiapas, the Balsas, Amacuzac, and Mezcala Rivers, and other locations in central and western Mexico. [...] Expanding populations of *P. anisitsi*, *P. disjunctivus*, and *P. multiradiatus* have also been reported in the Grijalva-Usumacinta Basin (Mendoza et al, 2009).”

“*Pterygoplichthys multiradiatus* has been reported established in Singapore (Hossain et al, 2008).”

“*P. multiradiatus* was recorded in the Dong-Nai River basin in Southern Vietnam in 2004 (Levin et al, 2008).”

From Krishnakumar et al. (2009):

“*P. multiradiatus* has been recorded from three natural freshwater ponds at Vylathur in Thrissur District [Ajith 1998], and the Chackai Canal of Thiruvananthapuram District [Baiju 2009] in Kerala.”

From Roshni et al. (2014):

“Four exotic fish species have been so far recorded in the lake [Lake Vembanad, India]: *Pangasianodon hypophthalmus*, *Oreochromis mossambicus*, *Pterygoplichthys multiradiatus* and *Clarias gariepinus* (Kurup and Samuel, 1985; Krishnakumar et al., 2011).”

Pterygoplichthys multiradiatus is listed as established in Taiwan (Page and Robins 2006 in Froese and Pauly 2017) but molecular investigation showed this species was absent from the wild in Taiwan (Wu et al. 2011).

Pterygoplichthys multiradiatus is established in the freshwater reservoir of the Eastern Province, Sri Lanka (Jinadasa et al. 2014).

Pterygoplichthys multiradiatus is present in West Bengal, India (Mogalekar et al. 2017).

Means of Introduction Outside the United States

From GISD (2017):

“Accidental release of *Pterygoplichthys* spp. has been documented, such as when typhoon Rosing struck the Philippines resulting in escape of the fish from commercial farms (Hubilla et al., 2007). *Pterygoplichthys* spp. are very common aquarium fish throughout the world. Nearly all of their introduced populations are believed to be the result of pet release or aquaculture escape (Page & Robins, 2006). While no substantial trade in catfish is thought to occur, the live food trade cannot be discounted completely as a potential mechanism for spread to new locations (Mendoza et al., 2009).”

“Its introduction [in Bangladesh] is believed to be the result of either release by aquarium owners or escapes from fish farms (Hossain et al, 2008).”

From Froese and Pauly (2017):

“Species was imported commercially for aquarium cleaning during the 1970's and has become widely distributed in streams, lakes and reservoirs.”

Short Description

From Nico et al. (2017):

“*Pterygoplichthys* and other suckermouth armored catfishes (family Loricariidae) can be distinguished from native North American catfishes (Ictaluridae) by the presence of flexible bony plates (absent in ictalurids) and a ventral suctorial mouth (terminal in ictalurids).

Pterygoplichthys is often confused with *Hypostomus*: these genera can be distinguished by the number of dorsal fin rays (7-8 in *Hypostomus* vs. 9-14 in *Pterygoplichthys*.)”

From Wu et al. (2011):

“[...] *P. multiradiatus* has discrete dark spots on the lateral and caudal peduncle, never coalescing or forming chevrons; [...]”

From Bijukumar et al. (2015):

“The species delineation within the genus *Pterygoplichthys* remains in chaos primarily because the four closely related species such as *P. anisitsi*, *P. multiradiatus*, *P. pardalis* and *P. disjunctivus* are separated only based on the nature of their abdominal patterns (Nico et al. 2012).”

Biology

From Froese and Pauly (2017):

“Occurs in streams and lakes [Yamamoto and Tagawa 2000] and in weedy, mud-bottomed canals [Page and Burr 1991]. Benthic [Mundy 2005]. Nocturnal, feeds on algae [Riehl and Baensch 1996], but will also feed on worms, insect larvae, and other bottom-dwelling aquatic animals [Yamamoto and Tagawa 2000]. Spawning period peaks once a year [Liang et al. 2005]. Reproductive behavior includes digging of burrows for egg laying [Nico et al. 2009]. May exhibit male parental care [Liang et al. 2005].”

“Reproduction: Mode: dioecism; Fertilization: external; Spawning frequency: throughout the year, but peaking once; Reproductive guild: guarders, nesters; Description of life cycle and mating behavior: Parental care may be exhibited by males.”

“Feeding type: mainly plants/detritus (troph. 2-2.19); Feeding habit: browsing on substrate.”

From GISD (2017):

“Growth of *Pterygoplichthys* is rapid during the first two years of life, with total lengths of many sailfin catfishes exceeding 300 mm by age 2. Specimens in aquaria may live more than 10 years. The size range for most of the adult species in the Loricariid family is 30–50 cm, but individuals have been observed to reach 70 cm. *Pterygoplichthys* spp. start reproducing at approximately 25 cm (Mendoza et al, 2009).”

“*Pterygoplichthys* spp. can be found in a wide variety of habitats, ranging from relatively cool, fast-flowing and oxygen-rich highland streams to slow-flowing, warm lowland rivers and stagnant pools poor in oxygen. They are tropical fish and populations are typically limited only by their lower lethal temperature which has been found to be about 8.8-11°C in some species (Gestring, 2006). [...] *Pterygoplichthys* spp. are also highly tolerant to poor water quality and are commonly found in polluted waters (Chavez et al., 2006). They are known to use outflow from

sewage treatment plants as thermal refugia and can readily adapt to changing water quality (Nico & Martin, 2001).”

“*Pterygoplichthys* spp. reproduce sexually and have high fecundancy (Gibbs et al, 2008). Males construct horizontal burrows in banks that are about 120-150 cm long extend downward. The burrows are used as nesting tunnels and eggs are guarded by males until the free-swimming larvae leave. Females may lay between 500-3,000 eggs per female depending on size and species. Their reproductive season peaks in the summer and usually lasts several months but may be year-long in certain locations (Mendoza et al, 2009).”

“*Pterygoplichthys* spp. feed primarily on benthic algae and detritus (Ozedilek, 2007). They may also consume worms, insect larvae, fish eggs and other bottom-dwellers but the vast majority of its diet consists of detritus, algae, and various plant matter (Mendoza et al., 2009).”

