

Ecological Risk Screening Summary for Maryland:  
**Swamp Eels of the Family Synbranchidae**  
(*Monopterus albus* and *Amphipnous cuchia*)



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**Department of Natural Resources  
Resource Assessment Service**



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# **Foreword**

The following document summarizes a risk assessment for swamp eels of the family Synbranchidae conducted by staff of the Maryland Department of Natural Resources. The risk assessment tools used in this analysis were developed elsewhere but adopted to assess potentially invasive animals in Maryland by the Maryland Department of Natural Resources' Invasive Species Matrix Team in 2020 (Kilian and Harbold 2020). The AS-ISK screening tool is one of the most widely applied, tested, and calibrated tools available for assessing invasive risk (Vilizzi et al. 2019). It has been adapted to assess various taxa, including amphibians, reptiles, marine and freshwater fishes, and marine and freshwater invertebrates in a wide range of environments. The Invasive Species Matrix Team also adopted the Great Lakes Assessment Framework (Fusaro et al. 2017) as a more comprehensive assessment to be used in conjunction with the AS-ISK screening tool when appropriate. The results of both tools are summarized below, along with a climate suitability analysis using the CLIMATCH model (Australian Bureau of Rural Sciences 2010). The ecological risk screening summary format used in this report was adapted from the Ecological Risk Screening Summary template developed by the U.S. Fish and Wildlife Service (USFWS 2018a).

# **1. Background and Description**

Swamp eels of the family Synbranchidae are teleost fishes that encompass at least five genera, including *Amphipnous*, *Macropterna*, *Monopterus*, *Ophisternon*, and *Synbranchus* and approximately 26 species (Nico et al. 2019; Froese and Pauly 2021). Taxonomy of this family is still in flux and there are many cryptic species that remain undescribed (Collins et al. 2002; Nico et al. 2019). Swamp eels are primarily freshwater fishes distributed in tropical and subtropical regions of Asia, Australia, Africa, and Central and South America. There are no swamp eel species native to North America (Nico et al. 2019). Two species of swamp eel *Monopterus albus* and *Amphipnous cuchia* are the most commonly imported species to the U.S. - sold for human consumption in live food markets and, to a lesser extent, as pets in the aquarium pet trade (Nico et al. 2019). These species occupy mostly low velocity freshwater environments where they serve as predators on a wide range of fishes, amphibians, and invertebrates. Swamp eels have been introduced outside of their native range and are currently established in five U.S. states including New Jersey, Georgia, Florida, Louisiana, and Hawaii (USFWS 2018b; Jordan et al. 2020; Fuller et al. 2021). Swamp eel (*A. cuchia*) was introduced to Maryland in Lake Needwood in 2014; however, it is believed to have failed to establish a reproducing population in this man-made impoundment (Nico et al. 2019).

Swamp eels are most morphologically similar to two North American fish families – Anguillidae (American Eel) and Petromyzontidae (Lampreys). Although not true eels, swamp eels are eel-like in body form but lack pectoral and pelvic fins. Dorsal, anal, and caudal fins are fused to form a continuous ribbon along the central axis of the body (Miah et al. 2015). Swamp eels can be distinguished from American Eel by the absence of pectoral fins. Swamp eels can be distinguished from lampreys by the presence of jaws and a single v-shaped gill opening (Fuller et al. 2021). *Monopterus albus* tends to be dorsally brown to olive in color often with small dark flecks. Ventral surfaces are usually yellow to orange (USFWS 2018b; Fuller et al. 2021). *Amphipnous cuchia* is morphologically very similar to and difficult to distinguish from *M. albus*. *Amphipnous cuchia* differs from *M. albus* in that it has small scales in the tail region and the speckling on the dorsum tends to form larger spots rather than flecks as in *M. albus* (Nico et al. 2019).

## 2. Distribution



Figure 1. Known global distribution of *Monopterus albus*. Map from GBIF Secretariat (2021). Denser concentrations of occurrence records that overlap at the current map scale are represented as darker-colored symbols.



Figure 2. Known global distribution of *Amphipnous cuchia*. Map from GBIF Secretariat (2021). Denser concentrations of occurrence records that overlap at the current map scale are represented as darker-colored symbols.

### **Native Range**

Swamp eels are distributed in tropical and subtropical regions of Asia, Australia, Africa, and Central and South America. *Monopterus albus* is native to Asia from India to the Indo-Malayan Archipelago (Fuller et al. 2021). *Amphipnous cuchia* is native to Bangladesh, northern portions of India, Pakistan, Nepal, and Myanmar (Miah et al. 2015; Nico et al. 2019.).

## Nonnative Range

### Outside the United States

*Monopterus albus* has been introduced to portions of Japan, and the Philippines. Introductions of other swamp eel species (*Synbranchus marmoratus* and *Ophisternon aenigmaticum*) have occurred to a limited extent in the West Indies and Brazil (Nico et al. 2019).

### Within the United States

*Monopterus albus* is currently established in four U.S. states including New Jersey, Georgia, Florida, and Hawaii (USFWS 2018b; Fuller et al. 2021). There are records of *Amphipnous cuchia* from several U.S. states – some from live food markets (Nico et al. 2019). The only known established population of this species in the U.S. is in Bayou St. John in New Orleans, Louisiana (Jordan et al. 2020).

### Within Maryland

*Amphipnous cuchia* was collected in Lake Needwood in Montgomery County, MD in 2014, but it is believed that this introduction failed to establish a reproducing population (Nico et al. 2019).

## 3. 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 Synbranchiformes  
Suborder Synbranchioidei  
Family Synbranchidae  
Genus *Monopterus* (Lacepède, 1800)  
Species *Monopterus albus* (Zuiew, 1793) – swamp eel, white ricefield eel, rice eel, Asian swamp eel  
Genus *Amphipnous* (Muller, 1841)  
Species *Amphipnous cuchia* (Hamilton, 1822) – swamp eel, cuchia, mud eel

The current taxonomic status for *Monopterus albus* is valid. The current taxonomic status for *Amphipnous cuchia* is ambiguous.

## Size, Weight, and Age

Swamp eels can reach a length of 100 cm (Davidson 1975). Males in Florida ranged in length from 505 – 855 mm TL; females were 229-774 mm TL (Shafland et al. 2010). Maximum weight for swamp eels is 0.45kg (CABI 2007).

## Preferred Climate and Habitat

Swamp eels are considered tropical to sub-tropical species that inhabit mostly freshwater slow-moving systems including ponds, swamps, and ephemeral wetlands. These eels are environmentally tolerant as a group. *Monopterus albus* and *A. cuchia* are known to tolerate low dissolved oxygen concentrations (as they are air breathers) (Nico et al. 2019), a wide range of salinity (up to 16 ppt) (Schofield and Nico 2009), and can survive freezing temperatures and ice cover (Starnes et al. 1998).

## Biology

Swamp eels are top predators, with adults reaching nearly 1 m in length, and they feed on a variety of animals including fishes, frogs, crayfishes, and other invertebrates (Collins et al. 2002). Presumably, there are species that consume swamp eels in their native range, but there are no reports on natural predators, except for humans. Shafland et al. (2010) reported predation on introduced swamp eels by Largemouth Bass (*Micropterus salmoides*) and wading birds. It is likely that their elusive behavior and secretive lifestyle limit their vulnerability to predators. *Monopterus albus* are sequential hermaphrodites - all individuals are born as females, and some later transform into males (Liem 1963, Shafland et al. 2010.). A female can produce 268 - 642 eggs (Shafland et al. 2010). Male swamp eels create bubble nests adjacent to aquatic vegetation and guard the eggs and juveniles (Yamamoto and Tagawa 2000, as cited in Froese and Pauly 2021). Swamp eels generally prefer slow-water habitats where they burrow into soft-sediments. These species are nocturnal – remaining in their burrows during daylight hours and feeding at night (Miah et al. 2015).

## Human uses

Two swamp eel species (*M. albus* and *A. cuchia*) have been widely utilized for human consumption worldwide. These species are the most frequently imported species to the U.S. (Nico et al. 2019). Swamp eels have been observed being offered for sale in Maryland pet stores (Harbold, W., personal communication 2019), but it is unknown whether the observed species were *M. albus* or *A. cuchia*. It is presumed that the sale of either species by pet retailers in Maryland is uncommon.

## Diseases

Swamp eels (Synbranchidae) are a common source of human gnathostomiasis (Cole et al. 2014) and are known to carry many parasites in their native range (Nico et al. 2011). Specimens obtained from live food markets and from the wild (introduced populations in Florida) contained a high parasite load including nematodes, acanthocephalans, and digenean parasites (Nico et al. 2011). It is unclear what risk these parasites pose to native North American or Maryland taxa.

## Threat to humans

Swamp eels (Synbranchidae) are a source of human gnathostomiasis. Live swamp eels imported to the U.S. could serve as a source of infection to humans in the United States (Cole et al. 2014).

