Amazon Sailfin Catfish (*Pterygoplichthys pardalis*)
Ecological Risk Screening Summary

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1 Native Range and Status in the United States

Native Range
From Froese and Pauly (2018):

"South America: Lower, middle and upper Amazon River basin."

Froese and Pauly (2018) list *Pterygoplichthys pardalis* as native in Brazil and Peru.

Status in the United States

From Nico et al. (2018):

"*Pterygoplichthys pardalis* has been present in the thermally polluted Julian Lake, North Carolina since 1997 (Bryn, T., personal communication). A single specimen was taken in Cherokee County, South Carolina, from the Broad River at 99 Island Dam in 1992 (museum specimen). Recently established in California (C. Swift, personal communication) and Puerto Rico."

"Established in Julian Lake, North Carolina and reported from South Carolina."

"L. Page has examined the specimen from South Carolina (UF 93286) and confirmed its identification as *Pterygoplichthys pardalis*."

From Froese and Pauly (2018):

"Known from Loíza River [Puerto Rico], including the Loíza Reservoir since 1993-2007. […] They are however popular aquarium fishes. Puerto Ricans are beginning to fish these catfishes for sport (Felix Grana, pers. comm.)."

From GISD (2018):

"*Pterygoplichthys pardalis* was reported to occur in the Sepulvida Basin and Los Angeles River in California. Large burrows found in the banks of the Sepulveda basin in Los Angeles suggest reproduction may be occurring there (Me[n]doza et al, 2009)."

From Godwin et al. (2016):

"[…] represent ecologically significant observations for Alabama (Table 1 [in source material]), including *Pterygoplichthys disjunctivus* Weber x *pardalis* Castelnau (hybrid Sailfin Catfish; Fig. 1 [in source material]) […]."

Means of Introductions in the United States

From Nico et al. (2018):

"Probable aquarium release."

Remarks

From Nico et al. (2018):

"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)."

Gestring et al. (2010) questions the identification of established populations of *Pterygoplichthys pardalis* in Florida based on unresolved taxonomy issues within loricariids.

From Wei et al. (2017):

"Specimens could be identified as either *P. pardalis* (6.2%), *P. disjunctivus* (17.8%) or as *P. pardalis* × *P. disjunctivus* hybrids (76%)."

From Godwin et al. (2016):

"Despite Weber's (1992) revision, more work is needed to determine the range of variability of color in *P. pardalis* to determine if *P. disjunctivus* is distinct. Specimens identified as both species are widely established in peninsular Florida and locally established in other southeastern states (USGS 2016); however, it is likely that the introduction was actually a hybrid of the 2 species. Wu et al. (2011) found that *Pterygoplichthys* in Taiwan confidently identified as *P. pardalis* had *P. disjunctivus* mitochondrial DNA and vice versa, and that many specimens had intermediate morphologies. They found evidence for free gene-flow from the *P. pardalis* morphotype and the *P. disjunctivus* morphotype indicating that either *P. disjunctivus* was not valid, or aquarium specimens were the result of an early hybridization event. Based on extensive examination of specimens and photos of introduced specimens from around the world by J.W. Ambruster (unpubl. data) and previous revisionary work on the genus (Armbruster and Page 2006), we recognize that introduced specimens worldwide, as well as specimens from the aquarium trade, range in morphology from *P. pardalis* to *P. disjunctivus* and should, per Wu et al. (2011), be classified as hybrids."

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 (2018):

"Kingdom Animalia
  Subkingdom Bilateria
    Infrakingdom Deuterostomia
      Phylum Chordata
        Subphylum Vertebrata
          Infraphylum Gnathostomata
            Superclass Actinopterygii
              Class Teleostei

Superorder Ostariophysi
Order Siluriformes
Family Loricariidae
Subfamily Hypostominae
Genus *Pterygoplichthys*
Species *Pterygoplichthys pardalis* (Castelnau, 1855)"

From Eschmeyer et al. (2018):

"***pardalis, Hypostomus*** Castelnau [F. L.] 1855:42, Pl. 20 (fig. 3) [Animaux nouveaux or rares v. 2; […]] Amazon River, Brazil. Holotype (unique): MNHN A-9574. Type catalog: Bertin & Estève 1950:69 […], Ferraris 2007:292 […]. •Valid as *Liposarcus pardalis* (Castelnau 1855) -- (Weber 1991:642 […], Weber 1992:10, 25 […], Chang & Ortega 1995:6 […], Burgess & Finley 1996:169 […], Scott & Crossman 1998:viii […], Isbrücker 2001:28, 29 […], Isbrücker 2002:20 […], Weber in Reis et al. 2003:365 […]). •Valid as *Pterygoplichthys pardalis* (Castelnau 1855) -- (Isbrücker 1980:42 […], Ortega & Vari 1986:18 […], Burgess 1989:433 […], Fuller et al. 1999:226 […], Nelson et al. 2004:84 […], Chavez et al. 2006[a]:59 […], Page & Robins 2006:455 […], Armbruster & Page 2006:403 […], Scharpf 2006:20 […], Ferraris 2007:292 […], Page & Burr 2011:370 […], Barriga S. 2012:113 […], Page et al. 2013:82 […], Kottelat 2013:216 […], Angulo et al. 2013:994 […], Sarmiento et al. 2014:192 […], DoNascimiento et al. 2017:82 […]). **Current status:** Valid as *Pterygoplichthys pardalis* (Castelnau 1855). Loricariidae: Hypostominae."