From Gestring et al. (2010):

“Detritus, algae (*Cladophora* sp. and *Lyngbya* sp.), sand, and plant material were found in 94%, 76%, 65%, and 39% of stomachs, and collectively comprised 99% of the total stomach volume (n = 108.1 ml; Table 3). Crustaceans (cladocerans, amphipods, ostracods, copepods, and conchostracans) occurred in 63% of the stomachs containing food, comprised 88% by number of identifiable prey items (n = 2,315), and contributed 1% of the total stomach content volume. Aquatic insects (primarily chironomid species) occurred in 35% of the stomachs, but comprised only 9% by number of identifiable prey items and <1% by volume of the total stomach content. “Presumed” fish eggs (n = 11) were found in six stomachs (2%) and made up <1% of the total stomach volume. Other identified prey items included snails, clams, spiders and water mites.”

Human Uses

From Froese and Pauly (2017):

“Fisheries: of no interest; aquarium: commercial”

“Available in pet stores in the country [Taiwan] [Liang et al. 2006].”

From Krishnakumar et al. (2009):

“*P. multiradiatus*, an armoured catfish native to the South American drainages, is a popular aquarium pet worldwide and is known commonly as ‘algae eater’.”

From Jinadasa et al. (2014):

“*P. multiradiatus* is new experience to Sri Lankans that they are not aware of consuming scavenger fish. However these fish are consumed in Brazil, Colombia and other countries”

Diseases

No records of OIE reportable diseases were found.

From Froese and Pauly (2017):

“Guyanema Infection (*Guyanema* sp.), Parasitic infestations (protozoa, worms, etc.)”

Poelen et al. (2014) list *Unilatus brevispinus*, and *U. longispinus* as parasites of *Pterygoplichthys multiradiatus*.

Acosta et al. (2017) list *Unilatus brittani* and *U. unilatus* as parasites of *Pterygoplichthys multiradiatus*.

Threat to Humans

From Froese and Pauly (2017):

“Harmless”

3 Impacts of Introductions

From Gestring et al. (2010):

“The absence of negative correlations between biomass estimates of Orinoco Sailfin and principal native fishes individually and collectively suggests Orinoco Sailfin are supplementing rather than competing with or displacing the principal native fishes (Fig. 1–3 [in source material]). Moreover, several moderate or strong positive associations between Orinoco Sailfin and native sportfish support this conclusion (Figs. 1–3 [in source material]). Orinoco Sailfin Catfish are abundant in many southeast Florida canals where native fish biomass fluctuated considerably; however, during this 12-yr study variations in native fish estimates appeared unrelated to the presence of Orinoco Sailfin.

In all our data analyses there was only one significant negative electrofishing correlation in one canal between Orinoco Sailfin Catfish and a native fish. This was with harvestable-sized (≥ 254 mm TL) Largemouth Bass in the Boynton Canal ($r = -0.693$; $p = 0.026$). However, nighttime catch rates for harvestable Largemouth Bass remained higher (mean = 1.03 fish/min, SD = 0.25, range = 0.67–1.53) than most other canals (mean = 0.55 fish/min, SD = 0.43, range = 0.00–1.85) during this time period (FWC unpublished data). In the near absence of negative correlations between Orinoco Sailfin and native fishes, we conclude their presence has had little negative effect on native fish abundances.”

“Competition for food between Orinoco Sailfin and native fish in Florida also seems unlikely because no native fish feeds primarily on detritus and plants although detritus appears seasonally important in Florida Flagfish (*Jordanella floridae*; Cox et al., 1981) and Lake Chubsucker (*Erimyzon sucetta*; Richards, 2002).

Orinoco Sailfin Catfish were collected from the Boynton Canal during peak spawning months for native fishes to determine if they might be feeding on the eggs of native fish and

thereby negatively effect them. The low number of presumed fish eggs found in these stomachs (i.e., 11 eggs from 6 of 426 stomachs; Table 3) suggests Orinoco Sailfin do not; however, fish eggs could be digested so quickly that their occurrence in stomachs could be missed using our methods.”

“We have received complaints from commercial fishers in Florida that loricariid catfishes negatively effect them economically. The most common complaints are that the bony “scales” and stout pectoral spines physically damage their nets and the fish they are targeting for harvest and sale; however, no good estimates of the actual dollars lost exist at this time.”

From Nico et al. (2017):

“Largely unknown. In Hawaii, the thousands of nesting tunnels excavated by male *Pterygoplichthys* in reservoir and stream banks have contributed to siltation problems (Devick 1989). Because of their abundance in Hawaii, *Pterygoplichthys* and other armored catfishes have the potential to affect native stream species negatively through competition for food and space (Devick 1989). In Florida, this species occupies waters adjacent to Everglades National Park and is considered a threat to the park (Courtenay 1989).

Male members of the genus *Pterygoplichthys* dig out river banks to create burrows in which an attracted female will lay and guard her eggs. In large numbers, this burrowing behavior by *Pterygoplichthys* contributes to problems with siltation. In addition, the burrows potentially destabilize the banks, leading to an increased rate of erosion (Nico et al. 2009). Diurnal aggregations of *Pterygoplichthys* can potentially alter nutrient dynamics by creating biogeochemical hotspots through nitrogen and phosphorus excretion and remineralization (Capps and Flecker 2013).”

From GISD (2017):

“Potential effects of *Pterygoplichthys* spp. include alteration of bank structure and erosion, disruption of aquatic food chains, competition with native species, mortality of endangered shore birds, changes in aquatic plant communities, and damage to fishing gear and industry. Environmental impacts of *Pterygoplichthys* spp. are not fully understood, but in locations where they are introduced and abundant, their feeding behaviours and burrowing activities can cause considerable disturbance. Their burrows have been reported as contributing to siltation problems and bank erosion and instability (Hoover et al., 2004; Nico et al, 2009b). *Pterygoplichthys* spp. forage along the bottoms of streams and lakes, occasionally burying their heads in the substrate and lashing their tails. These behaviours can uproot or shear aquatic plants and reduce the abundance of beds of submersed aquatic vegetation, creating floating mats that shade the benthos from sunlight. By grazing on benthic algae and detritus, they may alter or reduce food availability and the physical cover available for aquatic insects eaten by other native and non-native fishes where they are introduced (Mendoza et al, 2009; Hossain et al, 2008). *Pterygoplichthys* spp. may also compete with native fish. They are believed to displace several species of minnow in Texas including the Federally threatened and 'Vulnerable (VU)' Devils River minnow (see *Dionda diaboli*) (Cohen, 2008; Mendoza et al, 2009). *Pterygoplichthys* spp.

have also been found to ingest eggs of *Etheostoma fonticola*, also listed as vulnerable (Cook-Hildreth, 2009).

