U.S. Fish & Wildlife Service

Marbled Eel (*Anguilla marmorata*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, February 2011
Revised, July 2018
Web Version, 8/3/2018

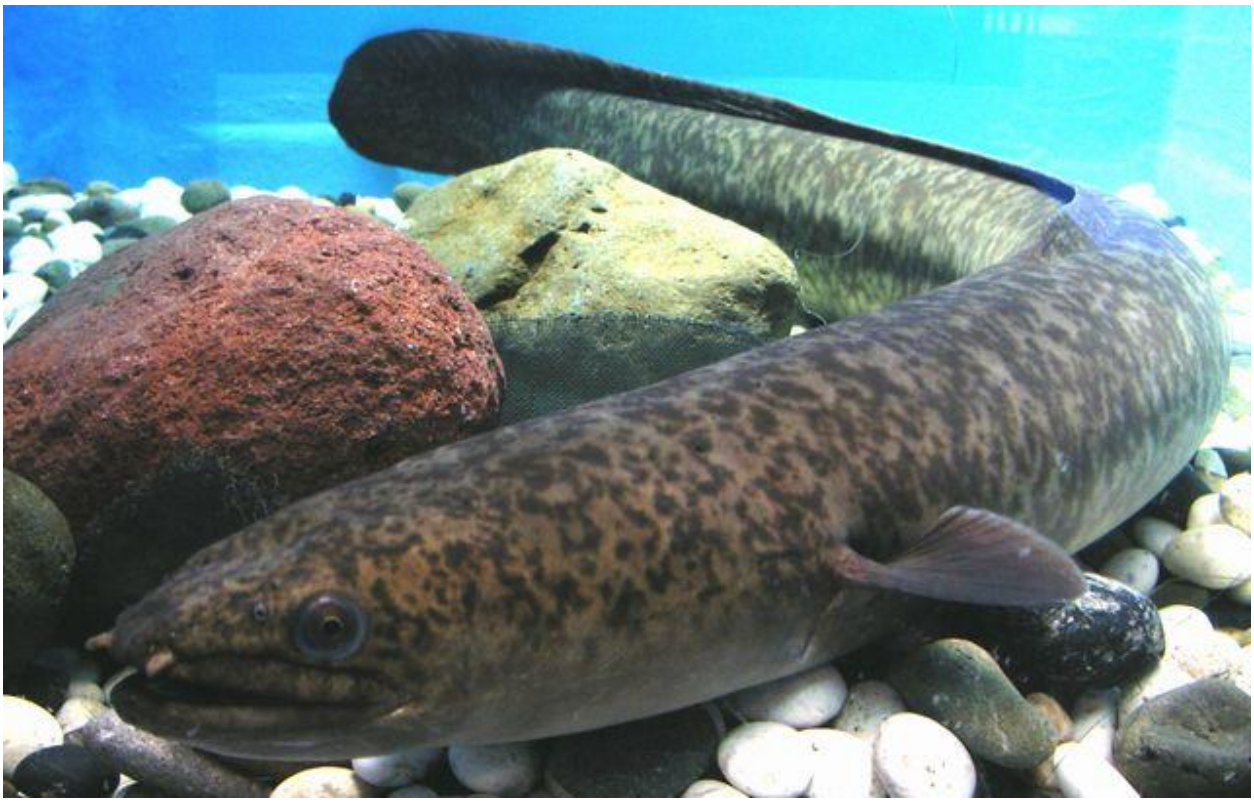

Photo: ふうけ. Licensed under CC BY-SA 3.0. Available: https://en.wikipedia.org/wiki/Giant_mottled_eel#/media/File:Oounagi070224.jpg. (July 2018).

1 Native Range and Status in the United States

Native Range

From Schofield and Fuller (2018):

"*Anguilla marmorata* has the widest distribution of the anguillid eels (Robinet et al. 2003). It is widely distributed in the tropical Indo-West Pacific, from South Africa to the Society Islands (French Polynesia) north to southern Japan (Smith 1999). Reports of individuals from the

Galápagos (McCosker et al. 2003) are thought to be periodic waifs from the west, possibly associated with El Niño/Southern Oscillation events."
From Eschmeyer et al. (2018):

"Africa, Asia, Australia, Indo-West Pacific: South African and East African watersheds and adjacent oceanic waters (including Madagascar and Mascarenes) east to Caroline Islands (Micronesia), Mariana Islands, Gambier Islands and Marquesas Islands, north to southern Japan, south to South Australia and New Caledonia."