Size, Weight, and Age Range

From Froese and Pauly (2018):

"Max length : 49.0 cm TL male/unsexed; [Jumawan and Seronay 2017]; max. published weight: 310.00 g [Jumawan and Seronay 2017]"

From Nico et al. (2018):

"Size: generally to 50 cm TL"

Environment

From Froese and Pauly (2018):

"Freshwater; demersal; pH range: 7.0 - 7.5; dH range: 10 - 20. […]; 23°C - 28°C [assumed to be recommended aquarium water temperature] [Baensch and Riehl 1997]"

From GISD (2018):

"*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). They can thrive in a range of acidic to alkaline waters in a range of about (pH

5.5.0 [sic] to 8.0) (Mendoza et al., 2009). They are often found in soft waters, but can adapt very quickly to hard waters. *Pterygoplichthys* spp. are also highly tolerant to poor water quality and are commonly found in polluted waters (Chavez et al., 2006[a]). They are known to use outflow from sewage treatment plants as thermal refugia and can readily adapt to changing water quality (Nico & Martin, 2001). […] Some species are salt tolerant (Mendoza et al., 2009)."

"Water quality in these areas can be characterized generally as polluted because these drainages receive waste materials and even sewage from households and industries."

Climate/Range

From Froese and Pauly (2018):

"Tropical; […]"

From GISD (2018):

"*Pterygoplichthys* spp. may be found in from lowlands to elevations of up to 3,000 m (Wakida-Kusunki, 2007)."

Distribution Outside the United States

Native

From Froese and Pauly (2018):

"South America: Lower, middle and upper Amazon River basin."

Froese and Pauly (2018) list *Pterygoplichthys pardalis* as native in Brazil and Peru.

Introduced

Froese and Pauly (2018) lists *Pterygoplichthys pardalis* as introduced and established in Java and Sumatra in Indonesia, Malaysia, Philippines, and Singapore; and as present in the aquarium trade in Spain.

From Froese and Pauly (2018):

"Recorded from Langat River [in Malaysia] [Samat et al. 2005]. Has firmly established in polluted urban lakes and rivers [Chong et al. 2010]. Also [Page and Robins 2006]."

"Recorded from Marikina river and Paitan Lake, Cuyapo, Nueva Ecija [Agasen 2005], Catmon and Banilad creeks, and San Pedro, Laguna de Bay [in the Philippines] [Chavez et al. 2006a]."

GISD (2018) lists *Pterygoplichthys pardalis* as alien and established in Indonesia and Vietnam, and as alien, invasive, and established in Mexico and the Philippines.

From GISD (2018):

"*P. pardalis* was first discovered in a freshwater pond near Frontera in 2005 with additional records in the region indicate that it was spreading through the Grijalva-Usumacinta River Basin (Wakida-Kusunoki et al, 2007)."

"They [*Pterygoplichthys pardalis* and *P. disjunctivus*] were collected from medium-velocity rivers no more than two meters deep near the riverbanks at sites including Marikina River in Marikina and Pasig Cities [Philippines]; Pasig River in the City of Manila; Catmon Creek in Bay, Laguna; Banilad Creek in Siniloan, Laguna; and Laguna de Bay in San Pedro, Laguna."

"*Pterygoplichthys pardalis* was found in the Red River near Yen Bai City in northern Vietnam in 2006."

Pagad et al. (2018) lists *Pterygoplichthys pardalis* as introduced to Costa Rica, Guatemala, Indonesia, Jamaica, Malaysia, Mexico, Philippines, Singapore, Thailand, and Vietnam.

From Barrientos et al. (2015):

"Moreover the highly invasive *Pterygoplichthys pardalis* (Castelnau 1855) is found in almost in every river connected to the Usumacinta [River] (Wakida-Kusunoki et al. 2007) and recently in Lake Petén Itzá [Guatemala] (Barrientos and Quintana 2012), but not in Lake Yaxhá."

From Wei et al. (2017):

"Specimens could be identified as either *P. pardalis* (6.2%), *P. disjunctivus* (17.8%) or as *P. pardalis* × *P. disjunctivus* hybrids (76%). This identification was consistent with morphological analyses on invasive *Pterygoplichthys* populations elsewhere (e.g. Wu et al. 2011; Nico et al. 2012; Jones et al. 2013), and indicates that invasions in [southeastern] China are most likely the result of a hybrid swarm of *P. pardalis*×*P. disjunctivus*."

From Emiroğlu et al. (2016):

"Our morphological analyses on the collected specimens from the stream (in İnönü town [Turkey]) fed hot spring water indicated that non-native *Pterygoplichthys* species should be identified as *P. disjunctivus* and *P. pardalis* or their hybrids."