Pterygoplichthys spp. are thought to create large, novel nutrient sinks in invaded streams of southern Mexico. They sequester the majority of nitrogen and phosphorus of systems in their body armor. These impacts on nutrient systems may also exacerbate the nutrient limitation of primary productivity in invaded streams (Capps et al, 2009).

Thousands of nesting tunnels excavated by *P. multiradiatus* have contributed to siltation problems in Hawai'i. Because of their abundance in Hawai'i, *P. multiradiatus* may compete with native stream species for food and space (Nico, 2006). The burrowing behaviour and overpopulation of *P. multiradiatus* may also displace native fish in Puerto Rico where they have been reported as detrimental to reservoir fishes (Bunkley-Williams et al, 1994). In Lake Okeechobee, Florida *P. multiradiatus* feeds and burrows at the bottom and destroys submerged vegetation, essentially displacing native fishes that would otherwise use the aquatic vegetation for spawning and refuge and interfering with their reproduction (Mendoza et al, 2009). *P.*

multiradiatus is known to cause economic losses to fisherman by damaging equipment such as cast and gill nets in India and displacing native fish (Krishnakumar et al, 2009).

P. multiradiatus and *P. pardalis* damage fishing gear and gill nets in various locations of Mexico (Wakida-Kusunoki et al, 2007).”

From Krishnakumar et al. (2009):

“*P. multiradiatus* has also established a substantial population in Chackai Canal, replacing other herbivorous fishes [Baiju 2009]. Apart from biological interactions, *P. multiradiatus* is also known to cause economic losses to fishermen through damage to fishing gears, especially cast and gill nets [Wakida-Kusunoki et al. 2007].”

From Froese and Pauly (2017):

“It has become a serious threat to freshwater fish diversity [Liang et al. 2005].”

“[...] one of the impacts of this fish on the reservoir [in Hawai'i] are the numerous spawning tunnels dug out into the banks, thus causing erosion and the build up of silt on the bottom of the reservoir [Yamamoto and Tagawa 2000].”

From Simonovic et al. (2010):

“The resistance of Amazon sailfin catfish *P. multiradiatus* to predators was observed at Puerto Rico, where the brown pelicans *Pelecanus occidentalis* have strangled trying to swallow them (Bunkley-Williams et al. 1994);”

From Wakida-Kusunoki et al. (2007):

“In contrast, the documented ecological effects of *P. multiradiatus* include disruption of aquatic food chain, decline in abundance of native species, mortality of shore birds, changes in aquatic plant communities, and bank erosion (Hoover et al. 2004). In Mexico, *P. multiradiatus* also has

been implicated in the reduction of the fisheries of carps and tilapias in Infiernillo Reservoir, Michoacan, and damage to fishing gear (La Jornada, 2005).”

4 Global Distribution



Figure 1. Known global distribution of *Pterygoplichthys multiradiatus*. Map from GBIF Secretariat (2017).



Figure 2. Known distribution in northern South America of *Pterygoplichthys multiradiatus*. Map from VertNet (2017).

The location in Thailand was not used as a source point. The observation record indicates it is the result of an aquarium specimen and not collected from the wild (GBIF Secretariat 2017). No other sources list any introductions in Thailand.

The location in Taiwan was not used as a source point for the climate match. *Pterygoplichthys multiradiatus* is listed as established in Taiwan (Page and Robins 2006 in Froese and Pauly

2017) but molecular investigation showed this species was absent from the wild in Taiwan (Wu et al. 2011).

5 Distribution Within the United States

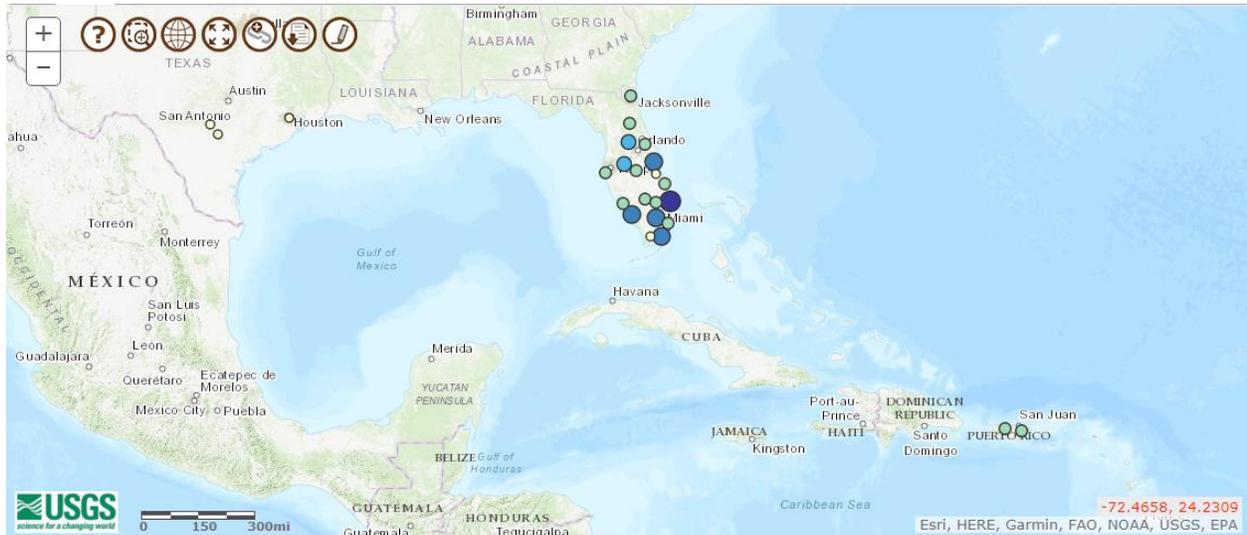


Figure 3. Known distribution of *Pterygoplichthys multiradiatus* in the continental United States and Puerto Rico. Map from Nico et al. (2017).

The populations in Texas are recorded as established (Nico et al. 2017) and were used as source points for the climate match.



Figure 4. Known distribution of *Pterygoplichthys multiradiatus* in Hawaii. Map from Nico et al. (2017).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match results for *Pterygoplichthys multiradiatus* were high in the south; particularly in Florida and Texas where there are established populations. Most of the Northeast, the Appalachian Mountain Range, Great Lakes, northern Midwest, Great Plains, and West Coast had a low match. Everywhere else had a medium match. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous U.S. was 0.148, high, and the following states had a high climate match: Alabama, Arizona, Arkansas, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Texas, and Virginia.