## 4. Introductions

### Means of Introduction

#### Outside the United States

Swamp eels have been introduced primarily through the live trade – for potential aquaculture, human consumption, and to be kept as pets (Guerrero 2014, and Nico et al. 2019). It is presumed that the establishment of swamp eels outside of their native range occurred through escape from aquaculture or the live release of eels as pets or from prayer-ritual release (Nico et al. 2019).

#### Within the United States

Swamp eel introductions within the U.S. have happened either by “an aquarium release, a fish farm escape or release, or release of specimens from the live food-fish market” (Fuller et al. 2021). The first introduction of swamp eels to the U.S. occurred in Hawaii. It is suspected that Asian immigrants introduced *M. albus* as a food fish (Devick 1991; Fuller et al. 2021). Established populations of *M. albus* are also known from New Jersey, Georgia, and Florida (Fuller et al. 2021). Although reported introductions of *A. cuchia* have occurred in many states, it is only reported as established in Louisiana (Jordan et al. 2020).

#### Within Maryland

There is only one known introduction of swamp eels (*A. cuchia*) in Maryland. Four individuals of this species were observed or collected from Lake Needwood near Rockville, Maryland in 2014. Subsequent trapping and electrofishing failed to detect additional swamp eels (Nico et al. 2019). Swamp eels do not appear to be established in the lake. It is unknown why these eels were released into Lake Needwood, but there are anecdotal reports of prayer-release rituals in Montgomery County (Harper, M., Mack, K. personal communication 2014). Swamp eels were sold at nearby live food markets at the time of the introduction (Nico et al. 2019).

## Impacts of Introduction

#### Outside the United States

Swamp eels have been reported as agricultural pests where they have been introduced outside of the U.S. In the Philippines, swamp eels are considered a pest due to their burrowing behavior in rice fields. This burrowing behavior in dikes and other infrastructure can cause water loss and affect nutrient management in rice fields (Gonzales 2014).

### Within the United States

Established populations of this species have not led to deleterious ecological effects in Florida (Shafland et al. 2010). However, Nico et al. (2011) reported the prevalence of internal parasites in imported and wild-caught swamp eels in the U.S. and speculated that these species could serve as a vector of introduction of macro-parasites to native fauna.

### Within Maryland

Swamp eels have been introduced to one known location in Maryland (Lake Needwood), but it is believed that they failed to establish a reproducing population in this man-made impoundment (Nico et al. 2019). There are currently no known impacts of their introduction to Maryland.

## 5. Climate Matching

### **Summary of Climate Matching Analysis**

The Climate 6 score (Australian Bureau of Rural Sciences 2010; 16 climate variables; Euclidean Distance) for Maryland was 1.00.

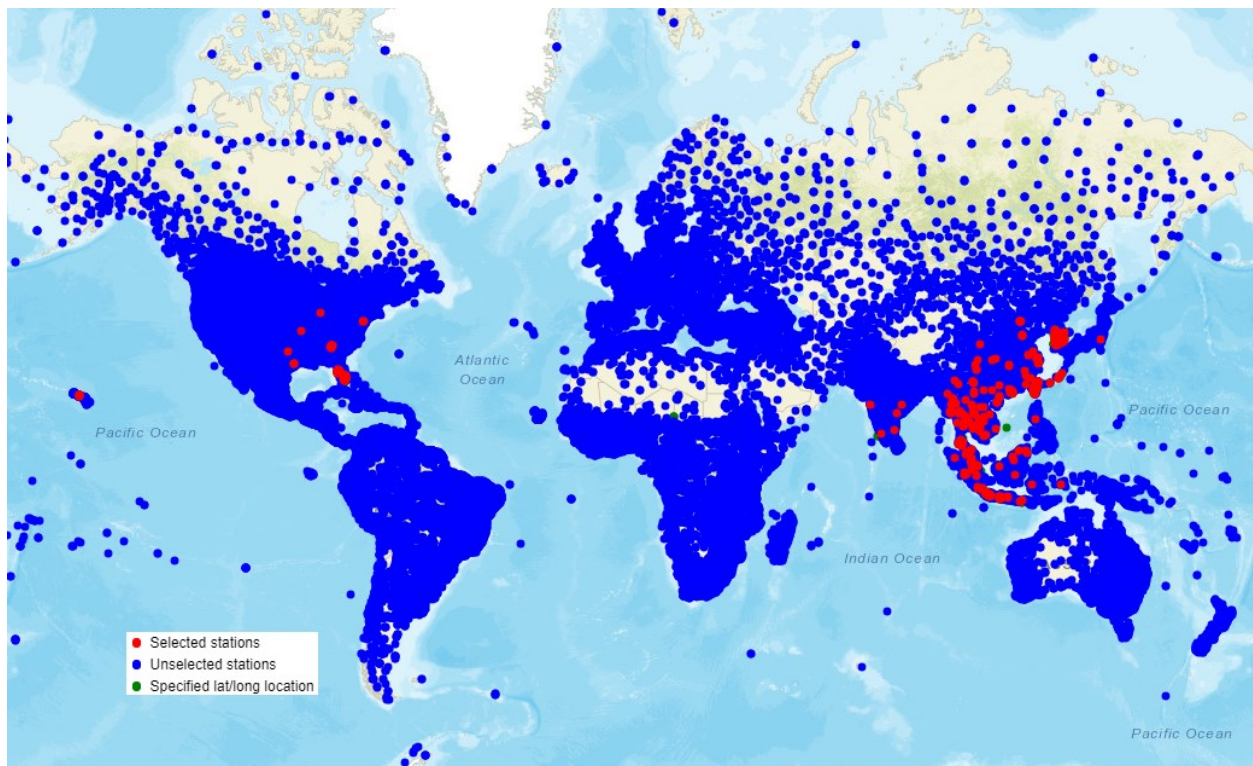


Figure 3: Climatch (Australian Bureau of Rural Science 2010) source map showing weather stations selected as source locations (red) and non-source locations (blue) for *M. albus* climate matching. Source locations from GBIF.org (2021) GBIF Occurrence [Download map of weather stations: https://www.gbif.org/occurrence/download/0088261-210914110416597](https://www.gbif.org/occurrence/download/0088261-210914110416597).

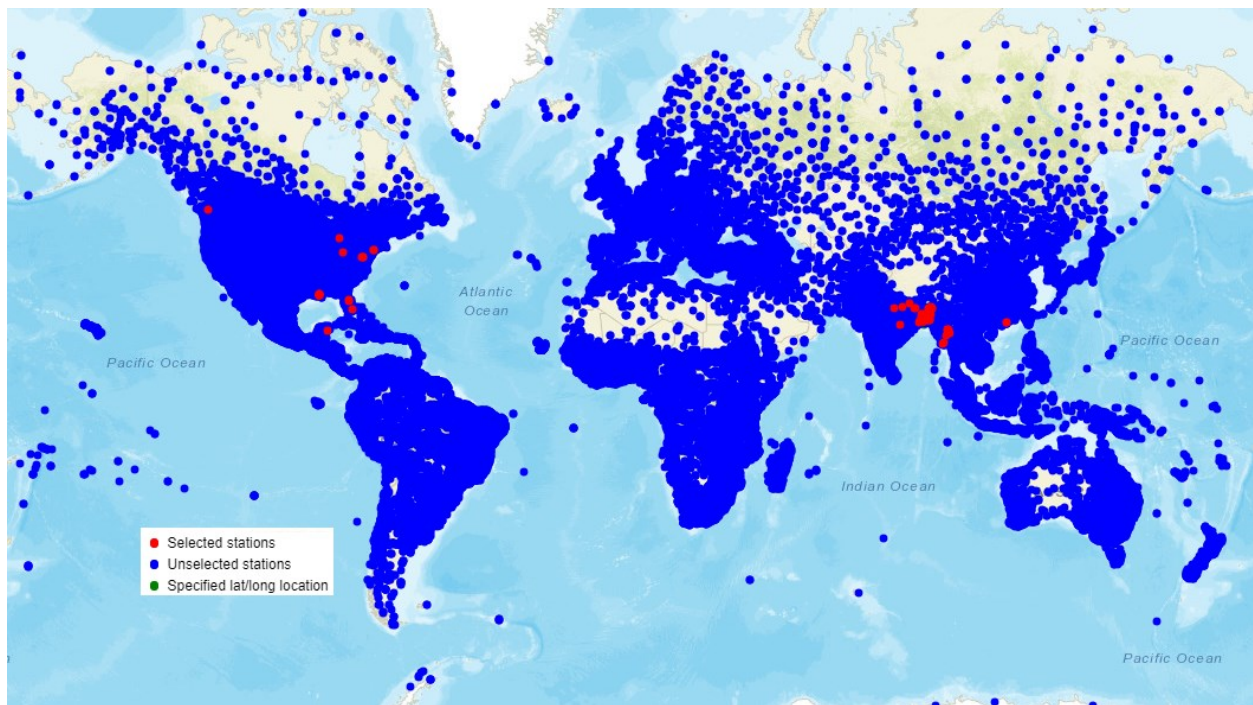


Figure 4: Climatch (Australian Bureau of Rural Science 2010) source map showing weather stations selected as source locations (red) and non-source locations (blue) for *A. cuchia* climate matching. Source locations from GBIF.org (2021) GBIF Occurrence Download [Climatch map](https://www.gbif.org/occurrence/download/0088263-210914110416597): <https://www.gbif.org/occurrence/download/0088263-210914110416597>.