From Chaichana et al. (2011):

"A species of Neotropical suckermouth armored catfish (family Loricariidae), tentatively identified as the Amazon sailfin catfish *Pterygoplichthys pardalis* Castelnau 1855, is established in Thailand where it is becoming increasingly widespread and abundant."

From Herder et al. (2012):

"A single specimen of the sailfin catfish *Pterygoplichthys pardalis* (Figure 1a [in source material]) was captured in 2 Sept. 2012 at south-western Lake Matano [Sulawesi, Indonesia], […]"

From Simonović et al. (2010):

"Amazon sailfin catfish *Pterygoplichthys pardalis* (Castelnau, 1855) (Loricariidae, Siluriformes) is a new non-indigenous fish species recorded in the Serbian section of the Danube River, being reported for the first time in inland waters of Europe, as well. A single, female fish was ripe and in good shape, although considering its original neotropical dispersal area and recording of occurrence in summer, with the only single female individual, its acclimatization is not likely."

From Bijukumar et al. (2015):

"The suckermouth armoured catfishes reported from India include […], *Pterygoplichthys disjunctivus* and *P. pardalis* from Andhra Pradesh, West Bengal, Bihar and Uttar Pradesh (Singh 2014)."

From Muralidharan et al. (2015):

"Eight specimens of *P. pardalis* (Fig. 1 [in source material]) were collected from Cauvery River (11°02'10.4"N, 78°08'45.2"E) at Mohanur (Fig. 2 [in source material]), Namakkal district, Tamilnadu on 24 October 2013."

From Wu et al. (2011):

"Based on our morphological identification and molecular data, exotic sailfin catfish in Taiwan should be identified as *P. pardalis, P. disjunctivus*, or a mixture between the two."

From Zworykin and Budaev (2013):

"In the Dinh River basin, we found individuals whose colouration coincided with the description of distinct species, such as *P. pardalis* (Fig. 3a [in source material]) and *P. disjunctivus* (Fig. 3b [in source material])."

From Sumanasinghe and Amarasinghe (2013):

"Amazon sailfin catfish, *Pterygoplichthys pardalis* was recently observed in Polgolla reservoir (7°19′18″N, 80°38′42″E) […]. P. pardalis is also found in many inland reservoirs of Sri Lanka such as Kala wewa, Balalu wewa, Kandalama wewa and Usgala Siyambangamuwa wewa (USA, pers. obs.)."

From Rao and Sunchu (2017):

"This paper documents that the invasion of *Pterygoplichthys pardalis* in the local freshwater tanks of Jangaon, Waranga and Karimnagar Districts of Telangana State [India] […]"

From Hossain et al. (2018):

"We did not find any nest (spawning) burrows in Bangladesh, but the six *P. pardalis* specimens from 2009 were juveniles, being 78–112 mm in SL (mean 92 mm) and 7.9–24.5 g in total weight. This suggests some reproductive success for this species in Bangladesh. Additionally, their occurrence in five different localities of the Ganges-Brahmaputra River drainage (north- and southwestern floodplains) (Figure 2 [in source material]) suggests possible dispersal."

"Israeli *P. pardalis* and *P. disjunctivus* inhabit shallow-brackish waters with salinities near 2 vs. 0.5 ppt, respectively [Golani et al. 2013]."

Means of Introduction Outside the United States

From GISD (2018):

"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* [sic] 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 [sic] 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)."

Short Description

From Nico et al. (2018):

"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 Muralidharan et al. (2015):

"This species is characterized by bony plates covering the body, a pair of subterminal barbels, sucking lips, usually a spine in front of the adipose fin, a flat-bottom body (Page and Burr, 1991) and uncoalesced dark spots on a light background (Page and Robins, 2006)."

"*Pterygoplichthys pardalis* is diagnosed by discrete dark spots on the lateral and caudal peduncle with a pattern of uncoalesced dark spots on a light background, stout pectoral fins with rough surfaces and inferior disc-like protrusible mouth. Fin ray counts for the fishes are D: I 12, A: I 4; P: I 6; V: I 5; C: 14; L.L: 26-32. […] Body behind head completely plated dorsally and laterally.

Belly naked, with the plates occurring on the ventral side of the body only at the caudal peduncle region. Ventral surface of the pectoral girdle covered in skin mesial to the coracoid strut. Caudal peduncle round in cross section. Adipose fin present in the peduncle region. Edge of snout covered with plates. Postdorsal ridge inconspicuous, with the single, median, unpaired preadipose plate. Body coloration, particularly on the abdomen, consists of dark spots on light background, however head exhibit linear patterns forming geometric shapes."

Biology

From Froese and Pauly (2018):

"Facultative air breather."

"Ingested food high in total organic matter, crude protein and C:N ration and low content of hydrolysis-resistant organic matter and ash [Yossa and Araujo-Lima 1998]."

From GISD (2018):

"*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)."