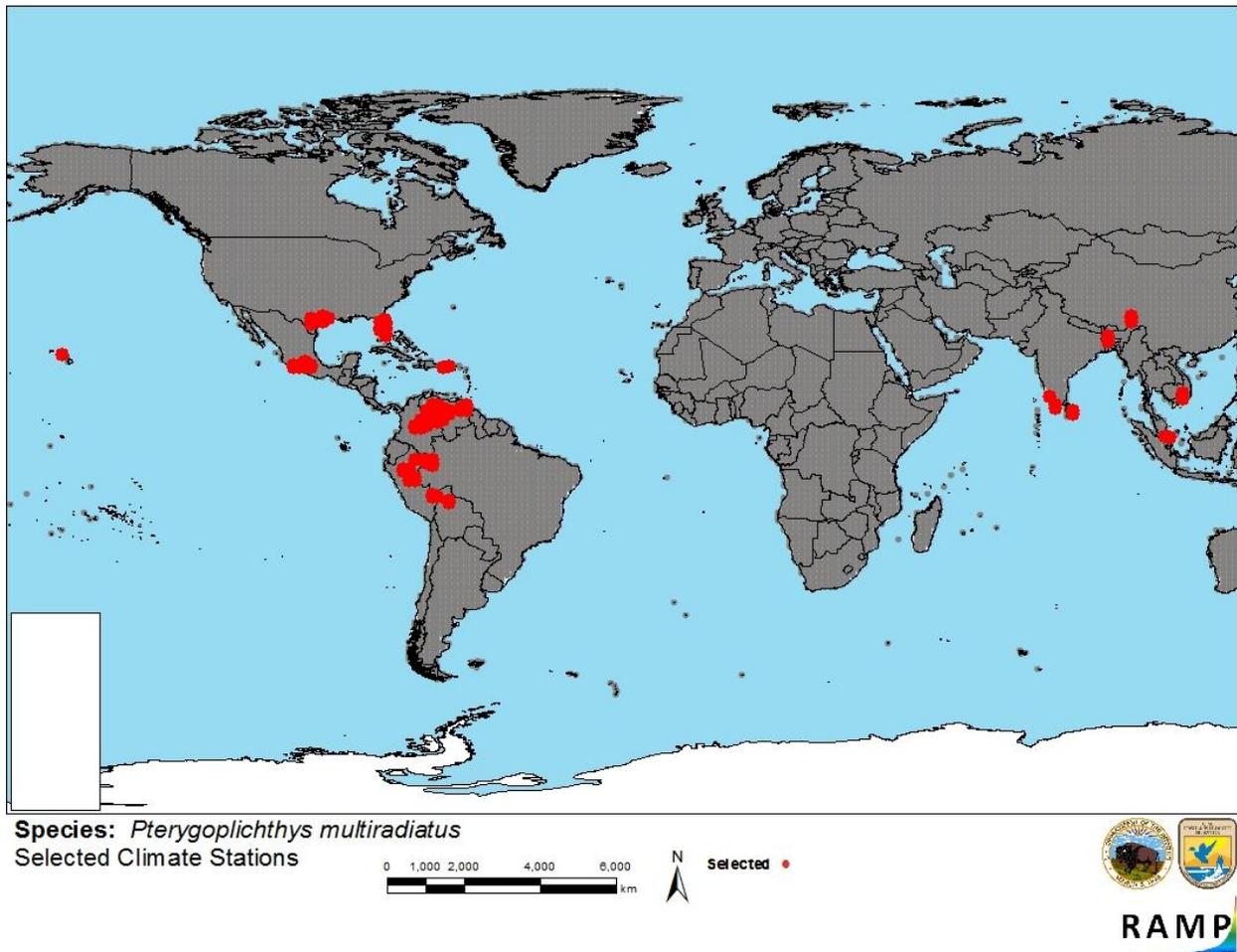


Figure 5. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Pterygoplichthys multiradiatus* climate matching. Source locations from Krishnakumar, et al. (2009), Jinadasa, et al. (2014), Roshni, et al. (2014), Froese and Pauly (2017), GBIF Secretariat (2017), GISD (2017), and VertNet (2017).

