Asian Swamp Eel (*Monopterus albus*)

Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, February 2011
Revised, May 2017
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Photo: L. Nico, U.S. Geological Survey.

1 Native Range and Status in the United States

Native Range

From Fuller et al. (2017):

"Asia, from northern India and Burma to China, perhaps Asiatic Russia, Japan, and the Indo-Malayan Archipelago (Bailey and Gans 1998); possibly northeastern Australia (Merrick and Schmida 1984). Because of taxonomic confusion and the probability of crytic undescribed taxa included within the nomen *M. albus* (Collins et al. 2002), this range description for the species *M. albus* is probably overly broad."

Status in the United States

From Fuller et al. (2017):

"**Nonindigenous Occurrences:** It was first found in 1994 in three spring-fed impoundments in Georgia (Chattahoochee River drainage) at the Chattahoochee Nature Center in Roswell, Fulton County, and the Chattahoochee River National Recreation Area, Gwinnett County (Starnes et al. 1998; Tilmant 1999). In the late 1990s, this species was discovered in several waterways in peninsular Florida near Tampa, Homestead, and Miami (Collins et al. 2002; L. Nico, unpublished data), and in the Everglades National Park (Kline et al. 201[4]). This species was introduced to Oahu, Hawaii, before 1900 (Brock 1960; Maciolek 1984; Devick 1991a, b). It is established on the island of Oahu, Hawaii (Mundy 2005). Swamp eels were also found in Silver Lake, Gibbsboro, New Jersey, in September 2008 (C. Smith, personal communication). It is possible a different species was released in the Passaic River, New Jersey […] However, that release was not well documented and no specimens were examined."

"**Status:** Established in Florida (Shafland et al. 2010), Georgia (Starnes et al. 1998), and Hawaii (Devick 1991b). Status in New Jersey is unknown."

Means of Introduction

From Fuller et al. (2017):

"Its introduction into Florida was probably the result of either an aquarium release, a fish farm escape or release, or release of specimens from the life [*sic*] food-fish market. The Tampa population is near a former fish farm. Colorful specimens may indicate selective breeding for the aquarium trade. They are a popular ethnic food item and may have been released by that trade. The eel was probably introduced into Georgia as an aquarium release. In Georgia, adults were first collected in 1994, although they were likely present since 1990 or before (Starnes et al. 1998; Turkewitz 2006). It was presumably brought to Hawaii by Asian immigrants as a food fish (Devick 1991b). Brock (1960) stated that it was established in Hawaii prior to 1900. Devick (1991b) listed it as one of six fish species that were successfully introduced into Hawaii in the 19th century. However, Cobb (1902) and Jordan and Evermann (1902, 1905) made no mention of finding the species in their turn-of-the-century surveys of Hawaiian fishes."

Remarks

From Fuller et al. (2017):

"Genetic analysis indicates that there have been multiple introductions from different geographic areas (Collins et al. 2002). The Atlanta population is from Japan or Korea; Florida populations in Tampa and North Miami are from Southern China while the population in Homestead is from Indo-China, the Malay Peninsula, or the East Indies (Collins et al. 2002). […] The taxonomy of the genus *Monopterus* is in need of systematic review. *Monopterus albus* was initially thought to be a single species, but subsequent study has shown four known populations of this "species" (in Florida and Georgia) may actually be three genetically distinct (yet morphologically similar/identical) species or taxa, each from a different area of Asia (Collins et al. 2002)."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2017):

"Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Acanthopterygii
Order Synbranchiformes
Suborder Synbranchoidei
Family Synbranchidae
Genus *Monopterus*
Species *Monopterus albus* (Zuiew, 1793)"

"Current Standing: valid"

Size, Weight, and Age Range

From Froese and Pauly (2017):

"Max length : 100.0 cm SL male/unsexed; [Davidson 1975]; common length : 40.0 cm SL male/unsexed; [Allen et al. 2002]"

Environment

From Froese and Pauly (2017):

"Freshwater; brackish; demersal; potamodromous [Riede 2004]; depth range 3 - ? m [Davidson 1975]."

