Oscar (*Astronotus ocellatus*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, January 2025
Revised, May 2025
Web Version, 6/13/2025

Organism Type: Fish
Overall Risk Assessment Category: Uncertain

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1 Native Range and Status in the United States

Native Range

From Fricke et al. (2025):

"South America: Amazon River basin, Brazil, Bolivia, Colombia, French Guiana and Peru."

From Froese and Pauly (2025):

"South America: western Amazon and Orinoco basins."

Status in the United States

From Nico et al. (2025):

"**Status:** Established in south Florida, Hawaii, and Puerto Rico. Failed in Alaska, Arizona, California, Georgia, Indiana, Louisiana, Maryland, Massachusetts, Minnesota, Mississippi, Ohio, Nebraska, New Jersey, North Carolina, Pennsylvania, Rhode Island, South Carolina, Texas, Vermont, Virginia, and Wisconsin."

"The distribution and abundance of this species in south Florida fluctuate widely based on the prevalence of cold temperatures (Shafland et al. 2008). […] Oscars have been established in Miami-Dade County, southeastern Florida, since late 1950s, but began to expand range greatly in late 1970s and early 1980s (Hogg 1976a, b; Courtenay and Stauffer 1990; Fury and Morello 1994)."

Nico et al. (2025) also report introductions that failed in Arkansas and Oklahoma.

Nico et al. (2025) report introductions with unknown outcome to the following states: Alabama, Kentucky, Missouri, Montana, Nevada, New York, and Utah.

According to Maddern (2014), *Astronotus ocellatus* has been introduced to Guam, where it is "Said to be established but current status unknown."

From Monticini (2010):

"Florida dominates freshwater ornamental fish culture with about 200 farms raising over 800 freshwater fish strains. The most important ornamental fish families for breeding in Florida are listed below. […] Cichlidae: all Central and South American cichlids (e.g. […] *Astronotus ocellatus*, […]) […]"

According to Chapman et al. (1997), *Astronotus ocellatus* comprised 0.9% of ornamental freshwater fish imports to the United States in 1971 and 1.2% of imports in 1992.

Rixon et al. (2005) recorded *Astronotus ocellatus* for sale in 70% of aquarium and pet stores sampled in Michigan and Ontario, Canada.

Regulations

Astronotus ocellatus is regulated at the genus level (*Astronotus*) in Hawaii (HDOA 2019). Please refer back to state agency regulatory documents for details on the regulations, including restrictions on activities involving this species. While effort was made to find all applicable regulations, this list may not be comprehensive. Notably, it does not include regulations that do not explicitly name this species or its genus or family, for example, when omitted from a list of authorized species with blanket regulation for all unnamed species.

Means of Introductions within the United States

From Nico et al. (2025):

"The first Florida records were the result of deliberate stockings from an aquarium fish farm in southeastern Dade County in the late 1950s (Courtenay et al. 1974; Courtenay and Hensley [1979]; Courtenay and Stauffer 1990; Jackson 1999). During the same period, attempts were made to popularize the species as a sport fish under the name "velvet cichlid." Anglers have aided dispersal in Florida by transporting fish to new locations (Courtenay et al. 1974). It was sighted at the Anhinga Trail in Everglades National Park in the late 1980s (Loftus and Kushlan 1987). It apparently gained access to the park by way of the South Florida Water Management District's Canal L31W, and it is now considered established (Courtenay 1989). The first introduction of this species into Hawaii was in 1952, for purposes of recreational fishing (Devick 1991a, b); Hawaii's Division of Fish and Game made additional reservoir stockings in 1958; the original source of the Hawaii plants was a small stock obtained from Steinhart Aquarium in San Francisco (Brock 1960). Introductions into all other states and in more northern portions of Florida are apparently the result of aquarium releases (Courtenay and Stauffer 1990; Nico, personal communication)."

"Oscars are very common in the aquarium trade. Because they grow large in aquaria and are piscivorous, individuals are likely to be released into natural waters by aquarists loathe to kill their pets. This likely accounts for the numerous instances of single specimen records from both temperate and subtropical states."

From Maddern (2014):

"*A. ocellatus* has been widely dispersed in the USA as a sportfish (USGS-NAS, 2014). […] Therefore, as *A. ocellatus* is considered a desirable sportfish by sections of the general public there is the potential for the species to be deliberately spread by recreational anglers (USGS-NAS, 2014)."

Remarks

This ERSS was previously published in July 2018. Revisions were completed to incorporate new information and conform to updated standards.

From Nico et al. (2025):

"Unfortunately, the taxonomy of this group is problematic and future research may determine that some oscars in the aquarium trade, as well as those taken in U.S. waters, are not *A. ocellatus* but another member of the genus (S. O. Kullander, personal communication). To confound the issue, artificial breeding has produced several color variants (Axelrod 1993), and genetic analyses have suggested the presence of morphologically [sic] cryptic species within *Astronotus* (Colatreli et al. 2012)."

Astronotus ocellatus has been intentionally stocked outside its native range within the United States by State fishery managers to achieve fishery management objectives. State fish and wildlife management agencies are responsible for balancing multiple fish and wildlife

management objectives. The potential for a species to become invasive is now one important consideration when balancing multiple management objectives and advancing sound, science-based management of fish and wildlife and their habitat in the public interest.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2025):

Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Acanthopterygii
Order Perciformes
Suborder Labroidei
Family Cichlidae
Genus *Astronotus*
Species *Astronotus ocellatus* (Agassiz in Spix and Agassiz, 1831)

According to Fricke et al. (2025), *Astronotus ocellatus* (Agassiz 1831) is the current valid name for this species. In addition to the valid scientific name, the following synonyms of *Astronotus ocellatus* from Fricke et al. (2025) were used to search for information for this report: *Acara compressus*, *Acara hyposticta*, *Astronotus orbiculatus*, *Lobotes ocellatus*.

Size, Weight, and Age Range

From Maddern (2014):

"*A. ocellatus* grows to 35-45 cm TL [total length], though usually to 20-28 cm TL."

"*A. ocellatus* reaches sexual maturity at about 12 cm TL and may live from 10-20 years (Robins, 2007)."

From Froese and Pauly (2025):

"[…] max. published weight: 1.6 kg [IGFA 2001]."

Environment

From Froese and Pauly (2025):

"Freshwater; benthopelagic; pH range: 6.0 - 8.0; dH range: 5 – 19."

From Maddern (2014):

"It has broad temperature tolerances, though higher temperatures are required for reproduction. Reported critical thermal minimum of 12.9°C Shafland and Pestrak (1982) [sic], though temperatures of greater than 25°C may be required for spawning (ACTFR, 2007). Lowe-McConnell (1987) reported water temperature ranges of 23-34°C in rivers and pools within the Amazon basin where *A. ocellatus* occurs."

"*A. ocellatus* is likely to be stenohaline, though critical salinity tolerance range is unknown. Based on its distribution (mid and upper reaches of rivers in the Amazon and Orinoco basins) the species is highly likely to have limited salinity tolerance (ACTFR, 2007; Froese and Pauly, 2014)."

"*A. ocellatus* is reported to be highly hypoxia-tolerant (Muusze et al., 1998), and may utilise surface respiration to help mitigate hypoxia (Kramer and McClure, 1982). Muusze et al. (1998) reported that the species may reduce its metabolic rate in hypoxic conditions. It can survive severe hypoxia (dissolved oxygen < 0.4 mg/l) and even 4 hrs of complete anoxia at 28 °C (Muusze et al., 1998)."