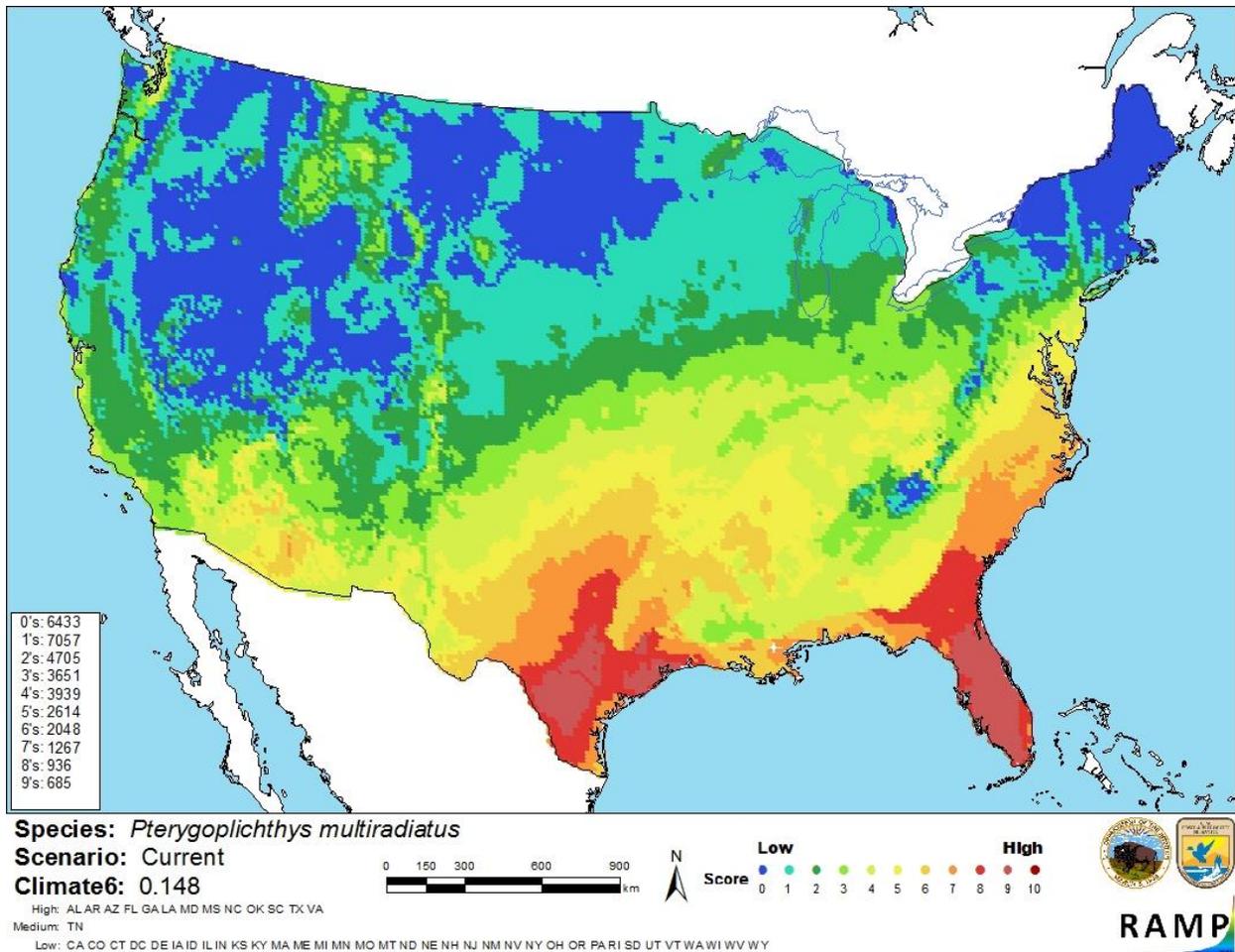


Figure 6. Map of RAMP (Sanders et al. 2014) climate matches for *Pterygoplichthys multiradiatus* in the contiguous United States based on source locations reported by Krishnakumar, et al. (2009), Jinadasa, et al. (2014), Roshni, et al. (2014), Froese and Pauly (2017), GBIF Secretariat (2017), GISD (2017), and VertNet (2017). 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

The certainty of assessment for *Pterygoplichthys multiradiatus* is high. There is a large amount of quality information available regarding the biology, ecology, introduction history, and impacts of introductions of *P. multiradiatus*.

8 Risk Assessment

Summary of Risk to the Contiguous United States

The history of invasiveness for *Pterygoplichthys multiradiatus* is high. There is a history of introductions resulting in established populations and those populations have had negative ecological and economic impacts. One study (Gestring et al. 2010) does indicate that the negative impacts to native fish may not be as great in magnitude as originally predicted in Florida, but there are documented impacts in other locations that support the classification of a high history of invasiveness. The climate match is high; the Climate 6 score is 0.148. The areas of highest match are concentrated around known established populations but there were additional areas of high match without known populations. The certainty of assessment is high. The overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information:** There are established populations in Florida, Hawaii, and Texas. Significant risk exists for further introductions of this species through aquarium dumps. The generalist nature of this species will allow it to pose significant threats to already threatened native species through direct competition and environmental degradation.
- **Overall Risk Assessment Category: High**

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.

Acosta, A. A., L. Franceschini, A. C. Zago, T. Scholz, and R. J. da Silva. 2017. Six new species of *Heteropriapulus* (Monogenea: Dactylogyridae) from South American fishes with an amended diagnosis to the genus. *Zootaxa* 4290(3):459–482.

Bijukumar, A., R. Smrithy, U. Sureshkumar, and S. George. 2015. Invasion of South American suckermouth armoured catfishes *Pterygoplichthys* spp. (Loricariidae) in Kerala, India – a case study. *Journal of Threatened Taxa* 7(3):6987–6995.

Eschmeyer, W. N., R. Fricke, and R. van der Laan, editors. 2017. Catalog of fishes: genera, species, references. Available: <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp>. (November 2017).

- Froese, R. and D. Pauly, editors. 2017. *Pterygoplichthys multiradiatus* (Hancock, 1828). FishBase. Available: <http://www.fishbase.se/summary/Pterygoplichthys-multiradiatus.html>. (November 2017).
- GBIF Secretariat. 2017. GBIF backbone taxonomy: *Pterygoplichthys multiradiatus* (Hancock, 1828). Global Biodiversity Information Facility, Copenhagen. Available: <https://www.gbif.org/species/2339962>. (November 2017).
- Gestring, K. B., P. L. Shafland, and M. S. Stanford. 2010. Status of the exotic Orinoco sailfin catfish (*Pterygoplichthys multiradiatus*) in Florida. *Florida Scientist* 73(2):122–137.
- GISD (Global Invasive Species Database). 2017. Species profile: *Pterygoplichthys multiradiatus*. Invasive Species Specialist Group, Gland, Switzerland. Available: <http://www.iucngisd.org/gisd/speciesname/Pterygoplichthys+multiradiatus>. (November 2017).
- ITIS (Integrated Taxonomic Information System). 2013. *Pterygoplichthys multiradiatus* (Hancock, 1828). Integrated Taxonomic Information System, Reston, Virginia. Available: http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=164375. (May 2013).
- Jinadasa, B. K. K. K., D. S. Ariyaratne, and S. B. N. Ahmad. 2014. Trace metal contaminants in tissues of the Orinoco Sailfin Catfish *Pterygoplichthys multiradiatus* (Hancock, 1828); Sri Lanka. *Nature and Science* 12(6):1–4.
- Krishnakumar, K., R. Raghavan, G. Prasad, A. Bijukumar, M. Sekharan, B. Pereira, and A. Ali. 2009. When pets become pests – exotic aquarium fishes and biological invasions in Kerala, India. *Current Science* 97(4):474–476.
- Mogalekar, H. S., J. Canciyal, C. P. Ansar, D. Bhakta, I. Biswas, and D. Kumar. 2017. Freshwater fish diversity of West Bengal, India. *Journal of Entomology and Zoology Studies* 5(2):37–45.
- NatureServe. 2017. NatureServe Explorer: an online encyclopedia of life, version 7.1. NatureServe, Arlington, Virginia. Available: <http://explorer.natureserve.org>. (November 2017).
- Nico, L., M. Cannister, and M. Neilson. 2017. *Pterygoplichthys multiradiatus* (Hancock, 1828). U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: <https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=768>. (November 2017).
- Poelen, J. H., J. D. Simons, and C. J. Mungall. 2014. Global Biotic Interactions: an open infrastructure to share and analyze species-interaction datasets. *Ecological Informatics* 24:148–159.