"[…] 25°C - 28°C [Baensch and Riehl 1985; assumed to be recommended aquarium temperature range]"

From Fuller et al. (2017):

"Swamp eel populations in Florida show significant extended tolerance to moderate salinity levels (up to 14-16 ppt), suggesting that coastal and estuarine areas are potential pathways for dispersal (Schofield and Nico 2009)."

Climate/Range

From Froese and Pauly (2017):

"Tropical; […] 34°N - 6°S"

From Fuller et al. (2017):

"Laboratory studies show that swamp eels stopped feeding at 14-16ºC and died at 8-9ºC (Shafland et al. 2010). This temperature coincides with a range that would not extend farther north than Jacksonville, Florida (Shafland and Pestrak 1982). However, the Georgia population has survived air temperatures below freezing and ice cover over their pond habitat (Starnes et al. 1998) for many years indicating that it is different genetically (as determined by Collins et al. 2002). Collins et al. (2002) predicted these ecological differences based on genetics."

Distribution Outside the United States

Native

From Fuller et al. (2017):

"Asia, from northern India and Burma to China, perhaps Asiatic Russia, Japan, and the Indo-Malayan Archipelago (Bailey and Gans 1998); possibly northeastern Australia (Merrick and Schmida 1984). Because of taxonomic confusion and the probability of crytic undescribed taxa included within the nomen *M. albus* (Collins et al. 2002), this range description for the species *M. albus* is probably overly broad."

From NIES (2017):

"Possibly Ryukyu Archipelago, Japan."

Introduced

From NIES (2017):

"[Japan:] Tokyo, Ibaraki, Kanagawa, Shizuoka, Aichi, Mie, Wakayama, Kyoto, Nara, Osaka, Tokushima, Kagawa, Ehime, and Kagoshima Prefs."

From Guerrero (2014):

"The four fishes introduced for culture in the [Philippines] that have become invasive are the *Channa striata*, *Clarias batrachus*, *Monopterus albus* and *Oreochromis mossambicus*."

Means of Introduction Outside the United States

From NIES (2017):

"Deliberate: Possibly escape of pet animal."

Short Description

From Froese and Pauly (2017):

"Anguilliform body; no scales; no pectoral and pelvic fins; dorsal, caudal and anal fins confluent and reduced to a skin fold; gill openings merged into single slit underneath the head [Kottelat 1998]. Rice paddy eels are red to brown with a sprinkling of dark flecks across their backs; large mouths and small eyes [Yamamoto and Tagawa 2000]."

Biology

From Froese and Pauly (2017):

"Found in hill streams to lowland wetlands [Vidthayanon 2002] often occurring in ephemeral waters [Allen et al. 2002]. Adults are found in medium to large rivers, flooded fields and stagnant waters including sluggish flowing canals [Taki 1978; Rainboth 1996], in streamlets and estuaries [Menon 1999]. Benthic [Mundy 2005], burrowing in moist earth in dry season surviving for long periods without water [Davidson 1975]. Occasionally dug out in old taro fields, in Hawaii, long after the field has been drained; more frequently observed in stream clearing operations using heavy equipment to remove large amounts of silt and vegetation where the eels are hidden [Yamamoto and Tagawa 2000]."

"Male builds a large free-floating bubblenest among the submerged vegetation close to the shoreline; eggs are spat into the nest after being laid; male guards the nest and continues to guard the young after hatching till they are on their own [Yamamoto and Tagawa 2000]. Spawning occurs in shallow water [Baensch and Riehl 1985]."