Figure 5. Map of Climatch (Australian Bureau of Rural Science 2010) climate matches for *M. albus* in Maryland based on source locations reported by GBIF.org (2021) GBIF Occurrence [Download climatch map](https://www.gbif.org/occurrence/download/0088261-210914110416597): <https://www.gbif.org/occurrence/download/0088261-210914110416597>. 0 = Lowest match, 10 = Highest match.

Table 1: Climatch (Australian Bureau of Rural Science 2010) climate match scores for *M. albus* for Maryland.

| Climate Match                                                                                    | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7  | 8  | 9  | 10 |
|--------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|----|----|----|----|
| Count                                                                                            | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 15 | 13 | 20 | 0  |
| Climate 6 Proportion = (Sum of Climate Score 6-10) / (Sum of Total Climate Scores) = 1.000: High |   |   |   |   |   |   |   |    |    |    |    |

Table 2: Basis for High, Medium, and Low Climate Match Categories.

| 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                   |

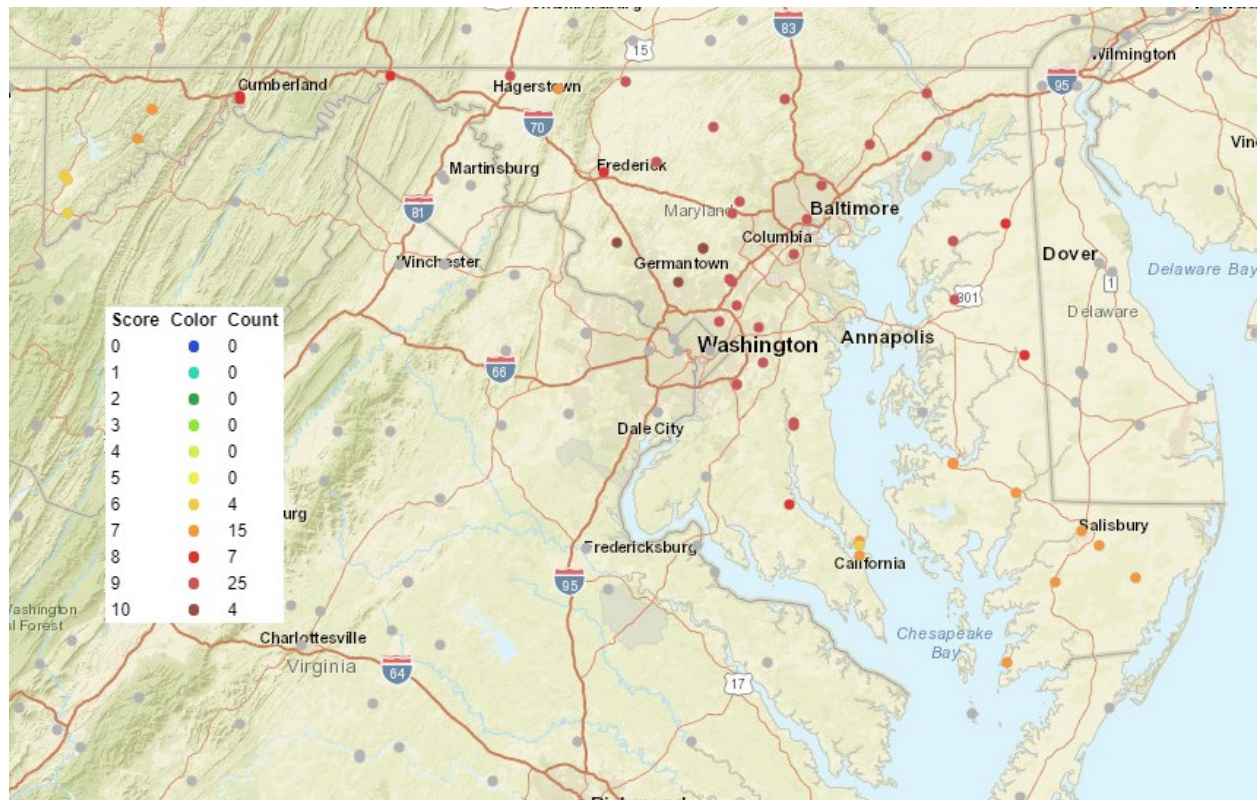


Figure 6. Map of Climatch (Australian Bureau of Rural Science 2010) climate matches for *A. cuchia* in Maryland based on source locations reported by GBIF.org (2021) GBIF Occurrence Download [Climatch](https://www.gbif.org/occurrence/download/0088261-210914110416597): <https://www.gbif.org/occurrence/download/0088261-210914110416597>. 0 = Lowest match, 10 = Highest match.

Table 3: Climatch (Australian Bureau of Rural Science 2010) climate match scores for *A. cuchia* for Maryland.

| Climate Match                                                                                    | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7  | 8 | 9  | 10 |
|--------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|----|---|----|----|
| Count                                                                                            | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 15 | 7 | 25 | 4  |
| Climate 6 Proportion = (Sum of Climate Score 6-10) / (Sum of Total Climate Scores) = 1.000: High |   |   |   |   |   |   |   |    |   |    |    |

Table 4: Basis for High, Medium, and Low Climate Match Categories.

| 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                   |

## 6. Risk Assessment

### Summary of Risk to Maryland

Swamp eels of the family Synbranchidae are native to tropical environments in Central and South America, Africa, Asia, and Australia. Some swamp eel species have been traded widely for human consumption, and to a lesser extent as pets. The two most traded species are *M. albus* and *A. cuchia* – the latter being the most common species imported to the U.S. in recent years. Both of these species have been introduced into U.S. waters either intentionally as released pets or through prayer-release rituals or unintentionally as escapes from aquaculture. Although impacts to invaded areas have been relatively minimal, swamp eels can attain large size (1 meter) and prey on a variety of organisms. Swamp eels are large, secretive predators, and it is possible that impacts have been underreported. Swamp eels serve as hosts to a variety of parasites that could be introduced when live eels are released into novel environments. *Monopterus albus* and *A. cuchia* formed the basis of this Synbranchidae risk assessment – as most introductions of swamp eels have involved these two species. The two risk assessment models used in this assessment indicated that swamp eels pose a high risk to Maryland waters. Swamp eels pose a high potential for introduction, moderate level for establishment and mixed levels of impact – including low environmental impact, high socio-economic impact, and low beneficial impact (see Appendices 1 and 2 below). Results of the Climate matching for these species indicate that most of Maryland is suitable for establishment. Projected increases in temperature with climate change will likely limit winter mortality (as these are tropical species in their native range) and increase the likelihood of establishment and persistence of these species in the future. The overall risk of these species to Maryland is considered High based on their invasive history, environmental tolerance, and prevalence in the live food trade.

### Assessment Elements

- AS-ISK Risk Screening (Basic Risk + Climate Change): High
- Great Lakes Aquatic Invaders Risk Assessment:
  - Potential for Introduction: High

- Potential For Establishment: Moderate
- Potential for Impact
  - Environmental: Low
  - Socio-Economic: High
  - Beneficial: Low

Full assessments are included as appendices at the end of this document.

## **7. Certainty of Assessment**

Confidence or certainty in this assessment is high. There is a lot of published scientific research on swamp eels documenting their introduction and establishment history, especially for the two most traded and introduced species *M. albus* and *A. cuchia*. These species have demonstrated an ability to establish populations in novel environments – including the Mid-Atlantic region.