- Roshni, K., C. R. Renjithkumar, and B. M. Kurup. 2011. Record of a newly introduced fish, red-bellied pacu *Piaractus brachypomus* (Cuvier, 1818) (Characiformes, Serrasalminidae), in a tropical wetland system, India. *Journal of Applied Ichthyology* 30:1037–1038.
- Sanders, S., C. Castiglione, and M. Hoff. 2014. Risk Assessment Mapping Program: RAMP. U.S. Fish and Wildlife Service.
- Simonovic, P., V. Nikolic, and S. Grujic. 2010. Amazon sailfin catfish *Pterygoplichthys pardalis* (Castellnau, 1855) (Loricariidae, Siluriformes), a new fish species recorded in the Serbian section of the Danube River. *Biotechnology and Biotechnological Equipment* 24:655–660.
- VertNet. 2017. VertNet. Available: <http://www.vertnet.org/index.html>. (November 2017).
- Wakida-Kusunoki, A. T., R. Ruiz-Carus, and E. Amador-del-Angel. 2007. Amazon sailfin catfish, *Pterygoplichthys pardalis* (Castelnau, 1855) (Loricariidae), another exotic species established in southeastern Mexico. *The Southwestern Naturalist* 52(1):141–144.
- Wu, L.-W., C.-C. Liu, and S.-M. Lin. 2011. Identification of exotic sailfin catfish species (*Pterygoplichthys*, Loricariidae) in Taiwan based on morphology and mtDNA sequences. *Zoological Studies* 50(2):235–246.

10 References Quoted But Not Accessed

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

- Ajithkumar, C. R., C. R. Biju, and R. Thomas. 1998. *Plecostomus multiradiatus* - an armoured catfish from freshwater ponds near Kunnankulam, Kerala and its possible impact on indigenous fishes. LAK News, Limnological Association of Kerala.
- Armbruster, J. W., and L. M. Page. 2006. Redescription of *Pterygoplichthys punctatus* and description of a new species of *Pterygoplichthys* (Siluriformes: Loricariidae). *Neotropical Ichthyology* 4(4):401–409.
- Baensch, H. A., and R. Riehl. 1991. *Aquarien atlas*. Bd. 3. Melle: Mergus, Verlag für Natur-und Heimtierkunde, Germany.
- Baiju, P. T. 2009. Population status of exotic catfish *Pterygoplichthys multiradiatus* (Hancock) in the feeder canals of Akkulam Lake, Thiruvananthapuram, Kerala. Master's thesis. University of Kerala, India.
- Bunkley-Williams, L., E. H. Williams Jr., C. G. Lilystrom, I. Corujo-Flores, A. J. Zerbi, and C. Aliaume. 1994. The South American sailfin armored catfish, *Liposarcus multiradiatus*

- (Hancock), a new exotic established in Puerto Rican fresh waters. *Caribbean Journal of Science* 30(1–2):90–94.
- Burgess, W. E. 1989. An atlas of freshwater and marine catfishes. A preliminary survey of the Siluriformes. T. F. H. Publications, Neptune City, New Jersey.
- Burgess, W. E., and L. Finley. 1996. An atlas of freshwater and marine catfishes: update. *Tropical Fish Hobbyist* 45(2):163–174.
- Capps, K. A., and A. S. Flecker. 2013. Invasive fishes generate biogeochemical hotspots in a nutrient-limited system. *Public Library of Science ONE* 8(1):e54093.
- Capps, K. A., A. S. Flecker, and R. Rodiles-Hernández. 2009. COS 45–8: Exotic fishes alter nutrient dynamics in tropical streams. *Proceedings of the 93rd Ecological Society of America Annual Meeting*.
- Capps, K. A., L. G. Nico, M. Mendoza-Carranza, W. Arévlo-Frías, A. J. Ropicki, S. A. Heilpern, and R. Rodiles-Hernández. 2011. Salinity tolerance of non-native suckermouth armoured catfish (Loricariidae: *Pterygoplichthys*) in south-eastern Mexico: implications for invasion and dispersal. *Aquatic Conservation: Marine and Freshwater Ecosystems* 21:528–540.
- Champeau, R. T., P. W. Stevens, and D. A. Blewett. 2009. Comparison of fish community metrics to assess long-term changes and hurricane impacts at Peace River Florida. *Florida Scientist* 72(4):289–309.
- Chang, F., and H. Ortega. 1995. Additions and corrections to the list of freshwater fishes of Peru. *Publicaciones del Museo de Historia Natural, Universidad Nacional Mayor de San Marcos. Serie A, Zoology Ser. A Zool.* 50:1–11.
- Chavez, J. M., R. M. De La Paz, S. K. Manohar, R. C. Pagulayan, and J. R. Carandang, VI. 2006. New Philippine record of South American sailfin catfishes (Pisces: Loricariidae). *Zootaxa* 1109:57–68.
- Cohen, K. 2008. Gut content and stable isotope analysis of exotic suckermouth catfishes in the San Marcos River, TX: a concern for spring endemics? Master's thesis. Texas State University, San Marcos.
- Cook-Hildreth, S. L. 2009. Exotic armored catfishes in Texas: reproductive biology, and effects of foraging on egg survival of native fishes (*Etheostoma fonticola*, endangered and *Dionda diabolic*, threatened). Master's thesis. Texas State University, San Marcos.
- Courtenay, W. R., Jr. 1989. Exotic fishes in the National Park System. Pages 237–252 in L. K. Thomas, editor. *Proceedings of the 1986 conference on science in the national parks 5. Management of exotic species in natural communities*. U.S. National Park Service and George Wright Society, Washington, D. C.