"*Pterygoplichthys* spp. reproduce sexually and have high fecundancy [sic] (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)."

"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. *Pterygoplicthys* spp. start reproducing at approximately 25 cm (Mendoza et al, 2009)."

From Wei et al. (2017):

"For example, *P. pardalis* in Malaysia were reported to mature at a smaller size than in other non-native populations, and this has been attributed to the warmer and more stable water temperatures of the tropical rivers in that region (Samat et al. 2016)."

From Chaichana and Jongphadungkiet (2012):

"Another interesting finding was that *P. pardalis* can consume first-feeding fry. This study is the first indication of the impact on this species on first-feeding fry."

Human Uses

From Froese and Pauly (2018):

"Fisheries: minor commercial; aquarium: commercial."

"Found in fish markets in Santarém [Brazil] [Ferreira et al. 1996]."

From GISD (2018):

"Recently a bounty system for the eradicated of the "janitor fish" [*Pterygoplichthys pardalis* and other *Pterygoplihthys* spp.] has been launched by the City Government of Marikina. The live fish is brought at the price of P5 per kilogram and then destroyed. A World Bank-funded project for the conversion of the species into fishmeal is being implemented by the Laguna Lake Development Authority in cooperation with a farmer's cooperative in Laguna (Joshi, 2006).

Experiments are also underway to use Janitor Fish for the Fish Amino Acid (FAA) concoction for Natural Farming Technology System (NFTS). Janitor fish is combined with molasses and fermented to produce the concoction to use on corn farms as fertiliser. (Agusan Marsh FOCAS, 2008). Other uses of janitor fish have also been proposed, including using the oil of the fish to make biofuel and soaps (Sarmiento, 2006)."

From Muralidharan et al. (2015):

"*Pterygoplichthys pardalis* and *P. multiradiatus* are among the most popular and intensively marketed varieties of tropical aquarium fish species in South India (Knight, 2010)."

Diseases

No records of OIE reportable diseases were found for *Pterygoplichthys pardalis*.

From Rodríguez-Santiago et al. (2016):

"Four ectoparasite species were found in *P. pardalis* (1 protozoan: *Ichthyophthirius multifiliis*; 2 monogeneans: *Urocleidoides vaginoclastrum* and *Heteropriapulus heterotylus*; 1 digenean: *Clinostomum* sp.), […]"

"Only two parasitological reports have been published in *Pterygoplichthys pardalis* from its native range (Central Amazonia, Brazil), where a total of 6 helminth species were found: *Megacoelium spinicavum* (Thatcher & Varella, 1981), *Austrodiplostomum compactum*, *Diplostomum* sp., *Gorytocephalus* sp., *Heteropriapulus* sp. and *Unilatus* sp. (Porto et al., 2012)."

Threat to Humans

From Froese and Pauly (2018):

"Harmless"

From Rodríguez-Santiago et al. (2016):

"Most parasite species recorded in this study have not been documented to be pathogenic to humans, although it is known that a species of *Clinostomum* (*C. complanatum*) has been found to infect humans (two in Korea and one in Japan) (Witenberg, 1944). This parasite was transmitted by eating raw or undercooked fish, which is linked to cultural factors of certain human populations (Park et al., 2009), and was found attached to the human mucous layer of larynx and pharynx. However, although the prevalence of these trematodes was very low in these hosts (*P. pardalis* and *P. disjunctivus*), it was not recommended to consume undercooked meat fish."

3 Impacts of Introductions

From GISD (2018):

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

"*P. disjunctivus* and *P. pardalis* are reportedly destroying cages and nets and causing a decline in native, more desirable fish in Laguna de Bay, Philippines (Chavez et al, 2006[a])."

From Froese and Pauly (2018):

"Has become abundant in recent years, replacing some commercial fishes in fishermen's catches [in the Philippines] [Agasen 2005]."

From Chaichana et al. (2011):

"The most abundant populations of *Pterygoplichthys* [*pardalis*] were present downstream, where the canal flows past the city. *Pterygoplichthys* [*pardalis*] composed over 70% of the species composition. This percentage increased to 100% downstream. Accordingly, the establishment of *Pterygoplichthys* [*pardalis*] seemed to have a negative effect on the native fish species."

From Sumanasinghe and Amarasinghe (2013):

"In Polgolla reservoir [India], although contribution of *P. pardalis* to the total commercial fisheries landings was only 21%, its impact on the commercial fishery is very significant because it causes economic losses by damaging commercial gillnets."

From Muralidharan et al. (2015):

"The ecological impacts upon introduction of this species to the aquatic habitat are disruption of food chain by overgrazing of benthic algae (Liang et al., 2005; Chavez et al., 2006[a]), competing with native species (Nico and Martin, 2001), modifying substrates and disrupting benthic communities (Hoover et al.,2004) and damaging the banks by burrowing (Bunkley-Williams et al., 1994)."

From Sandilyan (2016):

"Also, overpopulation of ornamental sucker mouth catfish *Pterygoplichthys multiradiatus* and *Pterygoplichthys pardalis* has resulted in the decline of commercially important inland native fish in Kerala and Tamil Nadu, respectively [Singh et al. 2013; Bijukumar et al. 2015]."