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## **9. Appendices**

1. [AS – ISK Risk Assessment Screening](#)
2. [Great Lakes Assessment Framework](#)

# Appendix 1: Results of AS-ISK Version 2

| Taxon and Assessor details         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Category                           | Fishes and Lampreys (freshwater)                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Taxon name                         | <i>Monopterus albus</i> ; <i>Amphipnous cuchia</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Common name                        | Asian Swamp Eel; Asian Rice Eel; Mud Eel                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Assessor                           | Jay Kilian                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Risk screening context             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Reason and socio-economic benefits | This analysis was performed to determine the level of risk to Maryland waters posed by all swamp eel species in the family Synbranchidae. It is based on the two most commonly traded swamp eel species, <i>Monopterus albus</i> and <i>A. cuchia</i> . Results of this assessment will inform the appropriate listing status of these species.                                                                                                                                                              |
| Risk assessment area               | Maryland                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Taxonomy                           | Kingdom Animalia Subkingdom Bilateria Infrakingdom Deuterostomia Phylum Chordata Subphylum Vertebrata Infraphylum Gnathostomata Superclass Actinopterygii Class Teleostei Superorder Acanthopterygii Order Synbranchiformes Suborder Synbranchioidei Family Synbranchidae Genus <i>Monopterus</i> (Lacépède, 1800) Species <i>Monopterus albus</i> (Zuiew, 1793) – swamp eel, white ricefield eel, rice eel, Asian swamp eel Species <i>M. cuchia</i> (Hamilton, 1822) – <i>cuchia</i> , rice eel, swamp eel |
| Native range                       | East and Southeast Asia for <i>M. albus</i> and <i>A. cuchia</i> . Swamp eels of the family Synbranchidae are also native to Australia and South America.                                                                                                                                                                                                                                                                                                                                                    |
| Introduced range                   | United States, primarily in the Southeast                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| URL                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

|                                                |      |                                                                                                                                                                  | Response | Justification (references and/or other info)                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Confidence |
|------------------------------------------------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| A. Biogeography/Historical                     |      |                                                                                                                                                                  |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |            |
| 1. Domestication/Cultivation                   |      |                                                                                                                                                                  |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |            |
| 1                                              | 1.01 | Has the taxon been the subject of domestication (or cultivation) for at least 20 generations?                                                                    | No       | Swamp eels do not seem to be bred in captivity in any appreciable quantity. <i>A. cuchia</i> are wild caught for export from Bangladesh (Khatun 2017, Sharmin et al. 2017) and attempts at breeding <i>A. cuchia</i> in aquaculture facilities have not been successful (Miah et al. 2015). <i>M. albus</i> may be captively bred. According to Fuller et al. (2021), "colorful specimens may indicate selective breeding for the aquarium trade."                                                                | Low        |
| 2                                              | 1.02 | Is the taxon harvested in the wild and likely to be sold or used in its live form?                                                                               | Yes      | Asian swamp eels are collected in the wild throughout their native range and imported to live food markets. (Froese and Pauly 2017; Khatun 2017; Sharmin et al. 2017; Nico et al. 2019; Fuller et al. 2021).                                                                                                                                                                                                                                                                                                      | Very high  |
| 3                                              | 1.03 | Does the taxon have invasive races, varieties, sub-taxa or congeners?                                                                                            | Yes      | Asian swamp eels <i>M. albus</i> and <i>A. cuchia</i> have established invasive populations in the United States as well as in the Philippines (Gonzales 2014; Nico et al. 2019, Fuller et al. 2021, Froese and Pauly 2021).                                                                                                                                                                                                                                                                                      | High       |
| 2. Climate, distribution and introduction risk |      |                                                                                                                                                                  |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |            |
| 4                                              | 2.01 | How similar are the climatic conditions of the Risk Assessment (RA) area and the taxon's native range?                                                           | High     | Using the Climatch climate matching model for both <i>M. albus</i> and <i>A. cuchia</i> , the climate of Maryland is determined to be a high match for the climate of these species' established and native ranges. Climate match scores for both species are 1.0, the highest possible (Australian Bureau of Rural Sciences 2010).                                                                                                                                                                               | High       |
| 5                                              | 2.02 | What is the quality of the climate matching data?                                                                                                                | Medium   | There are numerous georeferenced records of Asian Swamp eels (69 records for <i>A. cuchia</i> , 619 records for <i>M. albus</i> ) to use for comparisons between local weather stations' climate data and the 58 weather stations present in Maryland (GBIF 2021; Australian Bureau of Rural Sciences 2010).                                                                                                                                                                                                      | High       |
| 6                                              | 2.03 | Is the taxon already present outside of captivity in the RA area?                                                                                                | No       | Swamp eels ( <i>A. cuchia</i> ) were collected in Lake Needwood in Montgomery County, MD in 2014, but this species is not believed to be established.                                                                                                                                                                                                                                                                                                                                                             | Medium     |
| 7                                              | 2.04 | How many potential vectors could the taxon use to enter in the RA area?                                                                                          | >1       | Swamp eels are sold in live food markets where they may be purchased and then released, either intentionally or unintentionally (Nico et al. 2011; Cole et al. 2014; Nico et al. 2019). Swamp eels are also present in the aquarium trade (Starnes et al. 1998; CABI 2017; Nico et al. 2019; Fuller et al. 2021).                                                                                                                                                                                                 | High       |
| 8                                              | 2.05 | Is the taxon currently found in close proximity to, and likely to enter into, the RA area in the near future (e.g. unintentional and intentional introductions)? | Yes      | There is an established population of swamp eels ( <i>A. cuchia</i> ) in New Jersey (Nico et al. 2011; 2019). Swamp eels have been confiscated from live food markets (Nico et al. 2019) and observed in aquarium stores in Maryland (Harbold, W., personal observation).                                                                                                                                                                                                                                         | Very high  |
| 3. Invasive elsewhere                          |      |                                                                                                                                                                  |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |            |
| 9                                              | 3.01 | Has the taxon become naturalised (established viable populations) outside its native range?                                                                      | Yes      | Swamp eels have established populations in New Jersey, Georgia, Florida, and Hawaii (Nico et al. 2011; USFWS 2018). Established non-native populations exist outside the U.S. in Japan and the Philippines (USFWS 2018; Nico et al. 2019).                                                                                                                                                                                                                                                                        | Very high  |
| 10                                             | 3.02 | In the taxon's introduced range, are there known adverse impacts to wild stocks or commercial taxa?                                                              | No       | Introduced swamp eels have been found to have minimal impacts on both aquaculture and wild fish stocks in Florida (Hill and Watson 2007; Shaffland et al. 2010).                                                                                                                                                                                                                                                                                                                                                  | Medium     |
| 11                                             | 3.03 | In the taxon's introduced range, are there known adverse impacts to aquaculture?                                                                                 | Yes      | Introduced swamp eels have been found to have minimal impacts on both aquaculture (fish) and wild fish stocks in Florida (Hill and Watson 2007; Shaffland et al. 2010). Swamp eels are known to damage rice fields with their burrowing activities in the Philippines (Gascon 2011; Gonzales 2014; USFWS 2018).                                                                                                                                                                                                   | Medium     |
| 12                                             | 3.04 | In the taxon's introduced range, are there known adverse impacts to ecosystem services?                                                                          | No       | Swamp eels can damage irrigation systems and alter hydrology by burrowing (Gascon 2011; Gonzales 2014; USFWS 2018). They are a large predator that may disrupt aquatic food webs and pose a threat in isolated populations in invaded systems (Collins et al. 2002; Froese and Pauly 2021; Fuller et al. 2021). Despite this, diet studies have shown they may have minimal impact on other fishes (Shaffland et al. 2010) and there are no reported studies demonstrating adverse impacts to ecosystem services. | Low        |
| 13                                             | 3.05 | In the taxon's introduced range, are there known adverse socio-economic impacts?                                                                                 | Yes      | Swamp eels can damage irrigation systems and rice fields and alter hydrology by burrowing (Gascon 2011; Gonzales 2014; USFWS 2018).                                                                                                                                                                                                                                                                                                                                                                               | High       |
| B. Biology/Ecology                             |      |                                                                                                                                                                  |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |            |
| 4. Undesirable (or persistence) traits         |      |                                                                                                                                                                  |          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |            |