- Courtenay, W. R., Jr., D. A. Hensley, J. N. Taylor, and J. A. McCann. 1984. Distribution of exotic fishes in the continental United States. Pages 41–77 in W. R. Courtenay, Jr., and J. R. Stauffer, Jr., editors. *Distribution, biology and management of exotic fishes*. Johns Hopkins University Press, Baltimore, Maryland.
- Courtenay, W. R., Jr., and J. R. Stauffer, Jr. 1990. The introduced fish problem and the aquarium fish industry. *Journal of the World Aquaculture Society* 21(3):145–159.
- Cox, D. T., E. D. Vosatka, G. Horel, R. Eisenhauer, H. Moody, L. L. Connor, and R. Smith. 1981. Ecological aspects of the St. Johns River fishery. Florida Fish and Wildlife Conservation Commission, 1976–1981 Completion Report, Project F-33, Study 1, Tallahassee, Florida.
- Devick, W. S. 1988. Disturbances and fluctuations in the Wahiawa Reservoir ecosystem. Project F-14-R-12, Job 4, Study I. Division of Aquatic Resources, Hawaii Department of Land and Natural Resources.
- Devick, W. S. 1989. Disturbances and fluctuations in the Wahiawa Reservoir ecosystem. Project F-14-R-13, Job 4, Study I. Division of Aquatic Resources, Hawaii Department of Land and Natural Resources.
- Devick, W. S. 1991. Patterns of introductions of aquatic organisms to Hawaiian freshwater habitats. Pages 189–213 in *New directions in research, management and conservation of Hawaiian freshwater stream ecosystems*. Proceedings of the 1990 symposium on freshwater stream biology and fisheries management, Division of Aquatic Resources, Hawaii Department of Land and Natural Resources.
- Ferraris, C. J., Jr. 2007. Checklist of catfishes, recent and fossil (Osteichthyes: Siluriformes), and catalogue of siluriform primary types. *Zootaxa* 1418:1–628.
- FishBase. 2010[c]. *Pterygoplichthys anisitsi* Eigenmann and Kennedy, 1903. Available: <http://www.fishbase.org/summary/SpeciesSummary.php?id=12218>. (November 2009).
- FishBase. 2010[d]. *Pterygoplichthys gibbiceps* (Kner 1854). Available: <http://www.fishbase.org/summary/SpeciesSummary.php?id=12219>. (November 2009).
- Fuller, P. L., L. G. Nico, and J. D. Williams. 1999. Nonindigenous fishes introduced into inland waters of the United States. American Fisheries Society, Special Publication 27, Bethesda, Maryland.
- Gestring, K. B., P. L. Shafland, and M. S. Stanford. 2006. The status of Loricariid catfishes in Florida with emphasis on orinoco sailfin (*Pterygoplichthys multiradiatus*). Abstracts for the 26th Annual Meeting of the Florida Chapter American Fisheries Society.

- Gibbs, M. A., J. H. Shields, D. W. Lock, K. M. Talmadge, and T. M. Farrell. 2008. Reproduction in an invasive exotic catfish *Pterygoplichthys disjunctivus* in Volusia Blue Spring, Florida, U.S.A. *Journal of Fish Biology* 73(7):1562–1572.
- Hancock, J. 1828. Notes on some species of fishes and reptiles, from Demerara, presented to the Zoological Society by John Hancock, Esquire, corr. Mem. Zoological Society. In a letter addressed to the secretary of the Society. *Zoological Journal, London* 4:240–247.
- Hoover, J. J., K. J. Killgore, and A. F. Cofrancesco. 2004. Suckermouth catfishes: threats to aquatic ecosystems of the United States? *Aquatic Nuisance Species Research Program Bulletin* 4(1).
- Hossain, M. Y., M. M. Rahman, Z. F. Ahmed, J. Ohtomi, and A. B. M. S. Islam. 2008. First record of the South American sailfin catfish *Pterygoplichthys multiradiatus* in Bangladesh. *Journal of Applied Ichthyology* 24(6):718–720.
- Hubbs, C., R. J. Edwards, and G. P. Garrett. 2008. An annotated checklist of the freshwater fishes of Texas, with keys to identification of species. Texas Academy of Science.
- Hubilla, M., F. Kis, and J. Primavera. 2007. Janitor fish *Pterygoplichthys disjunctivus* in the Agusan Marsh: a threat to freshwater Biodiversity. *Journal of Environmental Science and Management* 10(1):10–23.
- Isbrücker, I. J. H. 1980. Classification and catalogue of the mailed Loricariidae (Pisces, Siluriformes). *Verslagen en Technische Gegevens, Instituut voor Taxonomische Zoölogie, Universiteit van Amsterdam* 22:1–181.
- Isbrücker, I. J. H. 2001. Nomenklator der Gattungen und Arten der Harnischwelse, Familie Loricariidae Rafinesque, 1815 (Teleostei, Ostariophysi). *DATZ-Sonderheft Harnischwelse* 2:25–32.
- Isbrücker, I. J. H. 2002. Nomenclator of the 108 genera with 692 species of the mailed catfishes, family Loricariidae Rafinesque, 1815 (Teleostei, Ostariophysi). *Cat Chat, Journal of the Catfish Study Group (UK)* 3(1):11–30.
- Krishnakumar, K., A. Ali, B. Pereira, and R. Raghavan. 2011. Unregulated aquaculture and invasive alien species: a case study of the African catfish *Clarias gariepinus* in Vembanad Lake (Ramsar Wetland), Kerala. India. *Journal of Threatened Taxa* 3:1737–1744.
- Kurup, B. M., and C. T. Samuel. 1985. Fish and fishery resources of Vembanad Lake. Pages 77–82 in K. Ravindran, N. U. Nair, P. A. Perigreen, A. G. G. Pillai, P. A. Panicker, and M. Thomas, editors. *Harvest and post-harvest technology of fishes*. Central Institute of Fisheries Technology (CIFT) and Society of Fisheries Technologists (SOFTI), Kochi, India.

- La Jornada. 2005. Sin control, la proliferación del pez diablo en la Presa Infiernillo. Available: <http://www.jornada.unam.mx/2005/mar05/050321/michoacan/10nl1soc.html>. (April 2005).
- Levin, B. A., P. H. Phuong, and D. S. Pavlov. 2008. Discovery of the Amazon sailfin catfish *Pterygoplichthys pardalis* (Castelnau, 1855) (Teleostei: Loricariidae) in Vietnam. *Journal of Applied Ichthyology* 24(6):715–717.
- Liang, S. H., L. C. Chuang, and M. H. Chang. 2006. The pet trade as a source of invasive fish in Taiwan. *Taiwania* 51(2):93–98.
- Liang, S. H., H. P. Wu, and B. S. Shieh. 2005. Size structure, reproductive phenology, and sex ratio of an exotic armored catfish (*Liposarcus multiradiatus*) in the Kaoping River of southern Taiwan. *Zoological Studies* 44(2):252–259.
- Loftus, W. F., and J. A. Kushlan. 1987. Freshwater fishes of southern Florida. *Bulletin of the Florida State Museum of Biological Science* 31(4):255.
- Lopez-Fernandez, H., and K. O. Winemiller. 2005. Status of *Dionda diaboli* and report of established populations of exotic fish species in lower San Felipe Creek, Val Verde County, Texas. *The Southwestern Naturalist* 50(2):246–251.
- Lopez, H. L., R. C. Menni, and A. M. Miguelarena. 1987. Lista de los peces de agua dulce de la Argentina. *Biología Acuática* 12.
- López, H. L., and A. M. Miquelarena. 1991. Los Hypostominae (Pisces: Loricariidae) de Argentina. *Fauna de agua dulce de la República Argentina. Fauna de Agua Dulce de la República Argentina Pisces* 40(2):1–64.
- Ludlow, M. E., and S. J. Walsh. 1991. Occurrence of a South American armored catfish in the Hillsborough River, Florida. *Florida Scientist* 54(1):48–5.
- Mendoza, R. E., B. Cudmore, R. Orr, S. C. Balderas, W. R. Courtenay, P. K. Osorio, N. Mandrak, P. A. Torres, M. A. Damian, C. E. Gallardo, A. G. Sanguines, G. Greene, D. Lee, A. Orbe-Mendoza, C. R. Martinez, and O. S. Arana. 2009. *Trinational Risk Assessment Guidelines for Aquatic Alien Invasive Species*. Commission for Environmental Cooperation. Montreal, Canada.
- Menni, R. C. 2004. Peces y ambientes en la Argentina continental. *Monografías del Museo Argentina Ciencias Naturales, Buenos Aires* 5:1–316.
- Montoya-Burgos, J.-I., S. Muller, C. Weber, and J. Pawlowski. 1998. Phylogenetic relationships of the Loricariidae (Siluriformes) based on mitochondrial rRNA gene sequences. Pages 363–374 *in* L. R. Malabarba, R. E. Reis, R. P. Vari, Z. M. S. de Lucena, and C. A. S. Lucena, editors. *Phylogeny and classification of Neotropical fishes*. Edipucrs, Porto Alegre, Brazil.