Climate

From Froese and Pauly (2025):

"Tropical; […]"

Distribution Outside the United States

Native

From Fricke et al. (2025):

"South America: Amazon River basin, Brazil, Bolivia, Colombia, French Guiana and Peru."

From Froese and Pauly (2025):

"South America: western Amazon and Orinoco basins."

Introduced

From Jawad et al. (2022):

"It has been reported as introduced or established in […] Australia, Poland, Singapore, and southern Brazil (Ng et al., 1993; Fury and Morello, 1994; Nowak, et al., 2008; Webb, 2008; Julio Junior et al., 2009; Nico et al., 2014)."

"The first record of a single specimen of oscar, *Astronotus ocellatus*, native to Amazon basin of Peru, Colombia and Brazil, is reported from the inland waters of Iraq. The specimen was caught

from one of the branches of the Euphrates River to the east of the Barnun city, ca. 5 km to the NW of Hilla city in Babylon Province in central Iraq in December 2021 using rod and line."

From Maddern (2014):

"Within Australia, successful introductions of *A. ocellatus* were first recorded at two locations in Queensland (northern Australia) in 1998. It has been recorded within the Ross River around Townsville and creeks around Cairns (Corfield et al., 2008). A single specimen was collected in an ornamental pond in the Australian Capital Territory in 2011 (RiotACT, 2014). This fish was collected during summer and would not have survived the temperate winter."

According to Maddern (2014), *Astronotus ocellatus* has also been introduced to the Philippines. No information was found on establishment status in this location.

From Tan et al. (2020):

"Distribution [in Singapore]. Singapore Botanic Gardens (Liew et al., 2012), Bishan Park (Tan HH, pers. obs., March 2017)."

Tan et al. (2020) do not consider *A. ocellatus* to have an established breeding population in Singapore.

From Witkowski (2002):

"Also reported [in Poland] are some single individuals of the velvet cichlid (*Astronotus ocellatus*), […]"

From Latini and Petrere (2004):

"The Parque Estadual do Rio Doce, an important reserve within the Atlantic Forest biome, is located in the middle River Doce, southeastern Brazil. The peacock cichlid, *Cichla* cf *monoculus* Spix & Agassiz, oscar, *Astronotus ocellatus* (Agassiz), and red piranha, *Pygocentrus nattereri* Kner, were introduced into lakes neighbouring this Park, later reaching the lakes within the reserve area (Sunaga & Verani 1985, 1987; Godinho & Formagio 1992)."

From Magalhães et al. (2019):

"The Muriaé Ornamental Aquaculture Center (Magalhães and Jacobi 2013); was founded in 1979 and is located on the drainage of Upper Muriaé River (length: 250 km, drainage area: 8,292 km^2), Glória River sub-basin (length: 101 km, drainage area: 1,045 km^2) in state of Minas Gerais, Paraíba do Sul River basin [Brazil]. The area comprises 13 cities and two villages with more than 350 fish farms and about 4,500 earthen/concrete ponds ranging from 4-m^2 to 70-ha water surface area (Magalhães and Jacobi 2016). Juveniles and adults [fish] were collected with sieves (0.3 mm mesh) every two months (January to December) in different years in seven headwater creeks […] Twelve samples were made at the Glória reservoir […] The occurrence of

juveniles and reproductive adults […]) of […] *A. ocellatus* was confirmed in all sites suggesting probable establishment by recruitment in the region […]"

According to FAO (2025), *Astronotus ocellatus* has been introduced to Canada, China, Italy, and Ivory Coast. It is not known to be established in any of these locations.

According to NOBANIS (2025), *Astronotus ocellatus* was introduced to Germany in 1987 and is not established.

Means of Introduction Outside the United States

From Maddern (2014):

"*A. ocellatus* is a popular ornamental species (Rixon et al., 2005; USGS NAS 2014). Researchers have speculated that the release of unwanted ornamental fishes is the most likely explanation for the nonindigenous populations in Australia […]"

From Magalhães et al. (2019):

"[…] unintentional escapes of production ponds, introduction into creeks and arrival in the Glória reservoir."

Short Description

From Froese and Pauly (2025):

"Dorsal spines (total): 12 - 14; Dorsal soft rays (total): 17 - 21; Anal spines: 3; Anal soft rays: 16 - 20. Large mouth with thick lips; 7 preopercular pores; first gill arch without lobe; gill rakers short and thick with many denticles; dorsal and anal fins bases densely scaled; many branched rays; body color dark with bright orange opercle margin and ventral parts of the lateral sides of the body; often a black rounded blotch with orange margin at caudal fin base [Keith et al. 2000]."

From Maddern (2014):

"*A. ocellatus* has an oval-shaped, laterally compressed body with a blunt head and large mouth with protrusible jaws. […] the eyes are large with orange/red iris."

"Juveniles are striped with white and orange wavy bands and white spots on the head."

"Various ornamental colour varieties have been produced by selective [sic] including copper/red and black mottled patterns and also albino forms. Long-finned varieties have also been produced."

Biology

From Maddern (2014):

"Fish mature at approximately one year and may be reproductively active for up to 9-10 years (Pinto-Paiva and Hilton Nepomucenko, 1989). Spawning is temperature dependant [sic] and may be restricted to warmer months (>25°C) in higher latitudes within its native or introduced range (ACTFR, 2007)."

"*A. ocellatus* is an oviparous substrate spawner with biparental care (Beeching, 1992). After a protracted courtship, males and females form breeding pairs. Adhesive eggs are laid on a cleaned flat rock, on woody debris or in a shallow pit excavated in substrate and both parents defend the nest site (Beeching, 1992). Fecundity is 300-2000 progeny per spawning (ACTFR, 2007). Eggs hatch in 3-4 days and parents move fry to another shallow pit in substrate where they remain for 6-7 days. Both parents continue to guard fry for several weeks (Baerends and Baerends-Van Roon, 1950; Fontinele, 1951)."

"*A. ocellatus* is omnivorous though predominantly carnivorous. Feeds on small fish, aquatic and terrestrial invertebrates, including crayfish, worms, insect larvae and molluscs, and even small vertebrates (Soares et al., 1986; Honebrink, 1990; Consoli et al., 1991; Fury and Morello, 1994; Froese and Pauly, 2014). May also consume fruits, benthic algae and water plants (Soares et al., 1986)."

Human Uses

From Froese and Pauly (2025):

"A highly esteemed food fish in South America [Yamamoto and Tagawa 2000]."

"Fisheries: commercial; gamefish: yes; aquarium: highly commercial"

From Maddern (2014):

"Economic Value
A. ocellatus is a popular ornamental species in Australia (Corfield et al., 2008), the United States (Rixon et al., 2005) and worldwide. It is considered of "High" importance as an ornamental fish in Australia, with the volume of fish sold ranked as "Medium" (between 10,000 and 100,000 fish sold annually Australia wide) (Corfield et al., 2008)."

"Social Benefit
A. ocellatus has been used as a model for behavioural research (Zaret, 1977; Beeching 1992; 1995; 1997)."

From Fury and Morello (1994):

"Recent peak season angler surveys in the Everglades [Florida, USA] have documented a substantial oscar fishery in terms of harvest and effort. […] Oscar ranked a close second behind largemouth bass (*Micropterus salmoides*) as the most sought after species."