"Interestingly, another species of suckermouth catfish *Pterygoplichthys pardalis* was reported to cause huge damage to the native species diversity of Vandiyur Lake, Madurai, southern India. The biomass of *Pterygoplichthys pardalis* was statistically significant compared to the indigenous varieties, which clearly shows the negative impacts of this exotic aquarium fish on inland aquaculture in terms of diminished production of edible fishes [Soundararajan et al. 2015]. Further, *Pterygoplichthys pardalis* does not hold any market value. So after harvest people discard the species on the banks of the lake, where it is not even scavenged (Figure 2 [in source material]) [Soundararajan et al. 2015]."

Orfinger and Goodding (2018) report that *Pterygoplichthys pardalis* has resulted in damaged fisheries equipment, declining native fish populations, and bioaccumulation of heavy metals and coliform bacteria in the Philippines and damaged fisheries equipment in Mexico.

From Capps (2012):

"High population densities of *Pterygoplichthys* [*P. pardalis, P. disjunctivis*, and their hybrids] reduced food resources and macroinvertebrate abundance in the Chacamax River. Additionally, *Pterygoplichthys* reduced the total stock of nutrients and carbon stored in epilithon and modified epilithon stoichiometry, potentially exacerbating P-limitation. Together, these results demonstrate *Pterygoplichthys* significantly reduced the quantity and quality of food resources, subsequently altering the abundance of the macroinvertebrate community and primary productivity in an invaded system.
[…] In the presence of grazing loricariids [*P. pardalis*, *P. disjunctivis*, and their hybrids], I measured approximately 50% less algal biomass and epilithon dry mass in the site comparison and in the experiments (Figs. 1.2, 1.3, 1.7 [in source material]). High fish standing stocks and high per-capita consumption rates of this low-quality food combine to yield the dramatic reduction in epilithon abundance."

"In my experiments, *Pterygoplichthys* [*P. pardalis, P. disjunctivis*, and their hybrids] grazing significantly reduced the amount of P stored in epilithon and increased epilithon C:P and N:P, indicating that loricariid grazing reduced the quality of food resources in the Chacamax River."

"However, in my study, macroinvertebrate density (total number, EPT, Leptohyphidae, and Chironomidae) correlated positively with increasing algal biomass rather than the total abundance of sediment (Appendix 5 [in source material]), suggesting that loricariids [*P. pardalis*, *P. disjunctivis*, and their hybrids] reduced macroinvertebrate populations indirectly via resource exploitation rather than by reducing the amount of available habitat."

"In this study, loricariid [*P. pardalis*, *P. disjunctivis*, and their hybrids] grazing depressed algal biomass and GPP in mesocosm and in situ NDS and exclosure experiments. In contrast, excretion by loricariids generated hotspots of nutrients in the Chacamax River and exposure to nutrients via remineralization by fish or amended nutrients in NDS stimulated primary productivity. Grazing by loricariids overshadowed the stimulation of algal growth by nutrient [r]emineralization or addition, suggesting introduced loricariids have a negative net impact on stream algal biomass and GPP."

"Loricariids [*P. pardalis*, *P. disjunctivis*, and their hybrids] created important sinks of nutrients after invasion. High densities of loricariids sequestered approximately 50% of the carbon, 75% of the N, and 97% of the P measured in dominant pools in the system (Fig. 3.5 [in source material]). As I predicted, loricariids dominated the particulate P pool due to their high body P content (Figure 3.9 [in source material]); however, my data also indicated loricariids stored half of the carbon and the majority of the N in the pools we sampled. Once again, these results are remarkable considering the short period of time loricariids have been documented in the Chacamax River."

4 Global Distribution

Figure 1. Known global distribution of *Pterygoplichthys pardalis*. Map from GBIF Secretariat (2018).

The location in Canada was not used as a source point for the climate match. The specimen was collected in 1991 and the collectors believed it to be an aquarium release (EDDMapS 2018). No records indicate an established population at this location.

The location in Illinois was not used as a source point for the climate match. There was no indication that there is an established population at this location.

The locations in North Carolina were not used as source points for the climate match. Nico et al. (2018) indicates that this location is thermally polluted and therefore not representative of the general climate of the area. The climate match program cannot account for this. Nico et al. (2018) lists the introduction in South Carolina as failed; this location was not used as a source point in the climate match.

The locations in Alabama were not used as source points for the climate match. The record details indicate that the record is the result of a laboratory specimen that was subsequently preserved for reference and not the result of an established population (GBIF Secretariat 2018).

The location near the southeastern coast of Brazil was not used as a source point for the climate match. The record is from 1867 and is outside the described range of the species in Brazil (GBIF Secretariat 2018) with no other sources indicating the presence of *Pterygoplichthys pardalis* outside of the Amazon basin in Brazil.