From Fuller et al. (2017):

"Swamp eels are generally found in slowly moving freshwater regions. They are noctural, and will often burrow into soft sediments or occupy crevices and small spaces (Shafland et al. 2010). In their native range, Asian Swamp Eel consumes a wide variety of invertebrate and vertebrate prey including fish (Yang et al. 1997; Cheng et al. 2003; Hill and Watson 2007). Hill and Watson's (2007) investigation into the diet of an introduced population near Tampa, Florida, revealed prey items such as amphipods, crayfish, fish, fish eggs, insects, oligochaetes, organic material, plant material and a tadpole. Shafland et al. (2010) found primarily fish (in 56% of stomachs), crustaceans (32%) (mostly crayfish), and insects (27%). Fish species included Swamp Darter (*Etheostoma fusiforme*), Bluefin Killifish (*Lucania goodei*), Eastern Mosquitofish (*Gambusia holbrooki*), other swamp eels, Fat Sleeper (*Dormitator maculatus*), Largemouth Bass (*Micropterus salmoides*), Mayan Cichlid (*Cichlasoma urophthalmus*), Tadpole Madtom (*Noturus gyrinus*), Bluegill (*Lepomis macrochirus*), Jaguar Guapote (*Parachromis managuensis*), African Jewelfish (*Hemichromis letourneuxi*), Black Acara (*Cichasoma bimaculatum*), and Spotted Sunfish (*Lepomis punctatus*). Swamp eels had also eaten mollusks, frogs, a turtle, fish eggs, and a snake's head. Shafland et al. (2010) gives further details on size and frequency of prey items, as well as comparison of day and night feeding."

"This species is a sequential hermaphrodite: all individuals are born and mature as females and some later transform into males (Liem 1963; Shafland et al. 2010). Populations studied in south

Florida tend to be heavily skewed towards females (90-98%; Shafland et al. 2010). In Snake Creek, individuals transitioning ranged in size from 694-782 mm TL, whereas the smallest male observed at another location was 434 mm TL. The smallest mature female was 318 mm TL and the smallest mature male was 434 mm TL (Shafland et al. 2010). A mature female averaged 439 (range 268-642) eggs (Shafland et al. 2010)."

"This species can breathe air, using atmospheric oxygen absorbed via a vascularized breathing apparatus at the rear of their mouths (Shafland et al. 2010)."

"Long and LaFleur (2011) used otoliths to estimate average daily growth rates and hatching dates for juvenile swamp eels in the Chattahoochee River, Georgia population, with an estimated growth rate of 0.2 cm/day."

"Although there are reports of this species moving over land, Shafland et al. (2010) found no evidence of that after studying them for many years. They are also reputed to be able to live out of water for a considerable length of time (Day 1958)."

Human Uses

From Froese and Pauly (2017):

"Fisheries: commercial; aquaculture: commercial; aquarium: commercial"

"Marketed fresh and can be kept alive for long periods of time as long as the skin is kept moist [Rainboth 1996]. Good flesh [Davidson 1975]. Important fisheries throughout Southeast Asia [Vidthayanon 2002]."

From Guerrero (2014):

"The rice paddy eel, *Monopterus albus*, earlier reported to be a "pest" in Northern Luzon is now a major export commodity and may no longer be considered invasive."

Diseases

From Froese and Pauly (2017):

"*Trypanosoma* Infection, Parasitic infestations (protozoa, worms, etc.)
Pallisentis Infestation, Parasitic infestations (protozoa, worms, etc.)
Dentiphilometra Infestation, Parasitic infestations (protozoa, worms, etc.)
Proleptinae Disease (general sp. larvae), Parasitic infestations (protozoa, worms, etc.)
Eustrongylides Disease (larvae), Parasitic infestations (protozoa, worms, etc.)"

Threat to Humans

From Froese and Pauly (2017):

"Harmless"

From Cole et al. (2014):

"Gnathostomiasis is a major foodborne parasitic zoonosis and a notable public health problem in areas where raw or undercooked freshwater fish are consumed by humans. […] Infected persons can exhibit intermittent migratory subcutaneous swellings, which often recur over several years because of larval migrans. In some instances, larvae migrate into deeper tissues, causing visceral gnathostomaisis [*sic*], which can be fatal if the larvae invade the central nervous system [Waikagul and Diaz Chamacho 2007]. […] Our data show that live swamp eels imported to the United States from gnathostome-endemic areas could serve as a source of infection to humans in the United States."