According to Chapman et al. (1997), *Astronotus ocellatus* comprised 0.9% of ornamental freshwater fish imports to the United States in 1971 and 1.2% of imports in 1992.

Rixon et al. (2005) recorded *Astronotus ocellatus* for sale in 70% of aquarium and pet stores sampled in Michigan, USA, and Ontario, Canada.

Diseases

No information was found associating *Astronotus ocellatus* with any diseases listed by the World Organisation for Animal Health (2025).

From Raj et al. (2024):

"This manuscript investigates a mass mortality event that occurred among Oscar fish (*Astronotus ocellatus*) in two ornamental fish farms in Kerala, India. The affected fish displayed various clinical signs, including abnormal swimming behaviour, lethargy, damaged fins, and skin haemorrhages. […] PCR analysis confirmed the presence of infectious spleen and kidney necrosis virus (ISKNV) infection in the affected fish."

From Tavares-Dias and Neves (2017):

"The community composition of parasites was characterized in *Astronotus ocellatus* from a tributary of the Amazon River, northern Brazil. […] Nine taxa of ecto- and endo-parasites were found in the 33 specimens of *A. ocellatus*, prevalence was 87.9% and a total of 526,052 parasites were collected. The mean number of parasites per fish was 15,941, with a strong predominance of ectoparasites (mean of 15,935.8 per fish, cf. mean of 2.1 endoparasites per fish). Species of Protozoa, Monogenoidea, Digenea, Cestoda, Nematoda and Crustacea were collected from host specimens. The dominant species was *Ichthyophthirius multifiliis* Fouquet 1876, followed by metacercariae (*Posthodiplostomum* sp.) and *Gussevia asota* Kritsky, Thatcher and Boeger 1989 […]"

From Sreedharan et al. (2011):

"Pathogenic strains of *Aeromonas veronii* resistant to multiple antibiotics were isolated from *A. ocellatus* individuals showing signs of infectious abdominal dropsy. The moribund fish showed haemorrhage in all internal organs […]"

From Peyghan et al. (2010):

"Hole in the head is one of the important diseases of cichlid fishes that caused by Heximita or Spironucleus infections. In December 2007, a diseased Oscar was referred to the veterinary hospital, Shahid Chamran University, Ahvaz, Iran. Infected fish showed an initial loss of appetite, exophthalmia, darkness of skin followed by holes appearing on the head surface and a complete refusal to feed. […] Heavy flagellate infection was detected in the smears and the parasite recognized as Hexamita […]"

From Peyghan et al. (2019):

“Saprolegniosis is one of the most frequent diseases in the ornamental fish industry that may cause by *Achlya* spp. […] An Oscar fish was referred to the Veterinary Hospital, Shahid Chamran University of Ahvaz, Ahvaz, Iran with saprolegniosis symptoms including loss of appetite and yellow to gray cottony mass on the skin of flank and caudal peduncle. […] It is the first report of cutaneous saprolegniosis in Oscar caused by *Achlya* spp. in Iran.”

From Vishnupriya et al. (2024):

“In the present study, six isolates were resolved from the diseased Oscar fish showing haemorrhages, necrosis, and loss of pigmentation. After phenotypic and genotypic characterization, the bacteria were identified as *Edwardsiella tarda*, *Klebsiella pneumoniae*, *Enterococcus faecalis*, *Escherichia coli*, *Brevibacillus borstelensis*, and *Staphylococcus hominis*. Experimental challenge studies in healthy Oscar fish showed that *E. tarda* caused 100% mortality within 240 h […]”

From Tukmechi et al. (2009):

“Streptococosis [sic] infection in fish can cause high mortality rates (>50 %) over a period of 3 to 7 days. Some outbreaks, however, are more chronic in nature and mortalities may extend over a period of several weeks, with only a fish dying each day [Buller 2004]. The present report describes the occurrence of Streptococcosis in Yellow oscar. […] Clinical examination of the affected fish identified erratic swimming, loss of buoyancy control, unilateral and bilateral exophthalmia, corneal opacity, hemorrhages around the eye, the gill plate, base of fins, vent/anus, and other parts of the body; ascites and ulcerations […]”

According to Poelen et al. (2014), *Astronotus ocellatus* is a host for the following additional parasites and pathogens: *Goezia* spp., *Gussevia astronoti*, *Gussevia rogersi*, and *Mycobacterium fortuitum*.

Threat to Humans

From Froese and Pauly (2025):

“Harmless”

From Nico et al. (2025):

“In 1993, the state of Florida issued a health advisory warning people about eating freshwater fish contaminated with mercury. For portions of south Florida, the oscar was included in the list of fish for which limited consumption was recommended.”

3 Impacts of Introductions

From Fury and Morello (1994):

"The status of native fish displacement [in the Everglades] by the oscar is unknown, but no evidence of displacement has evolved from preliminary population data."

From Nico et al. (2025):

"Impact of Introduction: Largely unknown. In 1993, the state of Florida issued a health advisory warning people about eating freshwater fish contaminated with mercury. For portions of south Florida, the oscar was included in the list of fish for which limited consumption was recommended."

From Latini and Petrere (2004):

"The consequences of introducing *Cichla* cf. *monoculus* Spix & Agassiz, *Astronotus ocellatus* (Agassiz) and *Pygocentrus nattereri* Kner into lakes in the River Doce basin, Brazil, on richness, diversity and efficiency of aquatic macrophytes as natural refugia to native fishes was investigated. Samples were taken from lakes with and without alien fishes in areas with and without aquatic macrophytes. The presence of alien fishes reduced richness and diversity of the native fish community."

The following quotations detail **potential, anecdotal,** or **highly generalized** information on impacts of introduction from *Astronotus ocellatus*.

From Corfield et al. (2008):

"Under the right conditions, oscars can grow to a large size (40 cm) and have been shown to be capable of feeding on other small fish as well as on invertebrates. The males display aggressive behaviour to other fish during spawning and the species is known to 'burrow' into the substrate (probably during nest preparation). These attributes collectively indicate a relatively high behavioural potential for impact on native fish and invertebrates."

From Maddern (2014):

"*A. ocellatus* may burrow/modify the substrate during nest preparation when breeding. Corfield et al. (2008) speculated that this behaviour may potentially impact aquatic habitats, native fish and invertebrate communities."

"Within Florida, USA, *A. ocellatus* is considered a potential competitor with native centrarchids (sunfishes) for food and possibly for spawning areas (Courtenay and Hensley, [1979]), and as predators on native fishes and invertebrates. Similarly, Robins (2007) opined that the spread of the species in southern Florida may have a negative effect on centrarchids which have similar habitat and ecological needs."

"The behaviour of *A. ocellatus* may, in some circumstances, increase potential impacts on sympatric fishes. The species is territorial and dominance hierarchies are established through agonistic displays (Beeching, 1992). It is likely this agonistic behaviour will be directed not only at conspecifics but also sympatric fishes. Furthermore, Beeching (1992) found that in the laboratory *A. ocellatus* can assess the size of other fish visually. Smaller native fishes co-occurring with *A. ocellatus* are potentially more likely to be targeted and also more vulnerable to agonistic behaviour."

Astronotus ocellatus is regulated at the genus level (*Astronotus*) in Hawaii (HDOA 2019).