The locations in Spain were not used as source points for the climate match. Froese and Pauly (2018) indicated that *P. pardalis* was present in the aquarium trade in Spain but not in the wild. The records corresponding to these locations are not the result of live specimens (GBIF Secretariat 2018) and cannot be determined to represent established populations.

The location in Turkey identified in Emiroğlu et al. (2016) was not used as a source location for the climate match as the population is established in a hot spring fed stream. The thermally elevated waters cannot be accounted for in the climate matching program.

The record in Serbia was not used as a source location for the climate match as there was no indication of an established population (Simonović et al. 2010).

The location shown in Figure 1 in India were not used as source points for the climate match. The records indicate that the specimens were collected in a market (GBIF Secretariat 2018) and as such the location is not indicative of where the specimens were caught.

Additional source locations in India, Bangladesh, and Taiwan were provided in Muralidharan et al. (2015), Wu et al. (2011), and Hossain et al. (2018).

5 Distribution Within the United States

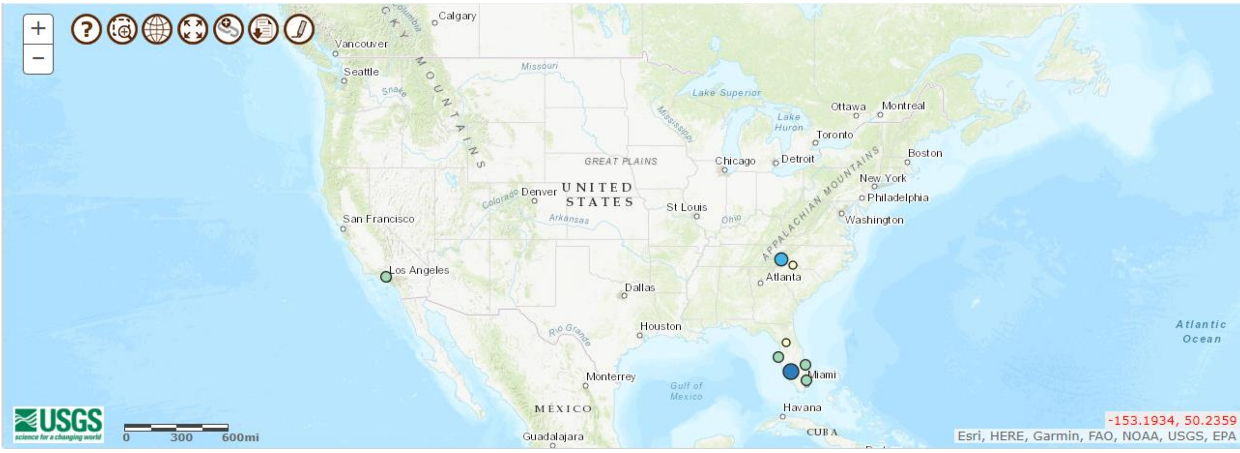

Figure 2. Known distribution of *Pterygoplichthys pardalis* in the contiguous United States. Map from Nico et al. (2018).

The locations in North Carolina were not used as source points for the climate match. Nico et al. (2018) indicates that this location is thermally polluted and therefore not representative of the general climate of the area. The climate match program cannot account for this. Nico et al. (2018) lists the introduction in South Carolina as failed; this locations was not used as a source point in the climate match.

Locations where the population is known to be composed of hybrids were not used as source locations in the climate match (i.e. Alabama (see Godwin et al. 2016)).