3 Impacts of Introductions

From Fuller et al. (2017):

"Largely unknown. Because they are generalized predators, this species is a potential threat to native fishes, frogs, and aquatic invertebrates. In both Georgia and Florida there is concern that the species will spread to adjacent water bodies as has occurred in the Everglades region of Florida (Kline et al. 201[4]). The Georgia impoundments are connected to the Chattahoochee River. Shafland et al. (2010) studied swamp eel populations established in south Florida and reported no deleterious ecological effects, although it should be noted that the investigators focused on populations inhabiting canals and associated waterways, habitats already highly disturbed. In addition, their study was largely interested in possible harm caused by swamp eels to sport fishes. Nico et al. (2011) examined the occurrence of internal parasites in both imported, wild-caught swamp eels from a U.S. retail food market and from an introduced population in Florida, finding parasites in nearly all specimens and highlighting the potential of *Monopterus* as a vector for introduction of macroparasites."

From CABI (2017):

"When burrowing nests to wait out the dry periods, they may play a part in altering the habitat under ponds and swampy areas. The burrows they dig may become large and branched reaching up to 1.5 m in depth. Hence swamp eels may accelerate the drying of ponds where they are abundant (Aguirre and Poss, 1999)."

From NIES (2017):

"Damaging rice field by digging."

From Hill and Watson (2007):

"Despite our expectations […] our sampling results suggest that the Asian swamp eel is not a serious pest species for tropical ornamental aquaculture and represents less of a predation risk than anticipated. Although Asian swamp eels were found in production ponds on farms, the results of considerable sampling effort indicate the density was apparently low. Moreover, over half of the sampled Asian swamp eels had empty stomachs and the remaining stomachs contained relatively low numbers and weight of prey. Of the observed prey, only a small number

was ornamental fish. Therefore, the expected negative effect of this introduced species in aquaculture ponds should be small (the product of a low apparent per capita consumption of ornamental fishes and a low apparent density of predators)."

From Guerrero (2014):

"The rice paddy eel (*M. albus*) has been reported to infest rice paddies in the Cagayan Valley. Locally known as "kiwet," it feeds on small fish, frogs and shrimp, and burrows into the bunds of the paddies causing water loss (Lazaro 2013, Valencia 2013)."

From Gonzales (2014):

"In the Philippines, rice scientists are worried about *Monopterus albus* on their potentially damaging impact on rice fields. Farmers observed that these survive long period of drought by burrowing in the moist earth such as dikes and rice fields. The burrowed holes destroy the rice dikes affecting irrigation during the vegetative stage of rice resulting to water loss that affects nutrient management. Farmers first reported the rice paddy eel as a pest to the Bureau of Fisheries and Aquatice Resources (BFAR) in Tuguegarao, Cagayan two years ago complained that these swamp eels were eating fingerlings in fishponds. PhilRice declared then the rice paddy eels as "an indirect pest" during the last dry season of 2010 [Icamina 2011]. Rice farmers in some parts of Nueva Ecija and 2 other provinces reported that *Monopterus albus* appeared in their farms and damaged their irrigation dikes."