- Mundy, B. C. 2005. Checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletins in Zoology 6:1–704.
- Nelson, J. S., E. J. Crossman, H. Espinosa Pérez, L. T. Findley, C. R. Gilbert, R. N. Lea, and J. D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico, 6th edition. American Fisheries Society, Special Publication 29, Bethesda, Maryland.
- Nico, L. 2006. *Pterygoplichthys multiradiatus*. USGS Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: <http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=768>.
- Nico, L. G., P. L. Butt, G. R. Johnson, H. L. Jelks, M. Kail, and S. J. Walsh. 2012. Discovery of the South American suckermouth armoured catfish (Loricariidae, *Pterygoplichthys* spp.) in the Santa Fe River drainage, Suwannee River basin, USA. Bioinvasion Records 1:179–200.
- Nico, L. G., H. L. Jelks, and T. Tuten. 2009b. Non-native suckermouth armored catfishes in Florida: description of nest burrows and burrow colonies with assessment of shoreline conditions. Aquatic Nuisance Species Research Programme (ANSRP) Bulletin 09–1.
- Nico, L. G., H. L. Jelks, and T. Tuten. 2009. Non-native suckermouth armored catfishes in Florida: description of nest burrows and burrow colonies with assessment of shoreline conditions. ANSRP Bulletin 9:1–30.
- Nico, L. G., and R. T. Martin. 2001. The South American suckermouth armored catfish, *Pterygoplichthys anisitsi* (Pisces: Loricariidae), in Texas, with comments on foreign fish introductions in the American Southwest. Southwestern Naturalist 46(1):98–104.
- Nico, L. G., W. F. Loftus, and J. P. Reid. 2009[a]. Interactions between non-native armored suckermouth catfish (Loricariidae: *Pterygoplichthys*) and native Florida manatee (*Trichechus manatus latirostris*) in artesian springs. Aquatic Invasions 4(3):511–519.
- Ortega, H., and R. P. Vari. 1986. Annotated checklist of the freshwater fishes of Peru. Smithsonian Contributions to Zoology 437.
- Oz[e]dilek, S. Y. 2007. Possible threat for Middle East inland water: an exotic and invasive species, *Pterygoplichthys disjunctivus* (Weber, 1991) in Asi River, Turkey (Pisces: Loricariidae). Journal of Fisheries and Aquatic Sciences 24(3–4):303–306.
- Page, L. M. 1994. Identification of sailfin catfishes introduced to Florida. Florida Scientist 57(4):171–172.
- Page, L. M., and B. M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin, Boston.

- Page, L. M., and B. M. Burr. 2011. Peterson field guide to freshwater fishes of North America north of Mexico, 2nd edition). Freshwater Fishes of North America.
- Page, L. M., H. Espinosa-Pérez, L. D. Findley, C. R. Gilbert, R. N. Lea, N. E. Mandrak, R. L. Mayden, and J. S. Nelson. 2013. Common and scientific names of fishes from the United States, Canada, and Mexico, 7th edition. American Fisheries Society, Special Publication 34, Bethesda, Maryland.
- Page, L. M., and R. H. Robins. 2006. Identification of sailfin catfishes (Teleostei: Loricariidae) in southeastern Asia. *Raffles Bulletin of Zoology* 54(2):455–457.
- Radhakrishnan, K. V., B. M. Kurup, B. R. Murphy, and S. G. Xie. 2012. Status of alien fish species in the Western Ghats (India) as revealed from 2000–2004 surveys and literature analyses. *Journal of Applied Ichthyology* 28:778–784.
- Reis, R. E., S. O. Kullander, and C. J. Ferraris, Jr., editors. 2003. Check list of the freshwater fishes of South and Central America. CLOFFSCA. EDIPUCRS, Porto Alegre, Brazil.
- Richards, D. 2002. Florida Fish and Wildlife Commission, Eustis, personal communication.
- Riehl, R., and H. A. Baensch. 1991. *Aquarien atlas*. Band. 1. Melle: Mergus, Verlag für Natur- und Heimtierkunde, Germany.
- Scharpf, C. 2006. Annotated checklist of North American freshwater fishes, including subspecies and undescribed forms. Part II: Catostomidae ... [through] Mugilidae. *American Currents* 32(4):1–40.
- Stevens, W. P., D. A. Blewett, and P. Casey. 2006. Short-term effects of a low dissolved oxygen event on estuarine fish assemblages following the passage of hurricane Charley. *Estuaries and Coasts* 29(6A):997–1003.
- USFWS. 2005. [Source material did not give full citation for this reference.]
- Weber, C. 1991. Nouveaux taxa dans *Pterygoplichthys* sensu lato (Pisces, Siluriformes, Loricariidae). *Revue Suisse de Zoologie* 98(3):637–643. (English summary.)
- Weber, C. 1992. Révision du genre *Pterygoplichthys* sensu lato (Pisces, Siluriformes, Loricariidae). *Revue Française d'Aquariologie* 19(1–2):1–36. (English summary.)
- Yamamoto, M. N., and A. W. Tagawa. 2000. Hawaii's native and exotic freshwater animals. Mutual Publishing, Honolulu, Hawaii.