|                                 |      |                                                                                                                                                                         |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |
|---------------------------------|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 14                              | 4.01 | Is it likely that the taxon will be poisonous or pose other risks to human health?                                                                                      | Yes            | Swamp eels (Synbranchidae) are a common source of human gnathostomiasis, a foodborne zoonosis caused by advanced third stage larvae of <i>Gnathostoma</i> spp. nematodes (Cole et al. 2014).                                                                                                                                                                                                                                                                                                                                                                                                              | High      |
| 15                              | 4.02 | Is it likely that the taxon will smother one or more native taxa (that are not threatened or protected)?                                                                | Not applicable | Swamp eels do not exhibit a growth or life habit that leads to smothering.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Very high |
| 16                              | 4.03 | Are there any threatened or protected taxa that the non-native taxon would parasitise in the RA area?                                                                   | Not applicable | Swamp eels are not parasites.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Very high |
| 17                              | 4.04 | Is the taxon adaptable in terms of climatic and other environmental conditions, thus enhancing its potential persistence if it has invaded or could invade the RA area? | No             | Swamp eels are tolerant of some extreme environmental conditions (USFWS 2018; Fuller et al. 2021), but there is no published evidence of adaptation to overcome physiological or other barriers to establish populations.                                                                                                                                                                                                                                                                                                                                                                                 | Low       |
| 18                              | 4.05 | Is the taxon likely to disrupt food-web structure/function in aquatic ecosystems if it has invaded or is likely to invade the RA area?                                  | Yes            | Swamp eels are potentially disruptive to already threatened native ecosystems. They are large predators, with adults reaching nearly 1 m in length, and they feed on a variety of animals, including fish. Their amphibious nature makes swamp eels more able to invade habitats out of reach to many other large predatory fish and therefore may pose a threat to isolated populations smaller fish, frogs, crayfish, etc. (Collins et al. 2002). "Because they are generalized predators, this species is a potential threat to native fishes, frogs, and aquatic invertebrates" (Fuller et al. 2021). | Medium    |
| 19                              | 4.06 | Is the taxon likely to exert adverse impacts on ecosystem services in the RA area?                                                                                      | Yes            | Swamp eels can damage irrigation systems and alter hydrology by burrowing (Gascon 2011; Gonzales 2014; USFWS 2018). They are a large predator that may disrupt aquatic food webs and pose a threat to isolated populations in invaded systems (Collins et al. 2002; Froese and Pauly 2021; Fuller et al. 2021). Despite this, diet studies have shown they may have minimal impact on other fishes (Shaffland et al. 2010).                                                                                                                                                                               | Low       |
| 20                              | 4.07 | Is it likely that the taxon will host, and/or act as a vector for, recognised pests and infectious agents that are endemic in the RA area?                              | No             | Swamp eels (Synbranchidae) are a common source of human gnathostomiasis (Cole et al. 2014) and are known to carry a number of parasites in their native range (Nico et al. 2011). It is unlikely that pest and infectious agents native to Maryland will utilize swamp eels as hosts.                                                                                                                                                                                                                                                                                                                     | Low       |
| 21                              | 4.08 | Is it likely that the taxon will host, and/or act as a vector for, recognised pests and infectious agents that are absent from (novel to) the RA area?                  | Yes            | Swamp eels (Synbranchidae) are a common source of human gnathostomiasis, a foodborne zoonosis caused by advanced third stage larvae of <i>Gnathostoma</i> spp. nematodes (Cole et al. 2014). Specimens obtained from live food markets and from the wild (introduced populations in Florida) contained a high parasite load including nematodes, acanthocephalans, and digenean parasites (Nico et al. 2011). However, it is unclear if these parasites are new to North American waters or if they pose a threat to native taxa.                                                                         | High      |
| 22                              | 4.09 | Is it likely that the taxon will achieve a body size that will make it more likely to be released from captivity?                                                       | Yes            | Swamp eels can achieve lengths of ~1m (Froese and Pauly 2021), so they may reach sizes where they are more readily released by aquarists. However, swamp eels are not common in the pet trade, so propagule pressure from size-related aquarium release is likely low.                                                                                                                                                                                                                                                                                                                                    | Low       |
| 23                              | 4.10 | Is the taxon capable of sustaining itself in a range of water velocity conditions (e.g. versatile in habitat use)?                                                      | No             | Swamp eels inhabit muddy ponds, canals, rivers, rice fields, and swamps (CABI 2017). This seems to suggest they are predominantly a slow-water specialist.                                                                                                                                                                                                                                                                                                                                                                                                                                                | High      |
| 24                              | 4.11 | Is it likely that the taxon's mode of existence (e.g. excretion of by-products) or behaviours (e.g. feeding) will reduce habitat quality for native taxa?               | Yes            | Introduced swamp eels may reduce habitat quality through their burrowing behavior by decreasing water clarity and may accelerate the drying of ponds and swamps (CABI 2017).                                                                                                                                                                                                                                                                                                                                                                                                                              | Low       |
| 25                              | 4.12 | Is the taxon likely to maintain a viable population even when present in low densities (or persisting in adverse conditions by way of a dormant form)?                  | Yes            | Once introduced, swamp eels were slow to increase in abundance in many locations in Florida (Shaffland et al. 2010). This suggests that these eels are likely to maintain viable populations even when present in low densities.                                                                                                                                                                                                                                                                                                                                                                          | High      |
| <b>5. Resource exploitation</b> |      |                                                                                                                                                                         |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |
| 26                              | 5.01 | Is the taxon likely to consume threatened or protected native taxa in the RA area?                                                                                      | Yes            | They are large predators, with adults reaching nearly 1 m in length, and they feed on a variety of animals, including fish. Their amphibious nature makes swamp eels more able to invade habitats out of reach to many other large predatory fish - posing a threat to isolated populations smaller fish, frogs, crayfish, etc. (Collins et al. 2002) including threatened or protected native Maryland taxa.                                                                                                                                                                                             | Medium    |
| 27                              | 5.02 | Is the taxon likely to sequester food resources (including nutrients) to the detriment of native taxa in the RA area?                                                   | Yes            | Swamp eels can reach a relatively large size of maximum length = 1m, Maximum weight = 0.45 kg (CABI 2017). This might make them the largest predator, or even largest organism in some potential invaded systems, like isolated wetlands. A large adult swamp eel may then sequester a disproportionate amount of nutrients in potentially nutrient-poor systems.                                                                                                                                                                                                                                         | Low       |
| <b>6. Reproduction</b>          |      |                                                                                                                                                                         |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |
| 28                              | 6.01 | Is the taxon likely to exhibit parental care and/or to reduce age-at-maturity in response to environmental conditions?                                                  | Yes            | Male swamp eels guard eggs and young in bubble nests (Froese and Pauly 2021).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Very high |
| 29                              | 6.02 | Is the taxon likely to produce viable gametes or propagules (in the RA area)?                                                                                           | Yes            | Established populations of swamp eels occur north and south of Maryland (Nico et al. 2019) suggesting that the production of viable gametes is not limited by climate in the RA area.                                                                                                                                                                                                                                                                                                                                                                                                                     | High      |
| 30                              | 6.03 | Is the taxon likely to hybridise naturally with native taxa?                                                                                                            | No             | There are no native congeners or fishes in the family Synbranchidae in Maryland. Therefore, hybridization with native fishes is highly unlikely.                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Very high |
| 31                              | 6.04 | Is the taxon likely to be hermaphroditic or to display asexual reproduction?                                                                                            | No             | The two most commonly traded species ( <i>M. albus</i> and <i>A. cuchia</i> ) are sequential hermaphrodites - all individuals are born as females and transform into males (USFWS 2018; Nico et al. 2019). However, the species is not known to produce asexually.                                                                                                                                                                                                                                                                                                                                        | Medium    |