4 Global Distribution

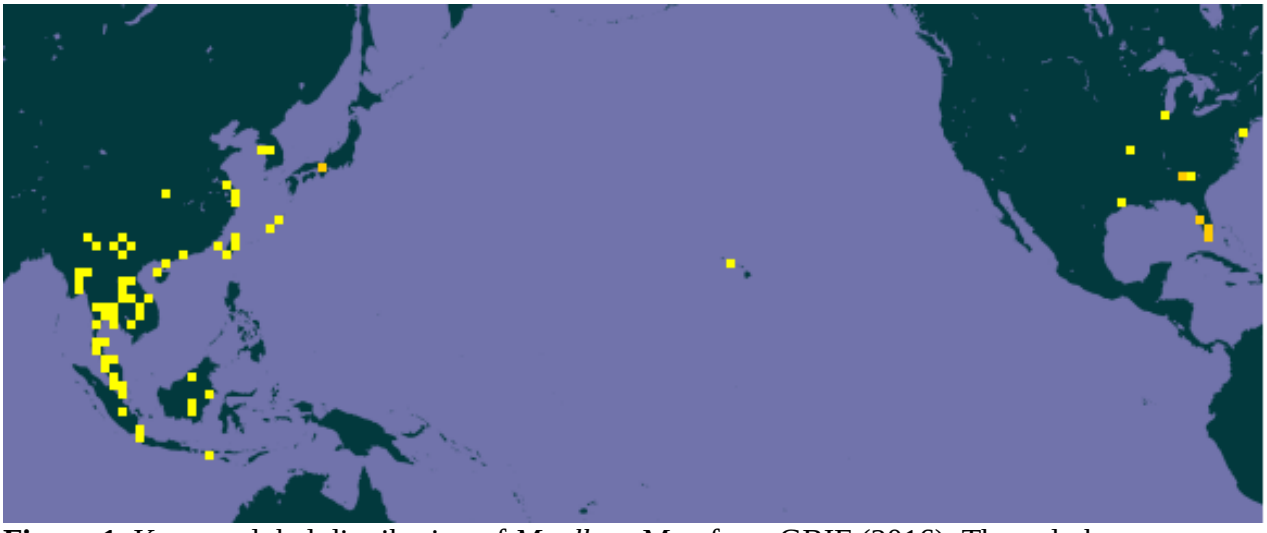

Figure 1. Known global distribution of *M. albus*. Map from GBIF (2016). The only known established populations in the U.S. are in the states of Georgia, Florida, and Hawaii. Two points near Tasmania were omitted from this map because of a lack of evidence that these points represent established populations.

5 Distribution in the United States

Figure 2. Known distribution of *M. albus* in the United States. Map from Fuller et al. (2017). Location in New Jersey has not been confirmed as an established population.

6 Climate Matching

Summary of Climate Matching Analysis

The climate match (Sanders et al. 2014; 16 climate variables; Euclidean Distance) was high in the Southeast, particularly peninsular Florida and northern Georgia where populations are already established. Medium matches covered much of the Mid-Atlantic, coastal New England, Central Plains, and Midwest regions. Low matches covered the West, northern New England and New York, and Lake Superior. Climate 6 proportion indicated that the contiguous United States has a high climate match. The range of proportions indicating a high climate match is 0.103 and greater; the Climate 6 proportion for *M. albus* was 0.173.