4 History of Invasiveness

The History of Invasiveness of *Astronotus ocellatus* is Data Deficient. There are established nonnative populations outside the native range. One report noted the presence of three nonnative fish species, including *A. ocellatus*, was correlated with reduced richness of the local fish community in the lakes of River Doce State Park, Brazil. However, it is unknown to what degree *A. ocellatus*, specifically, played a role in this outcome. Other sources discuss the invasiveness of *A. ocellatus* in terms of potential impacts but do not provide evidence of observed impacts. This species has been common in trade in the United States and globally, although the quantitative trade data found for this species were at least 20 years old at the time of writing of this ERSS.

5 Global Distribution

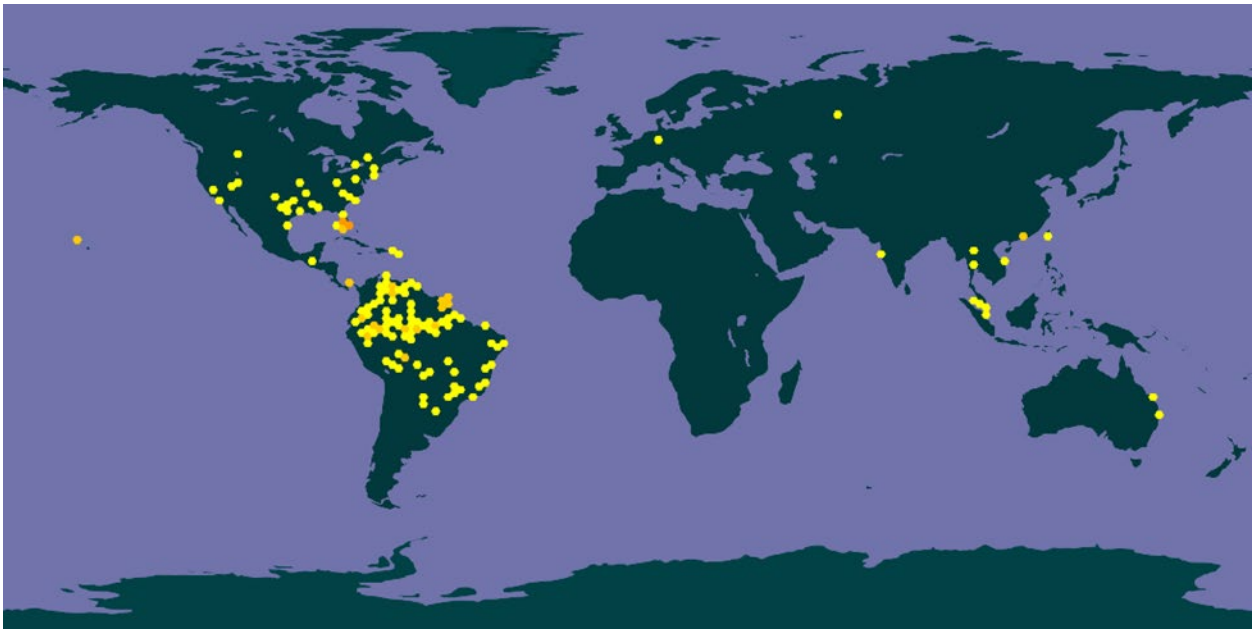

Figure 1. Reported global distribution of *Astronotus ocellatus*. Map from GBIF Secretariat (2023). Observations are reported from Canada, the contiguous United States, Hawaii, Puerto Rico, Guatemala, Panama, Aruba, Venezuela, Colombia, French Guiana, Brazil, Ecuador, Peru, Bolivia, Paraguay, Germany, Russia, India, Thailand, Vietnam, China, Taiwan, Malaysia, Singapore, and Australia.

Observations in Canada, Guatemala, Panama, Aruba, Paraguay, Germany, Russia, India, Thailand, Vietnam, China, Taiwan, Malaysia, and Singapore do not represent established populations and were not used to select source points for the climate matching analysis. Additionally, *A. ocellatus* is only known to be established in Brazil within the Amazon River basin and the state of Minas Gerais in southeastern Brazil; other locations in Brazil were not used to select source points for the climate matching analysis. Many observations within the United States were not used in the climate matching analysis, see section 6.

6 Distribution Within the United States

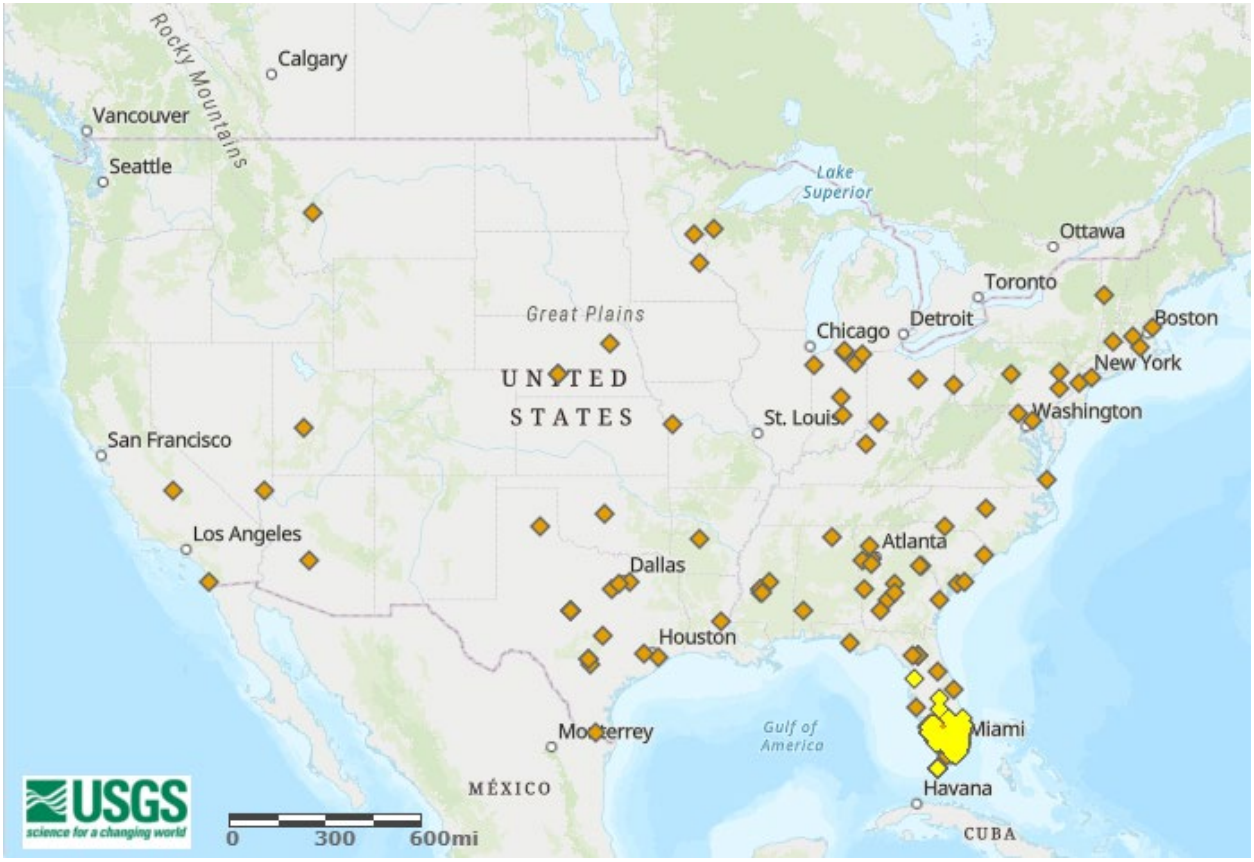

Figure 2. Reported distribution of *Astronotus ocellatus* in the contiguous United States. Map from Nico et al. (2025). Observations are reported from Alabama, Arkansas, Arizona, California, Florida, Georgia, Indiana, Kentucky, Louisiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Vermont, Virginia, and Wisconsin. Yellow points represent established populations. Orange points represent locations where population status is unknown, or where a population has failed or been eradicated. One failed introduction to Jewel Lake in Anchorage, Alaska, is not shown on the map. Only established populations were used to select source points for the climate matching analysis.