Status in the United States

From Schofield and Fuller (2018):

"A single individual was captured from a pond near Kaupo, Maui, Hawaii in 2002 (Wright 2003; Mundy 2005)."

"Failed in Hawaii (Mundy 2005)."

From James and Suzumoto (2006):

"Long-time aquarists in Honolulu can remember when *Anguilla* spp. were imported into Hawai'i, primarily as live food items with a few as part of the aquarium trade (1950s–1960s), prior to the eels being prohibited for import in 1974 (HRS 150A-6; Hawaii Administrative Rules, 1995, Chapter 4- 71)."

Means of Introductions in the United States

From Schofield and Fuller (2018):

"Means of introduction unclear; possible food-fish escape, aquarium escape or waif arrival."

From Wright (2003):

"The 39-inch, 10-pound specimen may come from someone's stock of eels dating to the 1960s when they were imported to Hawai'i as a delicacy, according to Shelley Anne James, researcher at the museum's Pacific Center for Molecular Biodiversity."

"Or, Bishop Museum ichthyologist Arnold Suzumoto told officials, the eel might have been carried here in ballast water aboard a ship, and somehow reached the pond."

"It is even possible that it could have crossed the ocean on its own from Tahiti, its nearest home."

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 Elopomorpha
Order Anguilliformes
Suborder Anguilloidei
Family Anguillidae
Genus *Anguilla*
Species *Anguilla marmorata* Quoy and Gaimard, 1824 – giant mottled eel, grande anguille marbrée, anguilla moteada gigante, marbled eel"

From Eschmeyer et al. (2018):

"Current status: Valid as *Anguilla marmorata* Quoy & Gaimard 1824. Anguillidae."

Size, Weight, and Age Range

From Froese and Pauly (2018):

"Max length : 70.0 cm TL male/unsexed; [Keith et al. 2006]; 200.0 cm TL (female); common length : 26.3 cm TL male/unsexed; [Nichols 1943]; max. published weight: 20.5 kg [Bell-Cross and Minshull 1988]; max. published weight: 20.5 kg; max. reported age: 40 years [Keith et al. 1999]"

Environment

From Froese and Pauly (2018):

"Marine; freshwater; brackish; demersal; catadromous [Riede 2004]; depth range 1 - 400 m [Shao and Lin 1991]."

Jacoby and Gollock (2014):

"*Anguilla marmorata* is facultatively catadromous, being found in freshwater, brackish and saline habitats during its continental growth stages (Briones et al. 2007, Lin et al. 2012)."

Climate/Range

From Froese and Pauly (2018):

"Tropical; 24°N - 33°S"

Distribution Outside the United States

Native

From Schofield and Fuller (2018):

"*Anguilla marmorata* has the widest distribution of the anguillid eels (Robinet et al. 2003). It is widely distributed in the tropical Indo-West Pacific, from South Africa to the Society Islands (French Polynesia) north to southern Japan (Smith 1999). Reports of individuals from the Galápagos (McCosker et al. 2003) are thought to be periodic waifs from the west, possibly associated with El Niño/Southern Oscillation events."
From Eschmeyer et al. (2018):

"Africa, Asia, Australia, Indo-West Pacific: South African and East African watersheds and adjacent oceanic waters (including Madagascar and Mascarenes) east to Caroline Islands (Micronesia), Mariana Islands, Gambier Islands and Marquesas Islands, north to southern Japan, south to South Australia and New Caledonia."

Introduced

From Jacoby and Gollock (2014):

"Individuals have recently been found in the Pacific in the Palmyra Atoll and as far east as the Galapagos Islands (McCosker et al. 2003), although it is not known if these are the result of natural migration, vagrant individuals, or introduction."

From FAO (2018):

"*Anguilla marmorata* introduced to China from Malaysia"

"Status of the introduced species in the wild : No data"

Means of Introduction Outside the United States

From FAO (2018):

"*Anguilla marmorata* introduced to China from Malaysia"

"Reasons of Introduction : 1) fisheries"

Short Description

From Froese and Pauly (2018):

"Vertebrae: 100 - 110. Adults have a brownish to black marbling on their back on a greyish yellow background. This coloration can fade away. White belly. Younger specimens are greyish to orange and the marbling is less visible [Keith et al. 2002]. Body color brown speckles scattered on back, sides and fins; yellow between speckles and edge of pectoral fin; belly white or pale blue [Wang 1988]. Head rounded; snout depressed; lower jaw protruded; gill openings small; scales matted-like under skin; pectoral fin rounded; pelvic fin absent [Wang 1988]. Distinguished from all other species by the mottled color and the long dorsal fin, which begins closer to the gill opening than to the anus [Smith 1999]."