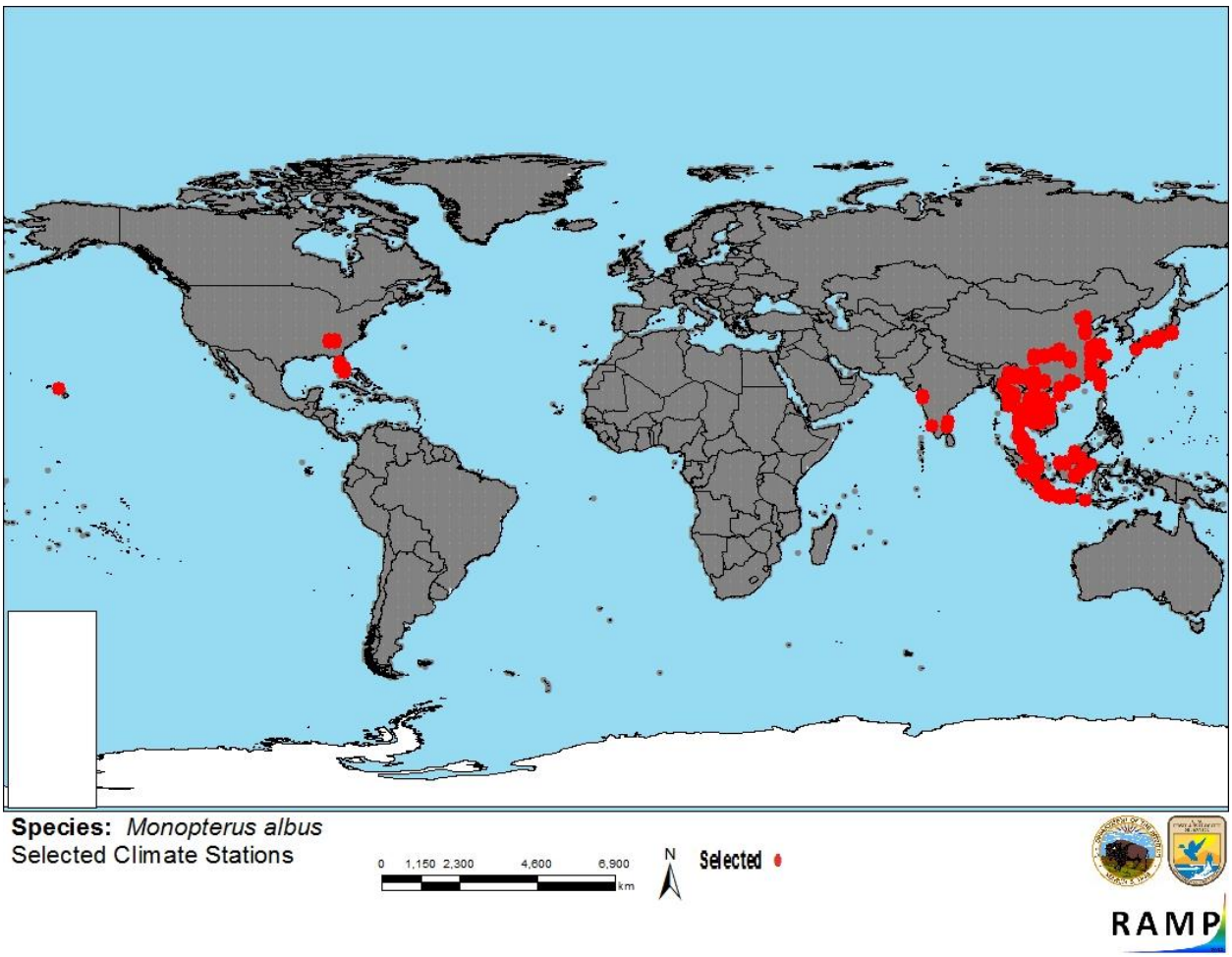

Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *M. albus* climate matching. Source locations from GBIF (2016) and NIES (2017).