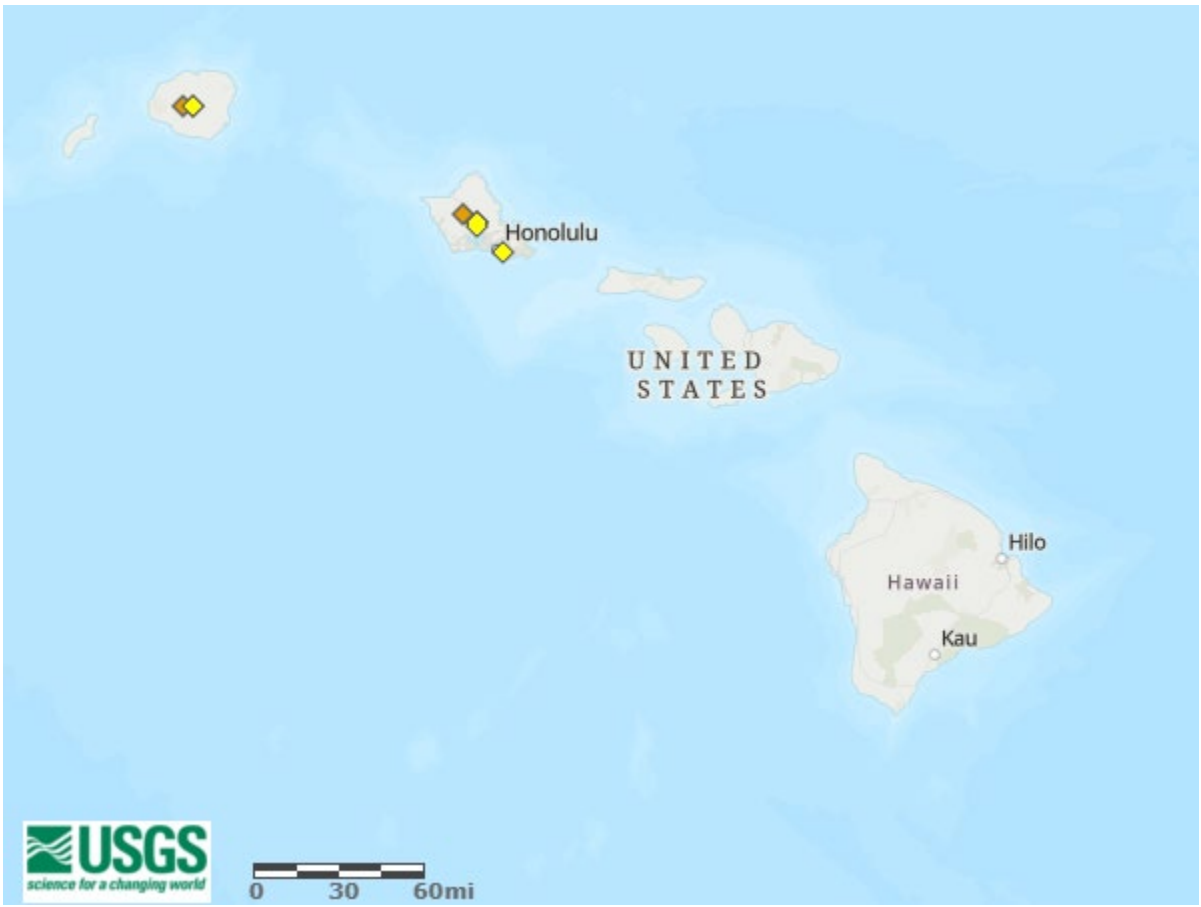

Figure 3. Reported distribution of *Astronotus ocellatus* in Hawaii. Map from Nico et al. (2025). Observations are reported from the islands of O‘ahu and Kaua‘i. Yellow points represent established populations. Orange points represent locations where population status is unknown, or where a population has failed or been eradicated. Only established populations were used to select source points for the climate matching analysis.

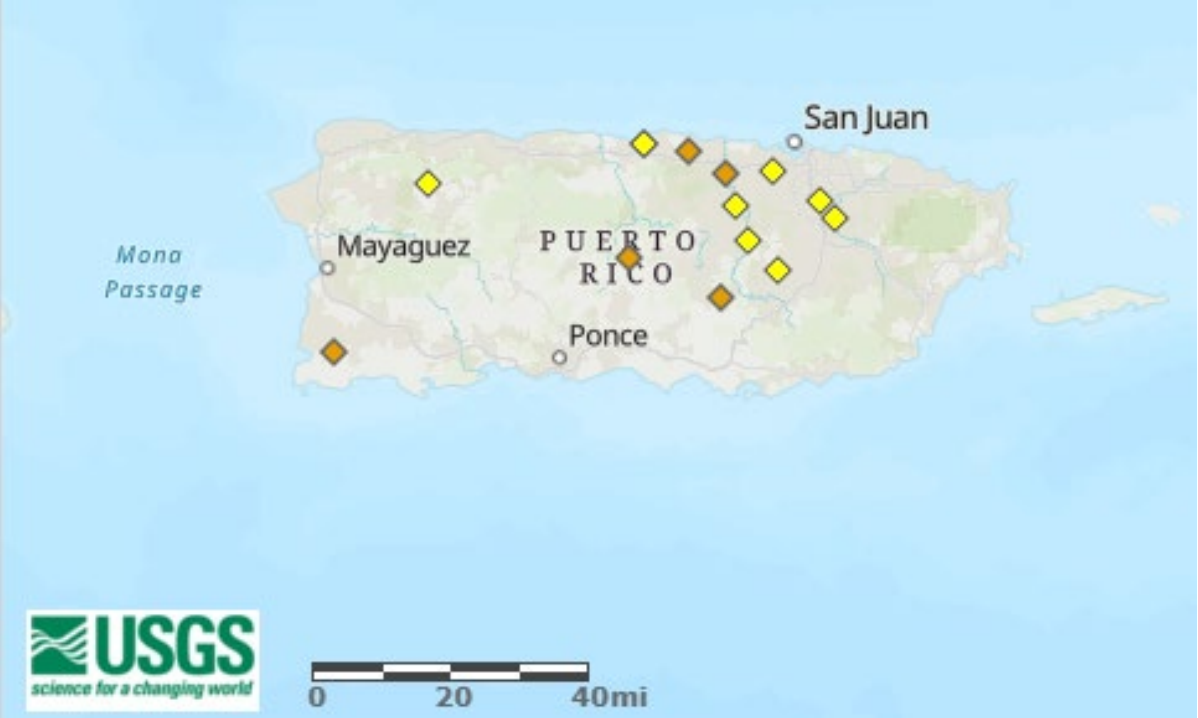

Figure 4. Reported distribution of *Astronotus ocellatus* in Puerto Rico. Map from Nico et al. (2025). Yellow points represent established populations. Orange points represent locations where population status is unknown, or where a population has failed or been eradicated. Only established populations were used to select source points for the climate matching analysis.