Biology

From Arai et al. (2002):

"The catadromous tropical eel *Anguilla marmorata* is one of the most common anguillid species in the Indo-Pacific (Ege 1939; Jespersen 1942). The adults of this species reach greater sizes than most temperate species, and range over a much more oceanographically diverse region than any temperate species, since *A. marmorata* is found around the southern half of Japan, throughout the Indo-Pacific, Polynesia, and in several areas in the Indian ocean. Like all anguillid species, *A. marmorata* spawns in the ocean and has a leptocephalus larva that undergoes a remarkable metamorphosis into the glass eel stage before recruitment to fresh water. The lengthy duration of the leptocephalus stage and the timing of metamorphosis is probably an important biological determinant of the geographical distribution of anguillid eels (Tsukamoto and Umezawa 1994). This potential for long-term larval migration in the ocean may have been a key factor in the worldwide distribution and speciation of anguillid eels (Tsukamoto and Aoyama 1998)."

"The wide distribution of *A. marmorata* throughout the subtropical and tropical western Pacific, the tropical western South Pacific, and Indian Ocean indicates that it differs from temperate species of anguillid eels and has many spawning areas. Recent studies on the genetic species identification, distribution and otolith microstructure of *A. marmorata* leptocephali in the North and South Pacific indicate that it must have several spawning areas, even within the western Pacific (Aoyama et al. 1999; Arai et al. [2001]). In addition, a genetic study of specimens from a variety of locations throughout the range of this species found genetic differentiation that suggested the presence of several regional populations (Ishikawa 1998)."

From Froese and Pauly (2018):

"Live in freshwater areas as adults, estuaries and seas as young [Rainboth 1996]. Found in lowland rivers as well as upland tributaries [Allen 1991]. While in river, the sex gland does not develop. But in winter when they move from the stream to river mouth, the sex gland begins to develop as mature individuals go to deep sea to breed [Wang 1998]. The spawning grounds are deep sea gullies among the south of the Philippines, east of Indonesia and Papua New Guinea [Wang 1998]. Are active at night, feeding on a wide range of prey [Skelton 1993, Louette 2004], especially crabs, frogs and fish [Skelton 1993]. Thought to breed east of Madagascar where the

young are wafted to the East Coast by ocean currents [Bell-Cross and Minshull 1988, Louette 2004]."

Human Uses

From Froese and Pauly (2018):

"Fisheries: commercial; aquaculture: commercial; gamefish: yes"

From Schofield and Fuller (2018):

"Anguillid eels are an important food source in many areas of the world, and are widely cultured. Large, live eels are especially sought-after by restaurateurs. In 1992, a typical 12 kg *A. marmorata* retailed for US $1,000 in China (Williamson and Boëtius 1993)."

Diseases

From Sasal et al. (2008):

"We encountered the gill monogeneans [*Pseudodactylogyrus*] *anguillae* Yin and Sproston, 1948 and *P. bini* Kikuchi, 1929. These parasites commonly occurred in *A. mossambica*, rarely in *A. marmorata*, […]"

"The swim bladder inhabiting nematode *Anguillicoloides crassus* (Kuwahara, Niimii, and Itagaki, 1974) was detected in all three native eel species, its prevalence ranging from 4% to 8%. Intensity did not exceed two worms […]. No eggs with L2-larvae were found in the lumen of the swim bladders, which might reflect the fact that just one eel (*A. marmorata*) contained two worms belonging to the same sex."

"Inside the gut, three identifiable helminths were found, the most prevalent being *Paraquimperia africana* Moravec et al. 2000 occurring in about 20% of the available *A. marmorata*. […] *A. marmorata* is a new host record for this parasite (see Moravec et al. 2000)."

"The acanthocephalan *Acanthocephalus reunionensis* Smales et al. 2007 occurred as a satellite or as a rare species (*A. marmorata*)."

"*Bothriocephalus claviceps* (Goetze, 1782) was a rare parasite of *A. marmorata* in this study, being demonstrated in this host for the first time (see Taraschewski 2006)."

No OIE-reportable diseases have been documented for this species.

Threat to Humans

From Froese and Pauly (2018):

"Harmless"

3 Impacts of Introductions

No information available.