|                                |      |                                                                                                                                                                                           |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |
|--------------------------------|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 32                             | 6.05 | Is the taxon dependent on the presence of another taxon (or specific habitat features) to complete its life cycle?                                                                        | No        | There is no evidence in the literature that species of the family Synbranchidae require another taxon for successful reproduction or to complete its life cycle.                                                                                                                                                                                                                                                                                                                                                                                                                     | Very high |
| 33                             | 6.06 | Is the taxon known (or likely) to produce a large number of propagules or offspring within a short time span (e.g. < 1 year)?                                                             | No        | A female can produce 268 - 642 eggs (Shafland et al. 2010), but this is low in comparison to fecundity of other fishes of the class Teleostei.                                                                                                                                                                                                                                                                                                                                                                                                                                       | Medium    |
| 34                             | 6.07 | How many time units (days, months, years) does the taxon require to reach the age-at-first-reproduction?                                                                                  | 1         | It is unclear from the current literature the age at first reproduction for the two most studied species - <i>M. albus</i> and <i>A. cuchia</i> . However, it is likely individuals must be at least 1 year old before becoming sexually reproductive.                                                                                                                                                                                                                                                                                                                               | Low       |
| <b>7. Dispersal mechanisms</b> |      |                                                                                                                                                                                           |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |
| 35                             | 7.01 | How many potential internal vectors/pathways could the taxon use to disperse within the RA area (with suitable habitats nearby)?                                                          | One       | Natural passive dispersal is likely within a waterbody once introduced. However, movement between waterbodies is only likely through intentional human-mediated means (illegal release/ stocking). Swamp eels are not likely to be carried (hitchhike) unintentionally on watercraft or other means.                                                                                                                                                                                                                                                                                 | Low       |
| 36                             | 7.02 | Will any of these vectors/pathways bring the taxon in close proximity to one or more protected areas (e.g. MCZ, MPA, SSSI)?                                                               | Yes       | Illegal stocking (release) of swamp eels could occur anywhere in the RA. The likelihood that an intentional release would occur in a rare or protected habitat in Maryland is low, but not zero.                                                                                                                                                                                                                                                                                                                                                                                     | Medium    |
| 37                             | 7.03 | Does the taxon have a means of actively attaching itself to hard substrata (e.g. ship hulls, pilings, buoys) such that it enhances the likelihood of dispersal?                           | No        | Swamp eels do not have a morphological adaptation that would facilitate its dispersal via attachment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Very high |
| 38                             | 7.04 | Is natural dispersal of the taxon likely to occur as eggs (for animals) or as propagules (for plants: seeds, spores) in the RA area?                                                      | No        | Most swamp eels that are traded in North America in the live food and pet trades are adults captured from the wild in source countries (Nico et al. 2019).                                                                                                                                                                                                                                                                                                                                                                                                                           | High      |
| 39                             | 7.05 | Is natural dispersal of the taxon likely to occur as larvae/juveniles (for animals) or as fragments/seedlings (for plants) in the RA area?                                                | Yes       | If swamp eels were to successfully reproduce in Maryland, natural dispersal may occur in juveniles. Dispersal of larvae is unlikely even during flood events due to the heavy yolk masses associated with swamp eels like <i>A. cuchia</i> (Miah et al. 2015).                                                                                                                                                                                                                                                                                                                       | Low       |
| 40                             | 7.06 | Are older life stages of the taxon likely to migrate in the RA area for reproduction?                                                                                                     | No        | There is no evidence in the literature that indicates that swamp eels are migratory.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | High      |
| 41                             | 7.07 | Are propagules or eggs of the taxon likely to be dispersed in the RA area by other animals?                                                                                               | No        | Swamp eels ( <i>M. albus</i> and <i>A. cuchia</i> ) are nest guards (Miah et al. 2015; Fuller et al. 2021). Males create nests among aquatic vegetation and keeps guard over the developing larvae and juveniles. This guarding behavior would limit potential dispersal by other animals. There is no evidence in the literature of swamp eels dispersal via waterfowl.                                                                                                                                                                                                             | High      |
| 42                             | 7.08 | Is dispersal of the taxon along any of the vectors/pathways mentioned in the previous seven questions (7.01–7.07; i.e. both unintentional or intentional) likely to be rapid?             | No        | Once introduced into a waterbody (likely by intentional stocking), it is not likely that swamp eels would disperse rapidly based on spread rates observed in Florida. Swamp eels are slow to increase in abundance and slow to spread to new areas - likely due to 'their slow growth, sedentary nature, and the presence of very few males that need first to mature as females' (Shafland et al. 2010). An introduced population in Silver Lake in New Jersey has not dispersed since 2008 to adjacent lotic habitats despite having access (Chris Smith, personal communication). | Low       |
| 43                             | 7.09 | Is dispersal of the taxon density dependent?                                                                                                                                              | No        | There is no published research indicating that swamp eel dispersal is density dependent.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Low       |
| <b>8. Tolerance attributes</b> |      |                                                                                                                                                                                           |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |
| 44                             | 8.01 | Is the taxon able to withstand being out of water for extended periods (e.g. minimum of one or more hours) at some stage of its life cycle?                                               | Yes       | Asian swamp eels can reportedly survive out of water for extended periods. These species can absorb atmospheric oxygen by gulping air (Shafland et al. 2010).                                                                                                                                                                                                                                                                                                                                                                                                                        | Very high |
| 45                             | 8.02 | Is the taxon tolerant of a wide range of water quality conditions relevant to that taxon? [In the Justification field, indicate the relevant water quality variable(s) being considered.] | Yes       | Swamp eels are tolerant to a wide range of water quality conditions - including high ammonia concentrations (Miah et al. 2015) and moderate levels of salinity in the 14-16 ppt range (Schofield and Nico 2009).                                                                                                                                                                                                                                                                                                                                                                     | High      |
| 46                             | 8.03 | Can the taxon be controlled or eradicated in the wild with chemical, biological, or other agents/means?                                                                                   | Yes       | Electrofishing has been used to collect large numbers of eels in Florida, though this technique alone would likely be insufficient for eradication (Schofield and Nico 2014). Rotenone is effective to cause mortality in swamp eels, but is also of limited utility due to the species' burrowing and evasive behavior (Schofield and Nico 2007).                                                                                                                                                                                                                                   | Low       |
| 47                             | 8.04 | Is the taxon likely to tolerate or benefit from environmental/human disturbance?                                                                                                          | Yes       | Swamp eels appear to be tolerant to low dissolved oxygen concentrations and are physiologically suited for man-made impoundments, stormwater ponds, canals, and disturbed systems like agricultural rice fields (Shafland et al. 2010; Fuller et al. 2021).                                                                                                                                                                                                                                                                                                                          | High      |
| 48                             | 8.05 | Is the taxon able to tolerate salinity levels that are higher or lower than those found in its usual environment?                                                                         | Yes       | Swamp eels are generally associated with freshwater environments, but some species ( <i>M. albus</i> ) appears to be quite tolerant to moderate salinity levels (14-16 ppt; Schofield and Nico 2007). This tolerance could aid its dispersal in the Chesapeake Bay region.                                                                                                                                                                                                                                                                                                           | High      |
| 49                             | 8.06 | Are there effective natural enemies (predators) of the taxon present in the RA area?                                                                                                      | Yes       | Shafland et al. (2010) reported predation on swamp eels by Largemouth Bass and wading birds, however this reported predation did not prevent establishment of the eels.                                                                                                                                                                                                                                                                                                                                                                                                              | Medium    |
| <b>C. Climate change</b>       |      |                                                                                                                                                                                           |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |
| <b>9. Climate change</b>       |      |                                                                                                                                                                                           |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |
| 50                             | 9.01 | Under the predicted future climatic conditions, are the risks of entry into the RA area posed by the taxon likely to increase, decrease or not change?                                    | No change | It is assumed that risk of entry would remain relatively the same even under warming climatic conditions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Medium    |
| 51                             | 9.02 | Under the predicted future climatic conditions, are the risks of establishment posed by the taxon likely to increase, decrease or not change?                                             | Increase  | Based on the Climatch analysis, the current climatic conditions within Maryland are suitable for establishment of swamp eels. Risk of establishment in Maryland may increase with predicted warming of Maryland facilitated by lower winter mortality events.                                                                                                                                                                                                                                                                                                                        | Medium    |
| 52                             | 9.03 | Under the predicted future climatic conditions, are the risks of dispersal within the RA area posed by the taxon likely to increase, decrease or not change?                              | No change | Risk of dispersal in Maryland is more likely influenced by the connectedness of the invaded waterbody to other suitable habitats. Dispersal is likely not limited by climate (e.g., temperature) within the RA.                                                                                                                                                                                                                                                                                                                                                                      | Low       |

|    |      |                                                                                                                                                              |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |     |
|----|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 53 | 9.04 | Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on biodiversity and/or ecological integrity/status? | No change | Swamp eels serve as a significant predator on a wide-range of prey and may disrupt aquatic food webs and pose a threat in isolated populations in invaded systems (Collins et al. 2002, Froese and Pauly 2021; Fuller et al. 2021). Limited number of diet studies have shown they may have minimal impact on other fishes (Shaffland et al. 2010). Potential impacts on biodiversity or ecological integrity are not likely to change substantially due to future climatic conditions. | Low |
| 54 | 9.05 | Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on ecosystem structure and/or function?             | No change | Potential impacts to Maryland ecosystems are likely to be localized and specific to the invaded waterbody if these species were to become established. Future climatic conditions are not expected to change the magnitude of future potential impacts.                                                                                                                                                                                                                                 | Low |
| 55 | 9.06 | Under the predicted future climatic conditions, what is the likely magnitude of future potential impacts on ecosystem services/socio-economic factors?       | No change | Potential impacts to Maryland ecosystem services/socio-economic factors are likely to be localized and specific to the invaded waterbody if these species were to become established. Future climatic conditions are not expected to change the magnitude of future potential impacts.                                                                                                                                                                                                  | Low |

Appendix 2: Results of Great Lakes Aquatic Invaders assessment of Asian Swamp Eel in Maryland

**A risk assessment of potential Great Lakes aquatic invaders, adapted to Maryland/the Mid-Atlantic**

|                         |                                                                                          |
|-------------------------|------------------------------------------------------------------------------------------|
| <b>Scientific Name:</b> | Swamp Eels of the Family Synbranchidae (including <i>M. albus</i> and <i>M. cuchia</i> ) |
| <b>Common Name:</b>     | Asian Swamp Eel; Asian Rice Eel; Mud Eel                                                 |

|                     |                 |
|---------------------|-----------------|
| <b>Assessed By:</b> | Jay Kilian      |
| <b>Reviewed By:</b> | William Harbold |
| <b>Reviewed By:</b> | Joe Love        |
| <b>Date:</b>        | 2021            |

| Scoring                      |                                                                   | Confidence Level |      |
|------------------------------|-------------------------------------------------------------------|------------------|------|
| Potential for Introduction:  | High                                                              | High             |      |
| Potential for Establishment: | Moderate                                                          | High             |      |
| Potential for Impact:        | unknowns/uncertainty are incorporated in impact potential scoring |                  |      |
| Environmental:               |                                                                   |                  | Low  |
| Socio-Economic:              |                                                                   |                  | High |
| Beneficial:                  |                                                                   |                  | Low  |