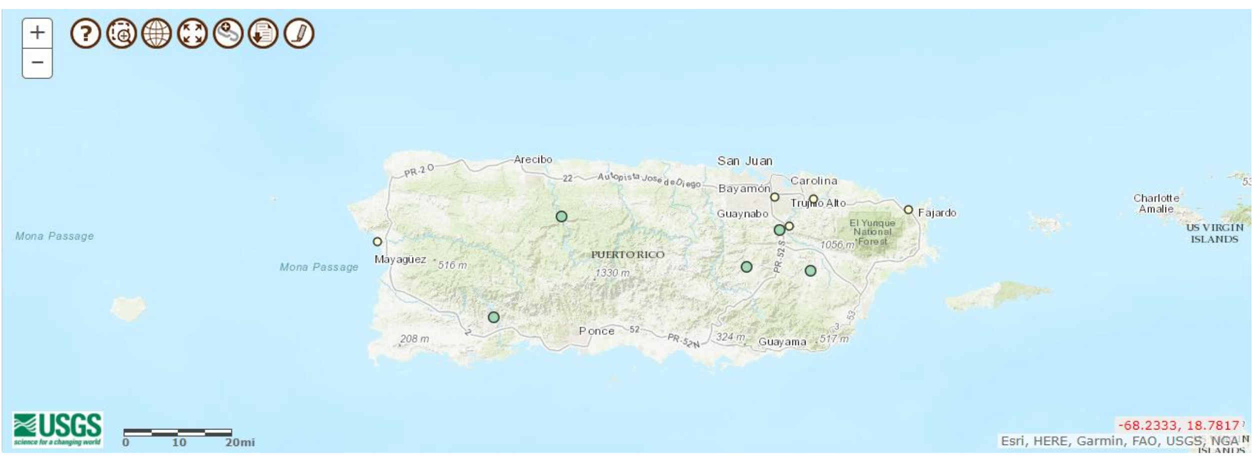

Figure 3. Known distribution of *Pterygoplichthys pardalis* in Puerto Rico. Map from Nico et al. (2018).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Pterygoplichthys pardalis* was high in Florida and along the southern Atlantic Coast, a small part of Texas' Gulf Coast and in much of California. The mid-Atlantic coast, the Gulf Coast between Texas and Florida, small areas along the Mexican border, and pockets in the western Rocky Mountains had a medium match. All other areas had a low climate match. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous U.S. was 0.063, medium. The following states had individually high climate matches: California, Florida, Georgia, North Carolina, and South Carolina.

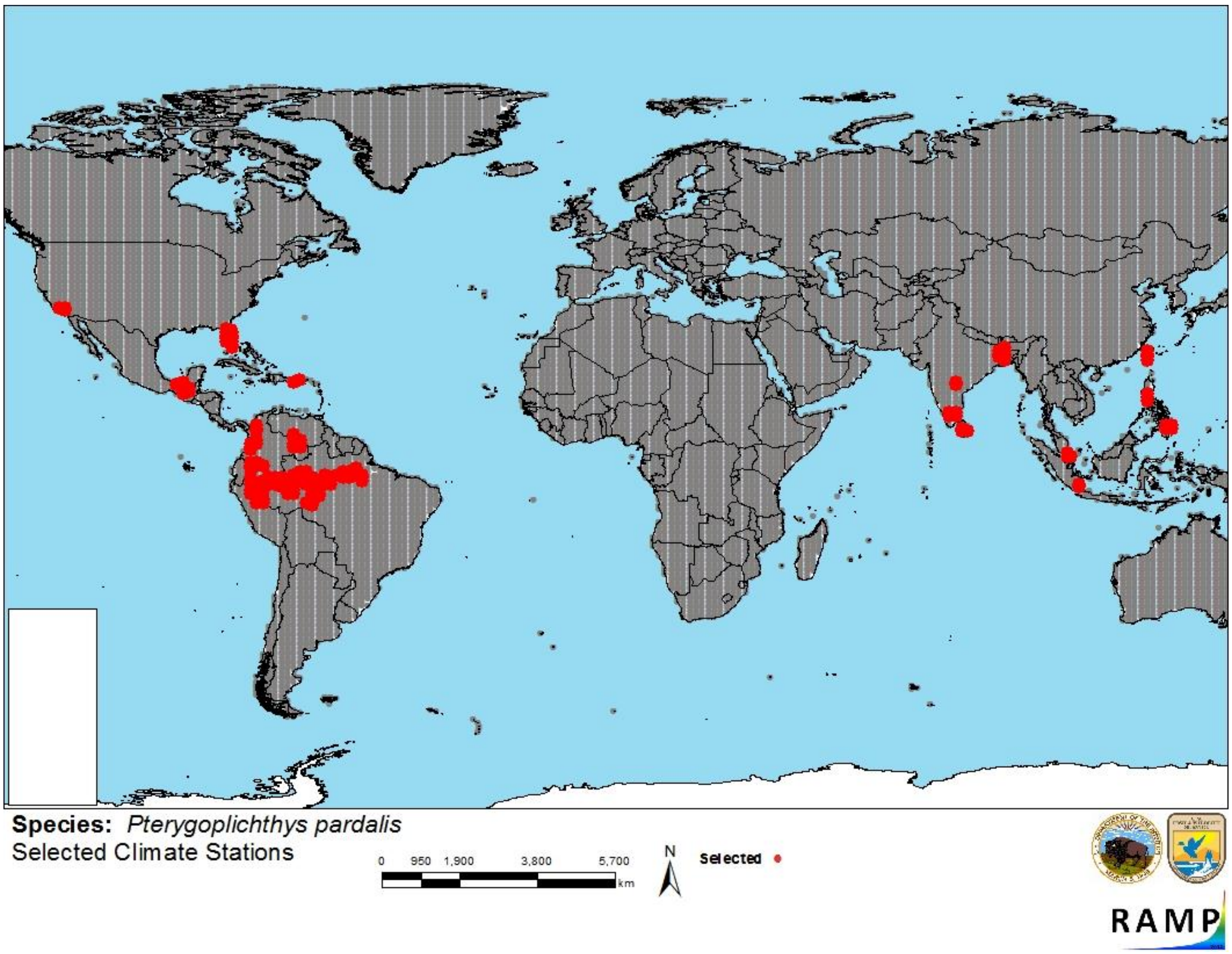

Figure 4. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Pterygoplichthys pardalis* climate matching. Source locations from Wu et al. (2011), Sumanasinghe and Amarasinghe (2013), Muralidharan et al. (2015), Rao and Sunchu (2017), EDDMapS (2018), GBIF Secretariat (2018), Hossain et al. (2018), and Nico et al. (2018).