4 Global Distribution

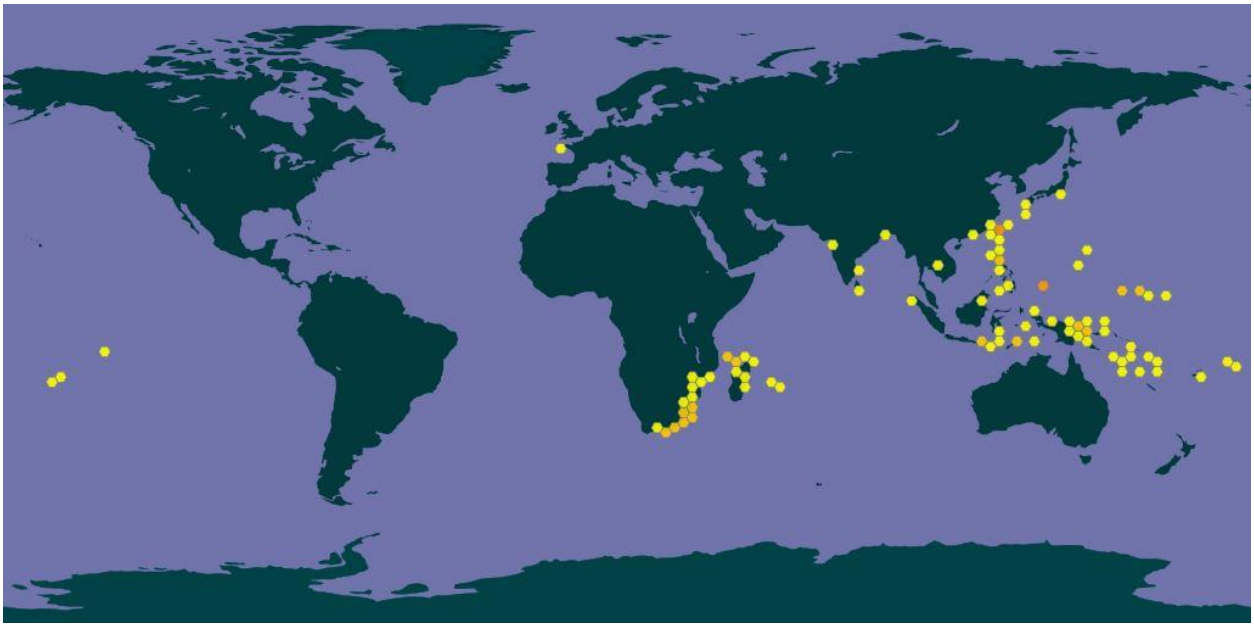

Figure 1. Known global distribution of *Anguilla marmorata*. Map from GBIF Secretariat (2017). No georeferenced occurrences were available for the part of the range of *A. marmorata* extending into Australia. The occurrences reported in northern France were marked as "suspicious" by GBIF Secretariat (2017) and were not used in the climate matching analysis.

Because the climate matching analysis is not valid for marine waters, no marine occurrences were used in the climate matching analysis. Riverine occurrences were reported in southeastern continental Africa, Madagascar, Reunion, Sri Lanka, eastern India, Cambodia, China, several islands of Indonesia, Papua New Guinea, the Philippines, Taiwan, Palau, and Vanuatu.

5 Distribution Within the United States

Figure 2. Known distribution of *Anguilla marmorata* in the United States. Map from Schofield and Fuller (2018). Point represents a failed population.

6 Climate Matching

Summary of Climate Matching Analysis

The climate match presented here refers only to where the species can survive in freshwater and brackish environments and not in the open ocean where it reproduces and juvenile stages live.

The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.026, which is a medium climate match. The climate score was high in Florida and Texas and medium in Arizona, Georgia, and South Carolina. All other states had a low climate score. Medium climate matches occurred in Florida, the Gulf Coast, most of Texas into New Mexico and Arizona, and up the Atlantic Coast as far north as North Carolina. The remainder of the contiguous United States had low match.