No georeferenced occurrences were available representing *Astronotus ocellatus* introduction to Guam.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Astronotus ocellatus* to the contiguous United States was highest in peninsular Florida. Other areas of high match were estimated for southern and central Texas, coastal Louisiana, and along the Southern Atlantic Coast as far north as North Carolina. Medium matches were found in other parts of the Gulf Coast and Southern Plains, across much of the Southwest, and in small areas around Chicago and the Southern Appalachians. The remainder of the contiguous United States was found to have a low match. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.146, indicating that Yes, there is establishment concern for this species. The Climate 6 score is calculated as: (count of target points with scores ≥ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Astronotus ocellatus* (see Appendix). These projected climate matches are provided

as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

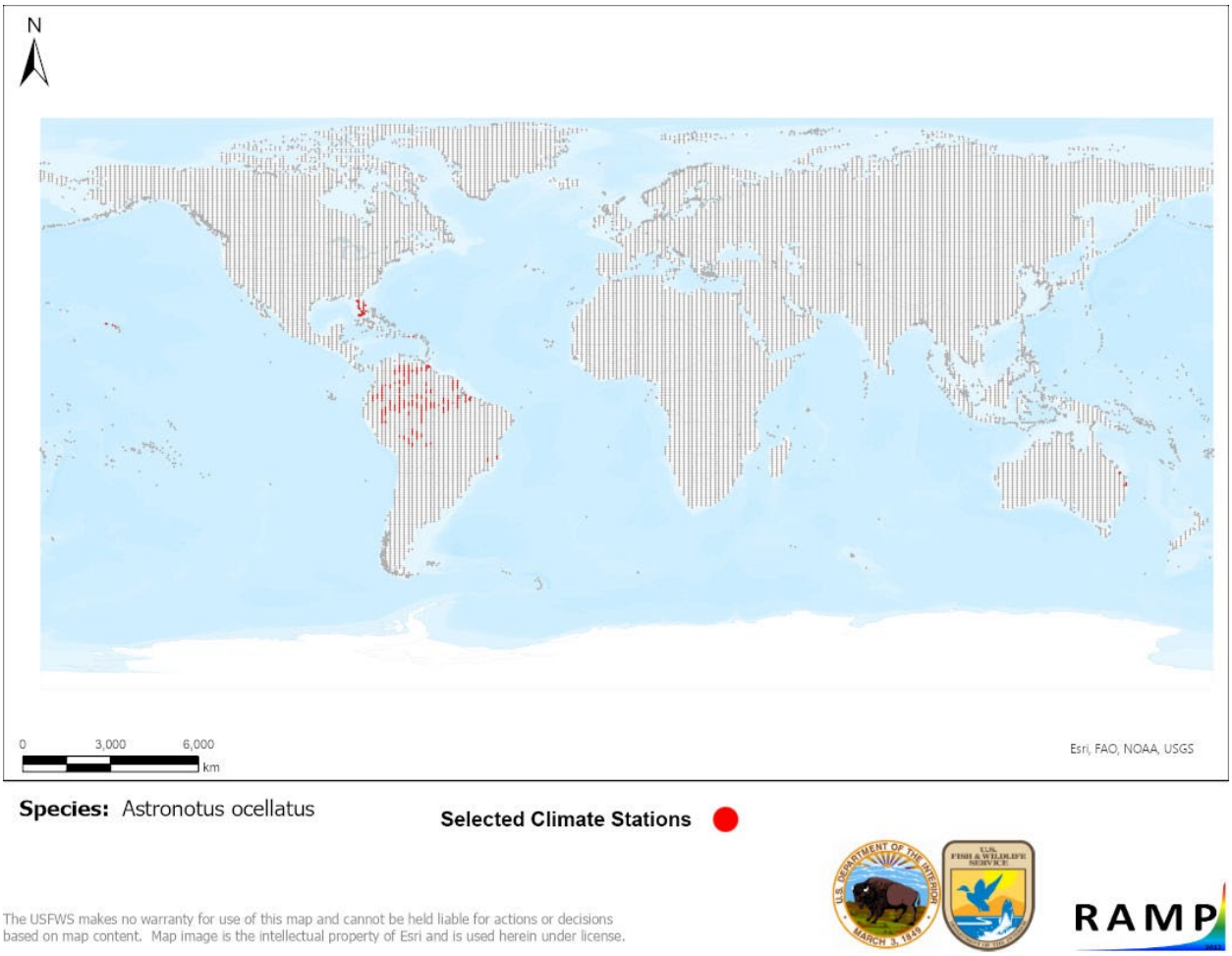

Figure 5. RAMP (Sanders et al. 2023) source map showing weather stations throughout the world selected as source locations (red; Australia, Bolivia, Brazil, Colombia, Ecuador, French Guiana, Peru, Puerto Rico, United States, and Venezuela) and non-source locations (gray) for *Astronotus ocellatus* climate matching. Source locations from GBIF Secretariat (2023). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