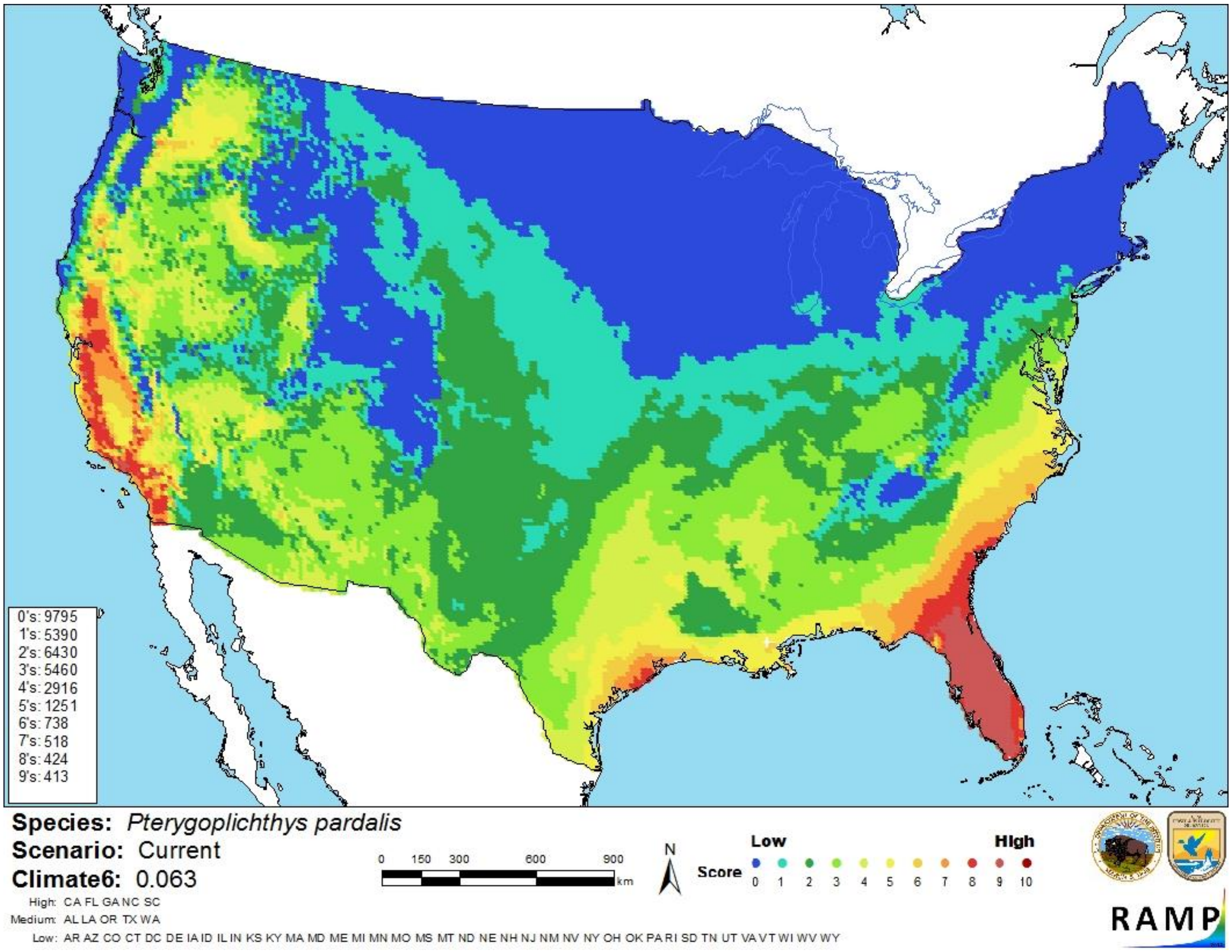

Figure 5. Map of RAMP (Sanders et al. 2014) climate matches for *Pterygoplichthys pardalis* in the contiguous United States based on source locations reported by Wu et al. (2011), Sumanasinghe and Amarasinghe (2013), Muralidharan et al. (2015), Rao and Sunchu (2017), EDDMapS (2018), GBIF Secretariat (2018), Hossain et al. (2018), 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

Certainty of assessment for *Pterygoplichthys pardalis* is high. Information on the biology of this species is readily available. Many records of introductions resulting in established populations were available. Information about actual, documented negative ecological and economic impacts were found.

8 Risk Assessment

Summary of Risk to the Contiguous United States

The history of invasiveness is high. *Pterygoplichthys pardalis* has been introduced to several countries in Southeast Asia, India, Puerto Rico, and the contiguous United States. Within the U.S., populations have established in Florida, North Carolina (in thermally altered waters), and California. Negative impacts on the economics of local fishermen, populations of native fish, and nutrient cycling were documented. This species has a medium climate match with the contiguous U.S. The certainty of assessment is high. Overall risk for this species is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): Medium**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information** This species readily hybridizes with other members of the *Pterygoplichthys* genus.
- **Overall Risk Assessment Category: High**

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