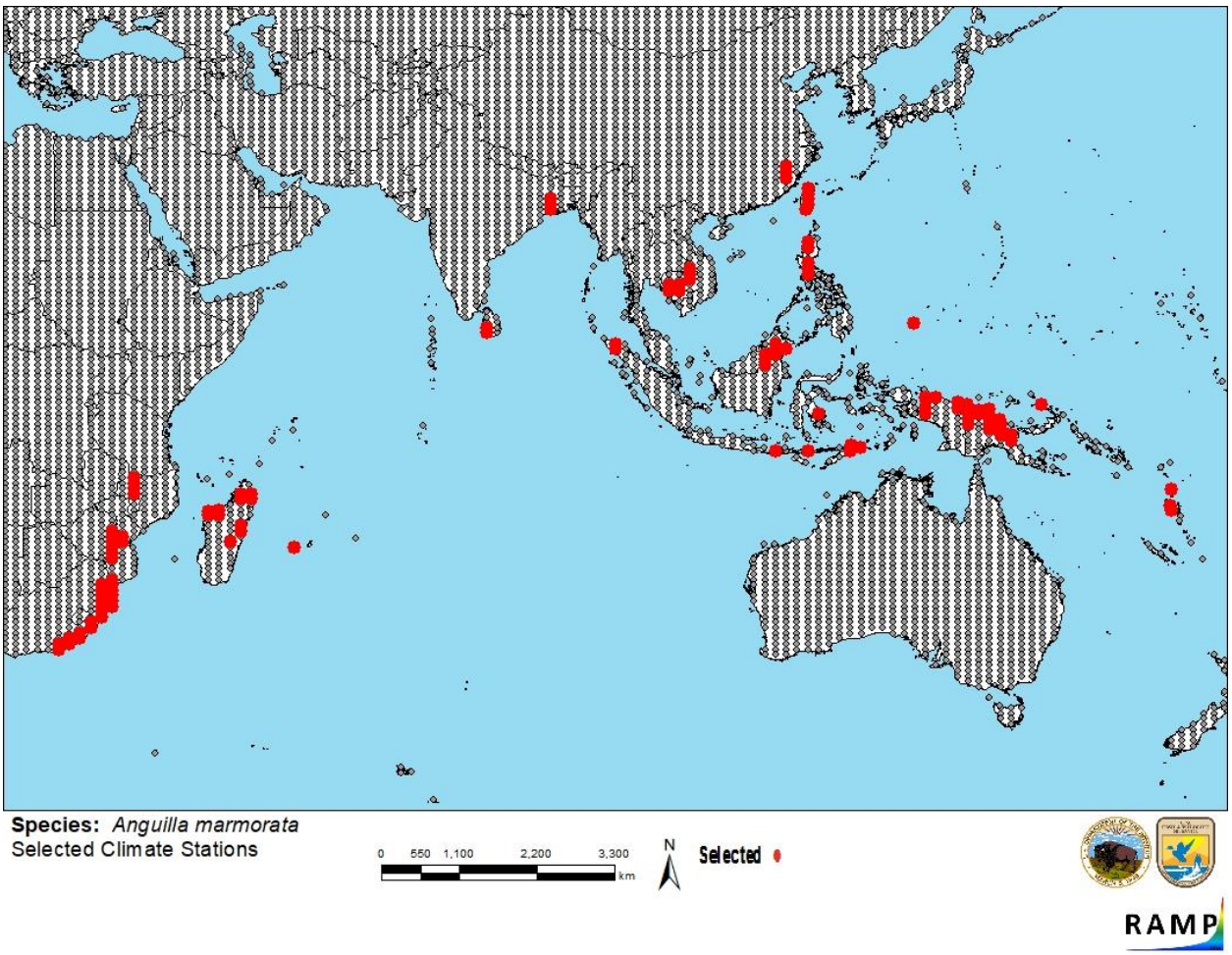

Figure 3. RAMP (Sanders et al. 2018) source map showing weather stations selected as source locations (red; South Africa, Swaziland, Mozambique, Zimbabwe, Malawi, Madagascar, Reunion, Sri Lanka, India, Cambodia, China, Indonesia, Papua New Guinea, Philippines, Taiwan, Palau, and Vanuatu) and non-source locations (gray) for *Anguilla marmorata* climate matching. Source locations from GBIF Secretariat (2017).