**POTENTIAL INTRODUCTION VIA DISPERSAL**

|            |                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                       | Score        |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 1a         | Does this species occur near waters (natural or artificial) connected to Maryland/the Mid-Atlantic* (e.g., streams, ponds, canals, or wetlands)? (*Maryland/the Mid-Atlantic = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes) | Yes, this species occurs near waters connected to Maryland/the Mid-Atlantic and is mobile or able to be transported by wind or water.                                                                                                                 | 100          |
|            |                                                                                                                                                                                                                                                                                                          | No, this species does not occur near waters connected to Maryland/the Mid-Atlantic and/or is not mobile or able to be transported by wind or water.                                                                                                   | 0            |
|            |                                                                                                                                                                                                                                                                                                          | Unknown                                                                                                                                                                                                                                               | U            |
| 1b         | What is the proximity of this species to Maryland/the Mid-Atlantic?                                                                                                                                                                                                                                      | This species occurs in waters within 20 kilometers of Maryland/the Mid-Atlantic, and no barrier (e.g., electric barrier, dam) to dispersal is present.                                                                                                | Score x 1    |
|            |                                                                                                                                                                                                                                                                                                          | This species occurs in waters within 20 kilometers of Maryland/the Mid-Atlantic, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of Maryland/the Mid-Atlantic, and no barrier to dispersal is present. | Score x 0.75 |
|            |                                                                                                                                                                                                                                                                                                          | This species occurs in waters within 100 kilometers of Maryland/the Mid-Atlantic, but dispersal to the basin is blocked.                                                                                                                              | Score x 0.5  |
|            |                                                                                                                                                                                                                                                                                                          | This species occurs in waters >100 kilometers from Maryland/the Mid-Atlantic.                                                                                                                                                                         | Score x 0.25 |
|            |                                                                                                                                                                                                                                                                                                          | Unknown                                                                                                                                                                                                                                               | U            |
| Notes      | The closest known population ( <i>M. albus</i> ) is in Silver Lake, New Jersey within the Passiac River basin. This is over 215 km from the Maryland border.                                                                                                                                             |                                                                                                                                                                                                                                                       |              |
| References | Nico et al. 2019                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                       |              |

Multiplier

0.25

**POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING**

|       |                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                    | Score       |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 2a    | 2a) Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering Maryland/the Mid-Atlantic? | Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering Maryland/the Mid-Atlantic.    | 100         |
|       |                                                                                                                                                                                                                                                                                                                       | No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering Maryland/the Mid-Atlantic. | 0           |
|       |                                                                                                                                                                                                                                                                                                                       | Unknown                                                                                                                                            | U           |
| 2b    | 2b) What is the proximity of this species to Maryland/the Mid-Atlantic?                                                                                                                                                                                                                                               | This species occurs in waters within 20 km of Maryland/the Mid-Atlantic.                                                                           | Score x 1   |
|       |                                                                                                                                                                                                                                                                                                                       | This species occurs in waters within 100 km of Maryland/the Mid-Atlantic.                                                                          | Score x 0.5 |
|       |                                                                                                                                                                                                                                                                                                                       | This species occurs in waters >100 km from Maryland/the Mid-Atlantic.                                                                              | Score x 0.1 |
|       |                                                                                                                                                                                                                                                                                                                       | Unknown                                                                                                                                            | U           |
|       |                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                    |             |
| Notes | Movement between waterbodies is only likely through intentional human-mediated means (illegal release/ stocking). Swamp eels are not likely to be carried (hitchhike) unintentionally on watercraft or other means.                                                                                                   |                                                                                                                                                    |             |

Multiplier

0.1

|            |                  |
|------------|------------------|
| References | Nico et al. 2019 |
|------------|------------------|

#### **POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE**

| POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE |                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                      |             | Score |
|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------|
| 3a                                                          | Is this species sold at aquarium/pet/garden stores (“brick & mortar” or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into Maryland/the Mid-Atlantic?                                                           | Yes, this species is available for purchase.                                                                                                                                         | 100         | 100   |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                        | No, this species this species is rarely/never sold.                                                                                                                                  | 0           |       |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                        | Unknown                                                                                                                                                                              | U           |       |
| 3b                                                          | How easily is this species obtained within the Mid-Atlantic region?                                                                                                                                                                                                                                                                                                    | This species is widely popular, frequently sold, and/or easily obtained within the Mid-Atlantic region.                                                                              | Score x 1   | 0.1   |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                        | This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Mid-Atlantic region. | Score x 0.5 |       |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                        | This species is not very popular or is not easily obtained within the Mid-Atlantic region.                                                                                           | Score x 0.1 |       |
|                                                             |                                                                                                                                                                                                                                                                                                                                                                        | Unknown                                                                                                                                                                              | U           |       |
| Notes                                                       | This species has been observed for sale in Maryland in specialty aquarium stores (Harbold, W., personal communication 2019). It has been observed for sale in live food markets in the suburbs of Washington D.C. (Kilian, J., personal observation 2016). However, overall, it is not easily obtained or widely available and popular within the Mid-Atlantic region. |                                                                                                                                                                                      |             |       |
| References                                                  | Harbold, W., personal communication 2019; Kilian, J., personal observation 2016; Nico et al. 2019                                                                                                                                                                                                                                                                      |                                                                                                                                                                                      |             |       |

#### **POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE**

|    |                                                                                                                           |                                                                                                                                                                                                                  |              | Score |
|----|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------|
| 4a | Is this species being stocked/planted to natural waters or outdoor water gardens around Maryland/the Mid-Atlantic region? | Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in Maryland/the Mid-Atlantic region. | 100          | 100   |
|    |                                                                                                                           | No, this species cannot be stocked/planted or there is not enough interest to do so in Maryland/the Mid-Atlantic region.                                                                                         | 0            |       |
|    |                                                                                                                           | Unknown                                                                                                                                                                                                          | U            |       |
| 4b | What is the nature and proximity of this activity to Maryland/the Mid-Atlantic basin?                                     | This activity is authorized and/or is occurring directly in Maryland/the Mid-Atlantic.                                                                                                                           | Score x 1    | 1     |
|    |                                                                                                                           | This activity is occurring in Maryland/the Mid-Atlantic tributaries or connecting waters, or within 20 km of Maryland/the Mid-Atlantic basin.                                                                    | Score x 0.75 |       |
|    |                                                                                                                           | This activity is likely to occur within 20 km of Maryland/the Mid-Atlantic basin because of its popularity/value and there are no widespread regulations against stocking/planting.                              | Score x 0.5  |       |

|            |                                                                                                                                                                                                                                                                                                                                                                                                  |              |   |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---|
|            | <p>Maryland/the Mid-Atlantic basin:</p> <p>This activity is occurring in waters &gt;20 km from Maryland/the Mid-Atlantic basin, or despite federal or state regulations in more than half the basin (&gt; 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.</p> <p>Unknown</p>                                                    | Score x 0.25 | U |
| Notes      | There is anecdotal evidence that swamp eels ( <i>A. cuchia</i> ) was released in Lake Needwood in 2014 and that this release may have been associated with a prayer release ritual. This activity is not authorized and it is uncertain how often these rituals occur in the region. Swamp eels may be released as unwanted pets as well, but it is uncertain how often this occurs in Maryland. |              |   |
| References | Nico et al. 2019                                                                                                                                                                                                                                                                                                                                                                                 |              |   |