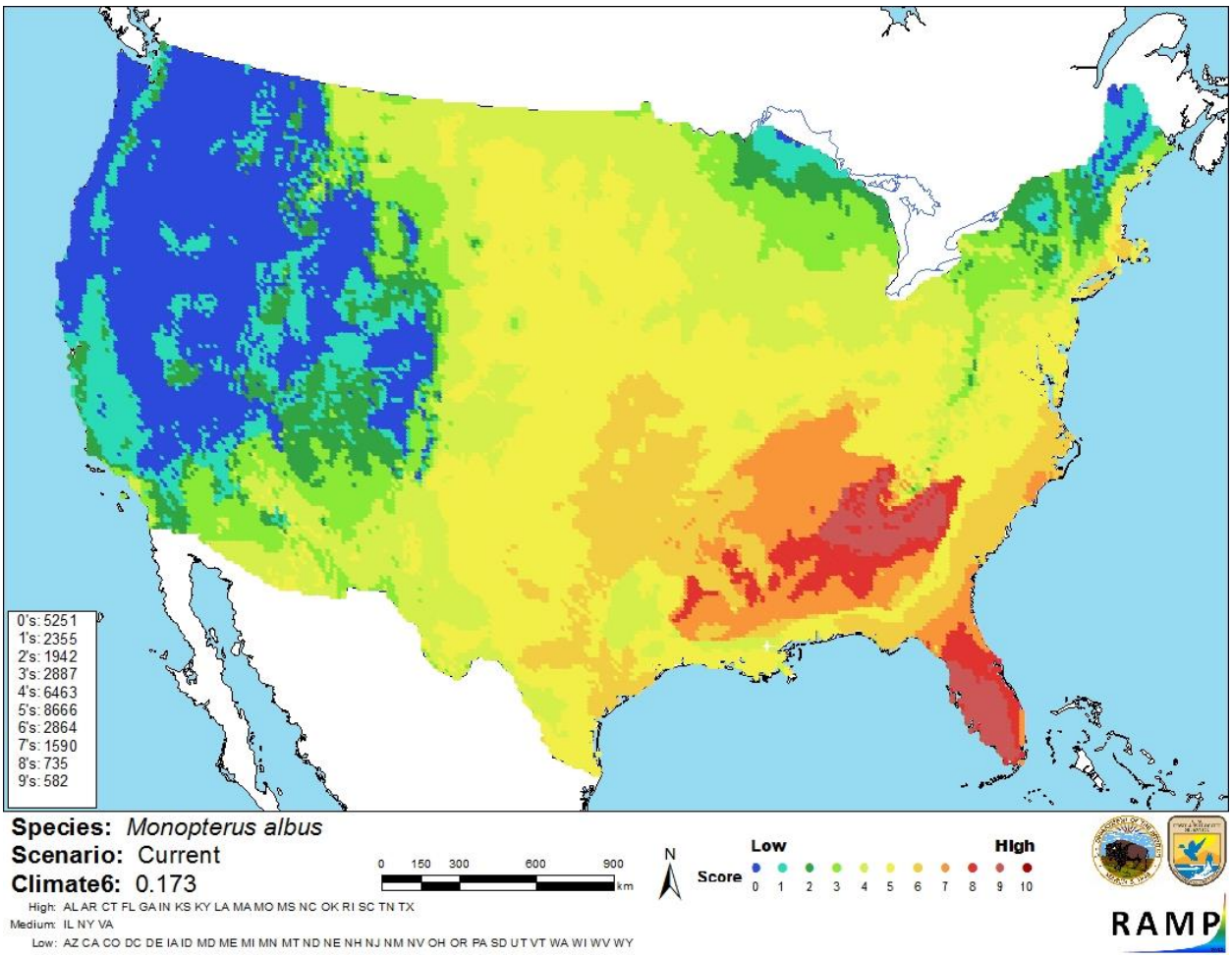

Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *M. albus* in the contiguous United States based on source locations reported by GBIF (2016) and NIES (2017). 0=Lowest match, 10=Highest match. Counts of climate match scores are tabulated on the left.

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≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

Information is available on the biology, ecology, and distribution of *M. albus*. However, the information available on impacts of introduction is conflicting and much comes from anecdotes rather than scientifically rigorous research. Additionally, uncertainty exists regarding taxonomic relationships between different established populations. Because of these factors, the certainty of assessment is low.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Monopterus albus, an eel species with a broad native distribution in Asia, is established in several U.S. locations. In the U.S., the species has not been shown to detrimentally impact native communities or aquaculture, but its burrowing behavior has been reported to damage rice fields in the Philippines and Japan. Without further robust scientific study, the history of invasiveness cannot be rated as "high". *M. albus* is a popular food fish among certain communities, and consumption of raw or undercooked *M. albus* can result in serious parasitic infections. Climate match to the contiguous U.S. is high, with areas of highest match occurring in the southeastern U.S. Overall risk to the contiguous U.S. is uncertain at this time.

Assessment Elements

- **History of Invasiveness: None Documented**
- **Climate Match: High**
- **Certainty of Assessment: Low**
- **Overall Risk Assessment Category: Uncertain**

9 References

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10 References Quoted But Not Accessed

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