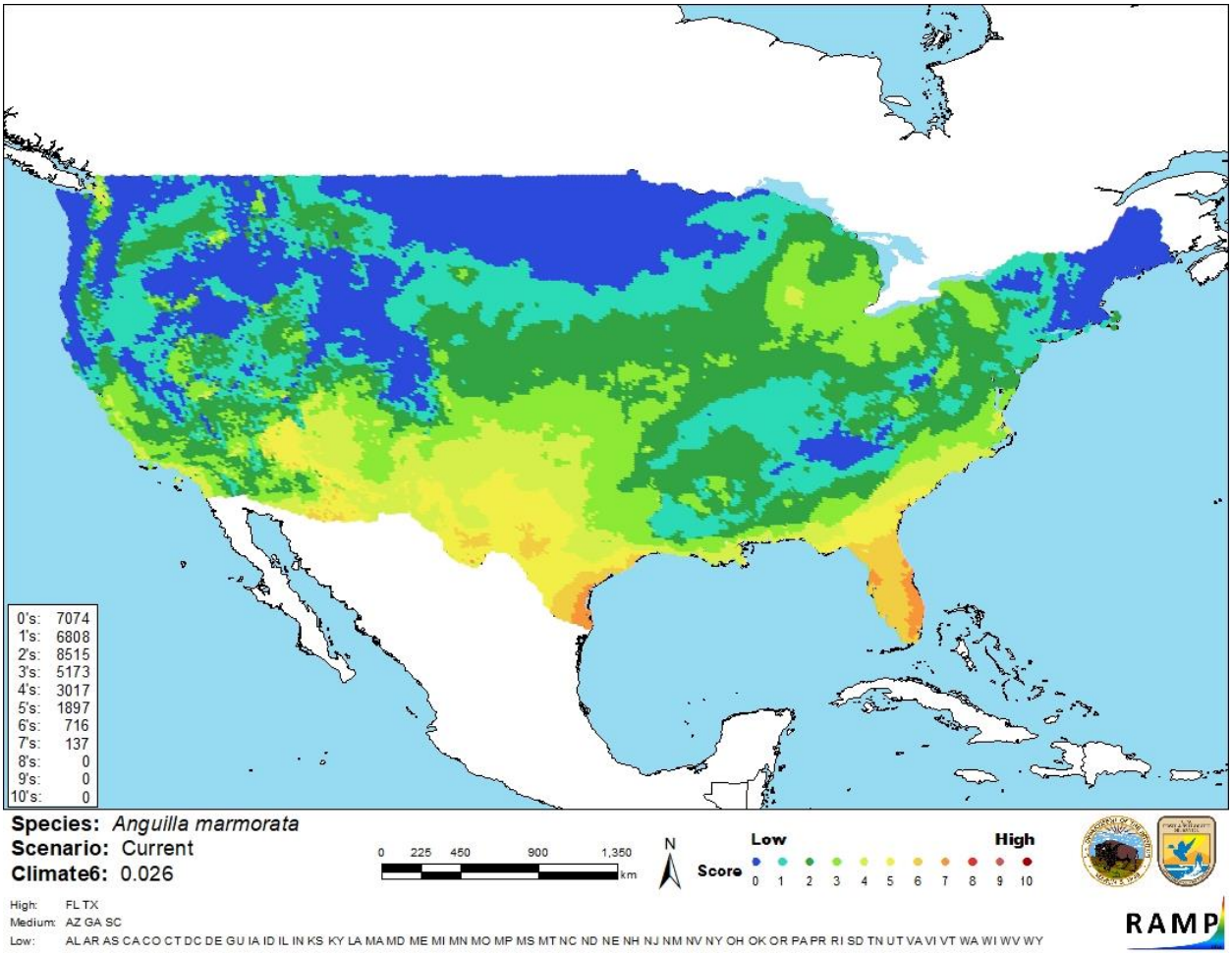

Figure 4. Map of RAMP (Sanders et al. 2018) climate matches for *Anguilla marmorata* in the contiguous United States based on source locations reported by GBIF Secretariat (2017). 0= Lowest match, 10=Highest match.

The "High", "Medium", and "Low" climate match categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

There is adequate information available about the biology and global distribution of *Anguilla marmorata*. *A. marmorata* has been documented outside of its native range, but because this species is capable of ranging great distances, it is unclear if these reports are due to introductions or natural migration. It is also not clear whether populations have established in these areas. No information is available on impacts of introductions of this species. *A. marmorata* reproduces, and the young live, in marine environments. The climate match in a marine environment, where

A. marmorata breeds and juveniles reside, cannot be assessed with an ERSS. Therefore, certainty of this assessment is low.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Anguilla marmorata, the marbled eel, is a catadromous tropical eel species ranging from the eastern coast of Africa to the western Pacific Ocean. Studies indicate it likely has multiple spawning areas, and there may be genetic differentiation among geographic locations. It is highly valued as a food fish. Individuals of this species have been found far outside the native range. Further information is needed to assess whether reports of this species outside of its native range are due to human-mediated translocation or whether individuals have naturally migrated outside their native range, and whether they have established in these new environments. *A. marmorata* has a medium climate match with the contiguous United States. *A. marmorata* reproduces and the young live in marine environments. RAMP (Sanders et al. 2018) was not developed for use in assessing climate match for marine species so the climate match in a marine environment cannot be assessed with an ERSS. Certainty of this assessment is therefore low, and the overall risk assessment category is uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 3): Uncertain**
- **Climate Match (Sec. 6): Medium**
- **Certainty of Assessment (Sec. 7): Low**
- **Overall Risk Assessment Category: Uncertain**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

Arai, T., M. Marui, M. Miller, and K. Tsukamoto. 2002. Growth history and inshore migration of the tropical eel, *Anguilla marmorata*, in the Pacific. Marine Biology 140(2):309-316.