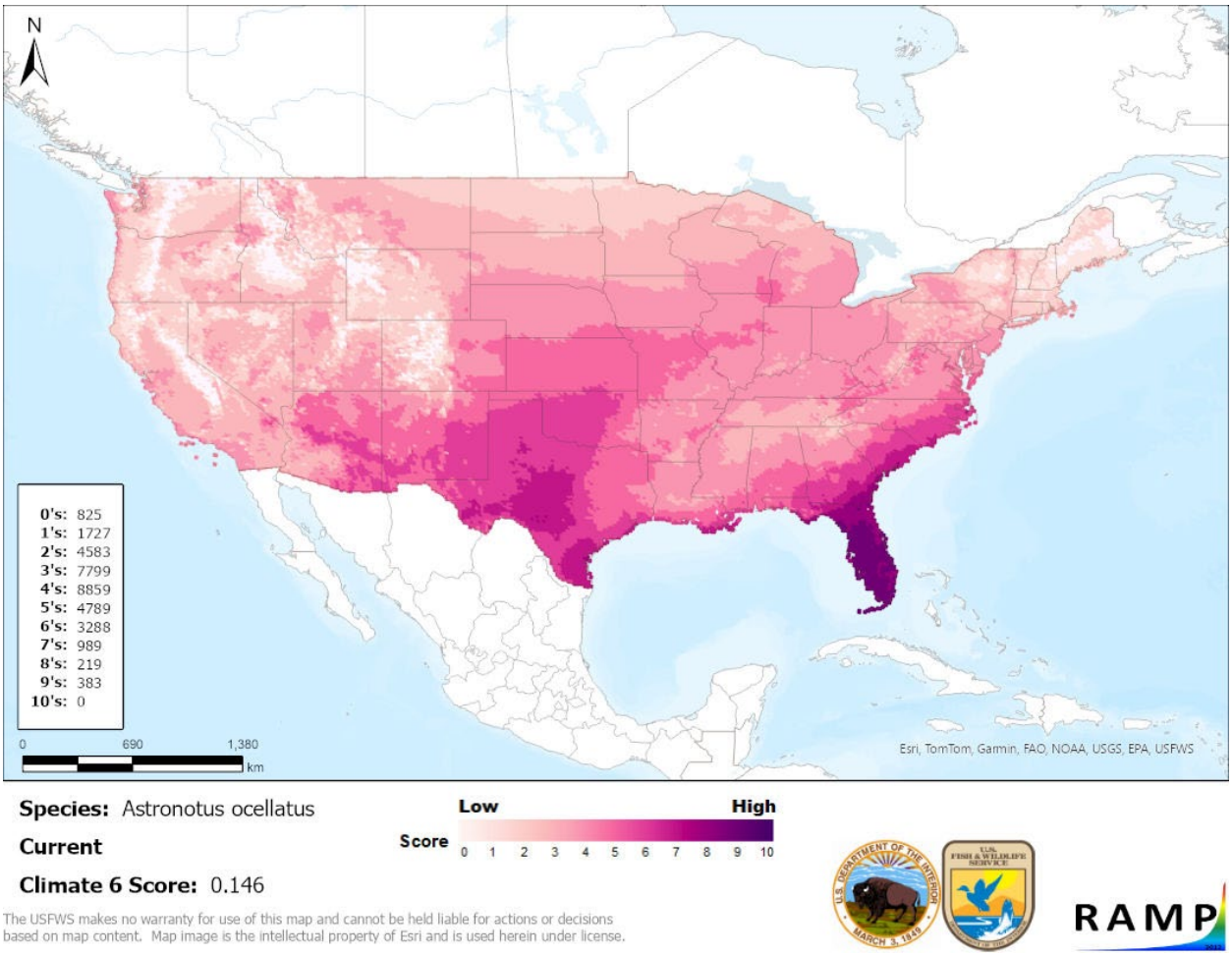

Figure 6. Map of RAMP (Sanders et al. 2023) climate matches for *Astronotus ocellatus* in the contiguous United States based on source locations reported by GBIF Secretariat (2023). Counts of climate match scores are tabulated on the left. 0/Pale Pink=Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

There is ample information available on the biology and ecology of *Astronotus ocellatus*. Despite numerous specimens being captured outside their native range, only a limited number of established nonnative populations have been documented. Impacts of introduction are largely unknown. Taxonomy of the species is somewhat problematic such that some individuals found outside the native range and recorded as *A. ocellatus* may later be determined to be a separate species. Given these factors, the certainty of assessment is Low.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Astronotus ocellatus, Oscar, is a fish native to northern South America. This species is popular in the aquarium trade, as a sport fish, and as a food fish. Due to the large size this species can obtain, it is likely that many introductions have occurred by humans translocating aquarium pets,

although this species has also been intentionally stocked as a sport fish outside of its native range and may also escape from aquaculture facilities. *A. ocellatus* was included by the State of Florida in a 1993 health advisory warning people about eating freshwater fish contaminated with mercury. *A. ocellatus* has been introduced to multiple U.S. States as well as internationally, but it is reported as established only in Hawaii, Florida, Puerto Rico, Guam, and Australia. The impacts of these introductions are largely unknown. In Brazil, introductions of *A. ocellatus*, *Pygocentrus nattereri*, and *Cichla cf. monoculus* have been associated with the disappearance of native species from several water bodies, although the distinct contributions of *A. ocellatus* to these native species losses were not identified. A variety of other potential impacts have yet to be documented in the nonnative range. The History of Invasiveness is therefore Data Deficient. The climate matching analysis for the contiguous United States indicates establishment concern for this species. The climate match was highest where the species is already established in southern Florida, with other areas of high match found along the southern Atlantic Coast and parts of the northern Gulf Coast and southern Texas. The Certainty of Assessment is Low due to limited available information on actual impacts of introduction, plus taxonomic uncertainty. The Overall Risk Assessment category for *Astronotus ocellatus* in the contiguous United States is Uncertain.

Assessment Elements

- **History of Invasiveness (see Section 4): Data Deficient**
- **Establishment Concern (see Section 7): Yes**
- **Certainty of Assessment (see Section 8): Low**
- **Remarks, Important additional information: None**
- **Overall Risk Assessment Category: Uncertain**

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Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2023).

Under the future climate scenarios (figure A1), on average, high climate match for *Astronotus ocellatus* was projected to occur in the Peninsular Florida region of the contiguous United States. Areas of low climate match were projected to occur in the Great Basin, Northeast, and Western Mountains regions. Medium match was projected to expand northeastward across the central contiguous United States from 2055 to 2085, also having a greater northern and eastern extent under SSP5 than SSP3. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.057 (model: IPSL-CM6A-LR, SSP5, 2085) to a high of 0.158 (model: IPSL-CM6A-LR, SSP5, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.146, figure 6) falls within the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under SSP5, 2085 time step, areas within the Great Lakes and Northern Plains saw a large increase in the climate match relative to current conditions. Additionally, areas within the Appalachian Range, Colorado Plateau, Great Basin, Northeast, Northern Pacific Coast, and Western Mountains saw a moderate increase in the climate match relative to current conditions primarily at the 2085 time step. Also primarily at the 2085 time step, areas within the Gulf Coast, Southern Atlantic Coast, Southern Florida, Southern Plains, and Southwest saw a moderate decrease in the climate match relative to current conditions. Changes relative to current conditions were projected to be small in most cases at the 2055 time step, except for moderate increases in climate match in the Great Lakes and Northern Plains. No large decreases were observed regardless of time step and climate scenarios. Additional, very small areas of large or moderate change may be visible on the maps (figure A3).