Eschmeyer, W. N., R. Fricke, and R. van der Laan, editors. 2018. Catalog of fishes: genera, species, references. Available: http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. (July 2018).

FAO (Fisheries and Agriculture Organization of the United Nations). 2018. Database on introductions of aquatic species. FAO, Rome. Available: http://www.fao.org/fishery/introsp/search/en. (July 2018).

Froese, R., and D. Pauly, editors. 2018. *Anguilla marmorata* (Quoy & Gaimard, 1824). FishBase. Available: https://www.fishbase.de/summary/Anguilla-marmorata.html. (July 2018).

GBIF Secretariat. 2017. GBIF backbone taxonomy: *Anguilla marmorata*, Quoy & Gaimard, 1824. Global Biodiversity Information Facility, Copenhagen. Available: https://www.gbif.org/species/5213048. (July 2018).

ITIS (Integrated Taxonomic Information System). 2018. *Anguilla marmorata* (Quoy & Gaimard, 1824). Integrated Taxonomic Information System, Reston, Virginia. Available: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161135#null. (July 2018).

Jacoby, D., and M. Gollock. 2014. *Anguilla marmorata*. The IUCN Red List of Threatened Species 2014: e.T166189A45832585. Available: http://www.iucnredlist.org/details/166189/0. (July 2018).

James, S. A., and A. Y. Suzumoto. 2006. Nonnative occurrence of *Anguilla marmorata* in Hawai'i: identification using morphological and molecular characters. Bishop Museum Occasional Papers 87:55-61.

Sanders, S., C. Castiglione, and M. H. Hoff. 2018. Risk Assessment Mapping Program: RAMP, version 3.1. U.S. Fish and Wildlife Service.

Sasal, P., H. Taraschewski, P. Valade, H. Grondin, S. Wielgoss, and F. Moravec. 2008. Parasite communities in eels of the Island of Reunion (Indian Ocean): a lesson in parasite introduction. Parasitology Research 102(6):1343-1350.

Schofield, P. J., and P. Fuller. 2018. *Anguilla marmorata* Quoy and Gaimard, 1824. U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=2291. (July 2018).

Wright, W. 2003. 10-pound eel found on Maui could be harmful. Honolulu Advertiser (January 27). Available: http://the.honoluluadvertiser.com/article/2003/Jan/27/ln/ln13a.html. (July 2018).

10 References Quoted But Not Accessed

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

Allen, G. R. 1991. Field guide to the freshwater fishes of New Guinea. Publication 9. Christensen Research Institute, Madang, Papua New Guinea.

Aoyama, J., N. Mochioka, T. Otake, S. Ishikawa, Y. Kawakami, P. H. J. Castle, M. Nishida, and K. Tsukamoto. 1999. Distribution and dispersal of anguillid leptocephali in the western Pacific Ocean revealed by molecular analysis. Marine Ecology Progress Series 188:193-200.

Arai, T., J. Aoyama, S. Ishikawa, M. J. Miller, T. Otake, T. Inagaki, and K. Tsukamoto. 2001. Early life history of tropical *Anguilla leptocephali* in the western Pacific Ocean. Marine Biology 138:887-895.

Bell-Cross, G., and J. L. Minshull. 1988. The fishes of Zimbabwe. National Museums and Monuments of Zimbabwe, Harare, Zimbabwe.

Briones, A. A., A. V. Yambot, J. C. Shiao, Y. Iizuka, and W.-N. Tzeng. 2007. Migratory pattern and habitat use of tropical eels *Anguilla* spp. (Teleostei: Anguilliformes: Anguillidae) in the Philippines, as revealed by otolith microchemistry. Raffles Bulletin of Zoology 14:141-149.

Ege, V. 1939. A revision of the genus *Anguilla* Shaw. Dana Report 16:1-256.

Hawaii Administrative Rules. 1995. Chapter 4-71, Plant and Non-Domestic Animal Quarantine: Non-Domestic Animal Import Rules, List of Prohibited Animals.

Ishikawa, S. 1998. Molecular study on the population structure of *Anguilla marmorata*. Doctoral thesis, The University of Tokyo, Tokyo.