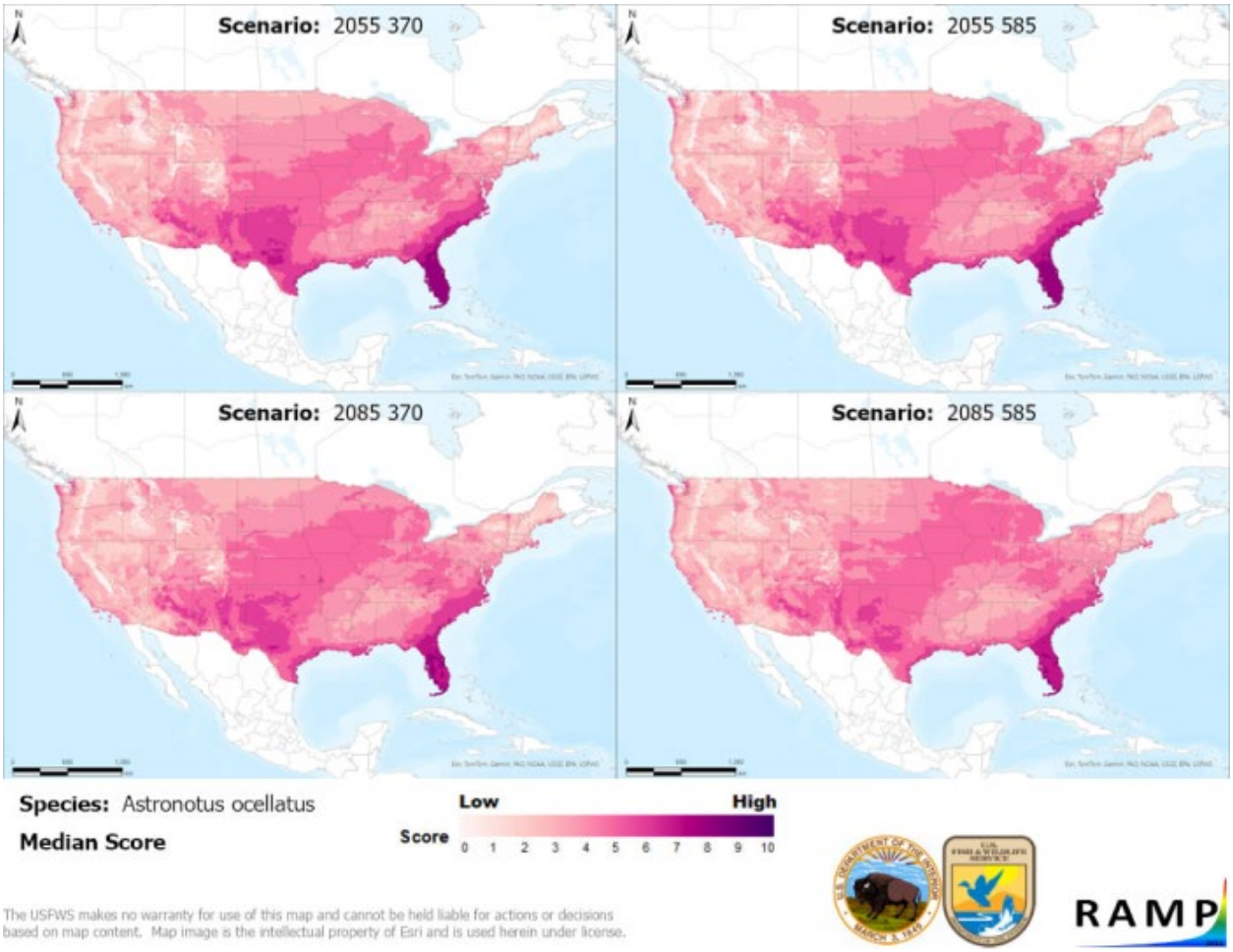

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Astronotus ocellatus* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2023). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

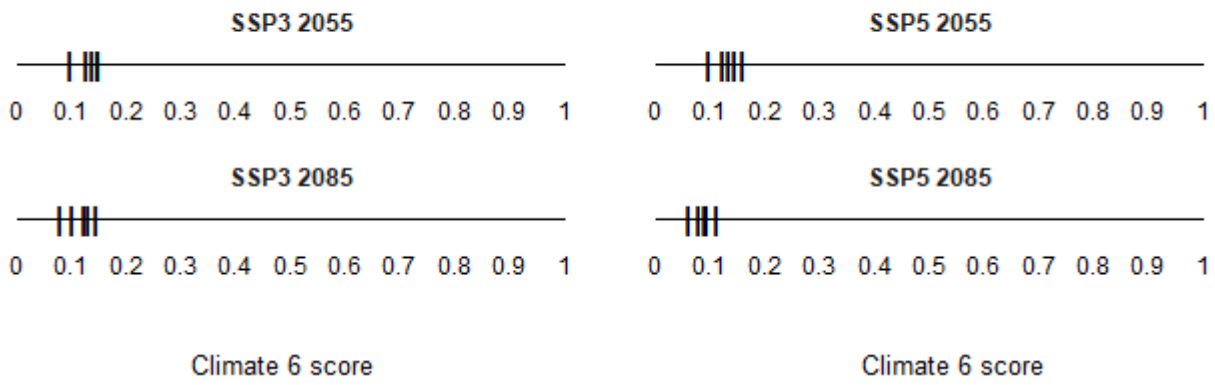

Figure A2. Comparison of projected future Climate 6 scores for *Astronotus ocellatus* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

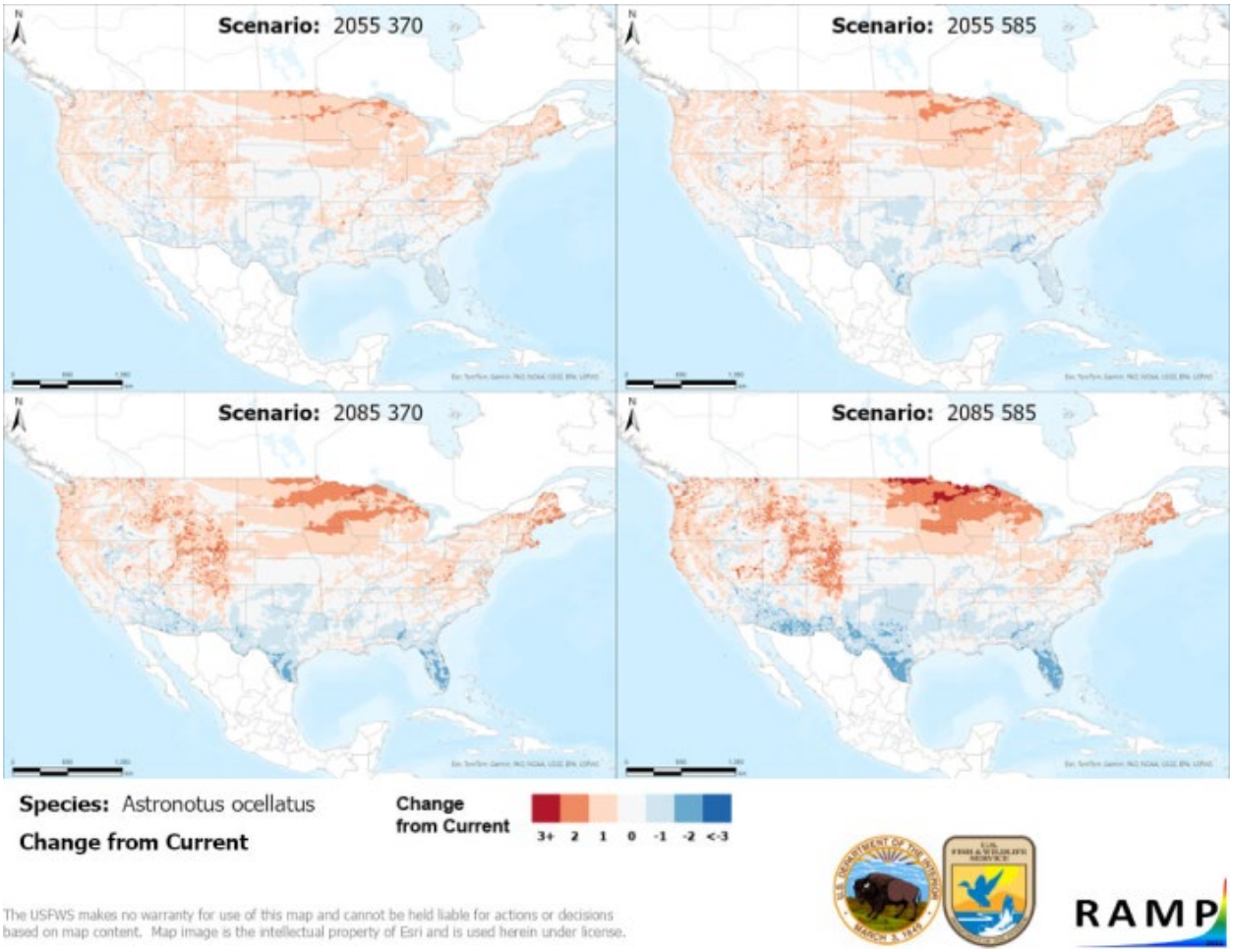

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 6) and the median target point score for future climate scenarios (figure A1) for *Astronotus ocellatus* based on source locations reported by GBIF Secretariat (2023). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

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