Jespersen, P. 1942. Indo-Pacific leptocephali of the genus *Anguilla*. Dana Report 22:1-128.

Keith, P., E. Vigneux, and P. Bosc. 1999. Atlas des poissons et des crustacés d'eau douce de La Réunion. Patrimoines Naturels 39. Muséum national d'Histoire naturelle, Paris.

Keith, P., E. Vigneux, and G. Marquet. 2002. Atlas des poissons et des crustacés d'eau douce de Polynésie Française. Patrimoines Naturels 55. Muséum national d'Histoire naturelle, Paris.

Keith, P., G. Marquet, P. Valade, P. Bosc and E. Vigneux. 2006. Atlas des poissons et des crustacés d'eau douce des Comores, Mascareignes et Seychelles. Patrimoines naturels 65. Muséum national d'Histoire naturelle, Paris.

Lin, Y.-J., B. M. Jessop, O. L. F. Weyl, Y. Iizuka, S.-H. Lin, W.-N. Tzeng, amd C.-L. Sun. 2012. Regional variation in otolith Sr:Ca ratios of African longfinned eel *Anguilla mossambica* and mottled eel *Anguilla marmorata*: a challenge to the classic tool for reconstructing migratory histories of fishes. Journal of Fish Biology 81(2):427-441.

Louette, M. 2004. Poissons d'eau douce. Pages 231-241 *in* M. Louette, D. Meirte, and R. Jocqué, editors. La faune terrestre de l'archipel des Comores. Studies in Afrotropical Zoology 293.

McCosker, J., R. Bustamante, and G. Wellington. 2003. The freshwater eel, *Anguilla marmorata*, discovered in Galápagos. Noticias de Galápagos 62.

Moravec, F., J. Boomker, and H. Taraschewski. 2000. *Paraquimperia africana* n. sp. (Nematoda: Quimperiidae), a new intestinal parasite of the eel *Anguilla mossambica* Peters, in South Africa. Journal of Parasitology 86:113-117.

Mundy, B. C. 2005. Fishes of the Hawaiian Archipelago. Bishop Museum Bulletin in Zoology 6.

Nichols, J. T. 1943. The freshwater fishes of China. Natural history of Central Asia: Volume IX. The American Museum of Natural History, New York.

Rainboth, W. J. 1996. Fishes of the Cambodian Mekong. FAO species identification field guide for fishery purposes. FAO, Rome.

Riede, K. 2004. Global register of migratory species - from global to regional scales. Final Report of the R&D-Projekt 808 05 081. Federal Agency for Nature Conservation, Bonn, Germany.

Robinet, T., S. Guyet, G. Marquet, B. Mounaix, J.-M. Olivier, K. Tsukamoto, P. Valade, and E. Feunteun. 2003. Elver invasion, population structure and growth of marbled eels *Anguilla marmorata* in a tropical river on Reunion Island in the Indian Ocean. Environmental Biology of Fishes 68:339-348.

Shao, K.-T., and P. L. Lim. 1991. Fishes of freshwater and estuary. Encyclopedia of field guide in Taiwan, volume 31. Recreation Press, Taipei, Taiwan. (In Chinese.)

Skelton, P. H. 1993. A complete guide to the freshwater fishes of southern Africa. Southern Book Publishers, Johannesburg, South Africa.

Smith, D. G. 1999. Anguillidae. Freshwater eels. Pages 1630-1636 *in* K. E. Carpenter. and V. H. Niem, editors. FAO species identification guide for fishery purposes. The living marine resources of the WCP, volume 3. Batoid fishes, chimaeras and bony fishes, part 1 (Elopidae to Linophrynidae). FAO, Rome.

Taraschewski, H. 2006. Hosts and parasites as aliens. Journal of Helminthology 80:99-128.

Tsukamoto, K., and J. Aoyama. 1998. Evolution of freshwater eels of the genus *Anguilla*: a probable scenario. Environmental Biology of Fishes 52:139-148.

Tsukamoto, K., and A. Umezawa. 1994. Metamorphosis: a key factor of larval migration determining geographic distribution and speciation of eels. Proceedings of the Fourth Indo-Pacific Fish Conference, Bangkok, Thailand 231-248. Kasetart University, Bangkok, Thailand.

Wang, S., editor. 1998. China red data book of endangered animals. Pisces. National Environmental Protection Agency. Endangered Species Scientific Commission. Science Press, Beijing.

Williamson, G. R., and J. Boëtius. 1993. The eels *Anguilla marmorata* and *A. japonica* in the Pearl River, China, and Hong Kong. Asian Fisheries Science 6:129-138.