#### **POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE**

|            |                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                            | Score        |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 5a         | Is this species known to be commercially cultured in or transported through Maryland/the Mid-Atlantic region?                                                                                                                                                                                      | Yes, this species is being commercially cultured in or transported through Maryland/the Mid-Atlantic region.                                                                                                                                                               | 100          |
|            |                                                                                                                                                                                                                                                                                                    | No, this species is not commercially cultured in or transported through Maryland/the Mid-Atlantic region.                                                                                                                                                                  | 0            |
|            |                                                                                                                                                                                                                                                                                                    | Unknown                                                                                                                                                                                                                                                                    | U            |
| 5b         | 5b) What is the nature and proximity of this activity to Maryland/the Mid-Atlantic basin?                                                                                                                                                                                                          | This activity is unregulated or minimally regulated and is occurring directly in Maryland/the Mid-Atlantic.                                                                                                                                                                | Score x 1    |
|            |                                                                                                                                                                                                                                                                                                    | This activity is unregulated or minimally regulated and is occurring in Maryland/the Mid-Atlantic tributaries or connecting waters, or within 20 km of Maryland/the Mid-Atlantic basin.                                                                                    | Score x 0.75 |
|            |                                                                                                                                                                                                                                                                                                    | This activity is strictly regulated but occurs directly in Maryland/the Mid-Atlantic, and/or this activity involves transport of live organisms on/across Maryland/the Mid-Atlantic.                                                                                       | Score x 0.5  |
|            |                                                                                                                                                                                                                                                                                                    | This activity is strictly regulated but occurs in Maryland/the Mid-Atlantic tributaries, connecting waters, or within 20 km of Maryland/the Mid-Atlantic basin, and/or this activity involves transport of live organisms within 20 km of Maryland/the Mid-Atlantic basin. | Score x 0.25 |
|            |                                                                                                                                                                                                                                                                                                    | This activity occurs >20 km from Maryland/the Mid-Atlantic basin and typically does not involve transport of live organisms closer to the basin.                                                                                                                           | Score x 0.1  |
|            |                                                                                                                                                                                                                                                                                                    | Unknown                                                                                                                                                                                                                                                                    | U            |
| Notes      | Although prohibited from possession and sale in Maryland, swamp eels have been observed in various live food markets in the suburbs of Washington, D.C. Eels confiscated from one store originated from Bangladesh and were transported to Maryland through Brooklyn, New York (Nico et al. 2019). |                                                                                                                                                                                                                                                                            |              |
| References | Kilian, J., personal observation 2016; Nico et al. 2019                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                            |              |

#### **POTENTIAL INTRODUCTION VIA SHIPPING**

Score

|            |                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                          |             |            |   |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------------|---|
| 6a         | Is this species likely to be taken up in ballast, and capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/flushing (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?                                | Yes, this species is able to survive in ballast tank environments for weeks at a time and is not substantially impacted by current regulatory requirements (e.g., exchange, flushing).                   | 100         | Multiplier | 0 |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                       | Yes, this species is able to survive in ballast tank environments for weeks at a time, but survival is substantially impacted by current regulatory requirements.                                        | 80          |            |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                       | No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.                                                         | 40          |            |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                       | No, this species is unlikely to be taken up in ballast, not able to survive adverse environments, does not foul transoceanic ship structures, or is unable to survive current ballast water regulations. | 0           |            |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                       | Unknown                                                                                                                                                                                                  | U           |            |   |
| 6b         | Does this species occur in waters from which shipping traffic to Maryland/the Mid-Atlantic originates?                                                                                                                                                                                                                                                                                                                | Yes, and this species has been observed in ballast of or fouling ships entering Maryland/the Mid-Atlantic.                                                                                               | Score x 1   |            | 0 |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                       | Yes, and this species has been observed in ports that have direct trade connections with Maryland/the Mid-Atlantic (e.g., Baltic Sea).                                                                   | Score x 0.5 |            |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                       | Yes, but this species has neither been observed in ballast/fouling ships entering Maryland/the Mid-Atlantic nor in ports in direct trade with Maryland/the Mid-Atlantic.                                 | Score x 0.1 |            |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                       | No, this species does not occur in waters from which shipping traffic to Maryland/the Mid-Atlantic originates.                                                                                           | Score x 0   |            |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                       | Unknown                                                                                                                                                                                                  | U           |            |   |
| Notes      | There is no evidence to suggest that ballast water from shipping is a viable pathway for these fishes. The primary pathway of Swamp Eel introduction is through the live trade of these animals for human consumption and pets - with unintentional release, intentional release (stocking), and cultural release (prayer release rituals) the suspected means these species have been introduced (Nico et al. 2019). |                                                                                                                                                                                                          |             |            |   |
| References | Nico et al. 2019                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                          |             |            |   |

# INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                   |   |   |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| 1)         | How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?                                                                                                                                                                                                                                                                                                 | This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels. | 9 | 9 |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                              | This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.    | 6 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                              | This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.                                                                         | 3 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                              | Unknown                                                                                                                                                                                                                           | U |   |
| Notes      | Although swamp eels have been described as a tropical species, these eels are tolerant of a wide range of temperature, salinity, and oxygen. Tolerance likely varies by species, but the two most traded species in North America ( <i>M. albus</i> , <i>A. cuchia</i> ) appear to be quite tolerant (USFWS 2018; Fuller et al. 2021) and conditions in many Maryland habitats are suitable for establishment based on published literature. |                                                                                                                                                                                                                                   |   |   |
| References | USFWS 2018; Fuller et al. 2021                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                   |   |   |
| 2)         | How likely is it that any life stage of this species can overwinter in Maryland/the Mid-Atlantic (survive extremely low levels of oxygen, light, and temperature)?                                                                                                                                                                                                                                                                           | Likely (This species is able to tolerate temperatures under 5°C and oxygen levels $\leq 0.5$ mg/L)                                                                                                                                | 9 | 9 |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                              | Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)                                                                                                             | 6 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                              | Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)                                                                                         | 3 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                              | Unlikely                                                                                                                                                                                                                          | 0 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                              | Unknown                                                                                                                                                                                                                           | U |   |
| Notes      | Swamp Eels ( <i>M. albus</i> ) are established north of Maryland in New Jersey near the New York border where they have survived freezing temperatures, etc. since 2008 (Smith, C. personal communication 2014; Nico et al. 2019). Georgia populations have also reportedly survived in ponds covered with ice (Starnes et al. 1998).                                                                                                        |                                                                                                                                                                                                                                   |   |   |
| References | Starnes et al. 1998; Smith, C., personal communication 2014; Nico et al. 2019.                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                   |   |   |
|            | If this species is a heterotroph, how would                                                                                                                                                                                                                                                                                                                                                                                                  | This species is a dietary generalist with a broad, assorted, AND flexible diet.                                                                                                                                                   | 9 | 9 |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                              | This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.                                                                                                                                         | 6 |   |

|            |                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| <b>3)</b>  | <p>If this species is a heterotroph, how would the flexibility of its diet be described?</p> <p>This species is a dietary specialist with a limited and inflexible diet.</p> <p>This species is an autotroph.</p> <p>Unknown</p>                                                                  | <p>3</p> <p>0</p> <p>U</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |
| Notes      | <p>“Because they are generalized predators, this species is a potential threat to native fishes, frogs, and aquatic invertebrates” (Fuller et al. 2021).</p>                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |
| References | <p>Fuller et al. 2021</p>                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |
| <b>4)</b>  | <p>How likely is this species to outcompete species in Maryland/the Mid-Atlantic for available resources?</p>                                                                                                                                                                                     | <p>Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in Maryland/the Mid-Atlantic) 9</p> <p>Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in Maryland/the Mid-Atlantic) 6</p> <p>Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in Maryland/the Mid-Atlantic) 3</p> <p>Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in Maryland/the Mid-Atlantic) 0</p> <p>Unknown U</p> | 3 |
| Notes      | <p>Swamp Eels can grow to one meter in size and the eel species are considered generalist predators (USFWS 2018; Fuller et al. 2021). There is no published research that provides evidence that these eel species represent significant competitors to native taxa in Maryland or elsewhere.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |
| References | <p>USFWS 2018; Fuller et al. 2021</p>                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |   |
| <b>5)</b>  | <p>How would the fecundity of this species be described relative to other species in the same taxonomic Class?</p>                                                                                                                                                                                | <p>Very high 9</p> <p>High 6</p> <p>Moderate 3</p> <p>Low 0</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0 |

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
|            | Unknown                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | U                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |   |
| Notes      | A female can produce 268 - 642 eggs (Shafland et al. 2010; Miah et al. 2015). This is low compared to many other families in the class Teleostei.                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |
| References | Shafland et al. 2010; Miah et al. 2015                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |
| 6)         | How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly Maryland/the Mid-Atlantic (e.g., parthenogenesis/self-crossing, self-fertility, vegetative fragmentation)?                                                                                                                                                                                                                                                           | Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in Maryland/the Mid-Atlantic based on these attributes) 9<br>Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in Maryland/the Mid-Atlantic based on these attributes) 6<br>Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in Maryland/the Mid-Atlantic based on these attributes) 3<br>Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments) 0<br>Unknown U | 6 |
| Notes      | The two most commonly traded species ( <i>M. albus</i> and <i>A. cuchia</i> ) are sequential hermaphrodites - all individuals are born as females and some transform into males later in life (USFWS 2018; Nico et al. 2019). These species are not known to produce asexually. However, this reproductive strategy may aid them in establishment in new environments. There is no published literature that this strategy will aid establishment in Maryland or the Mid-Atlantic region. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |
| References | USFWS 2018; Nico et al. 2019                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |

#### **ENVIRONMENTAL COMPATIBILITY**

|    |                                                                                                                          |                                                                                                                                                                                                                                                                                                                                         |   |
|----|--------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 7) | How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced | Very similar (The climatic conditions are practically identical to those of Maryland/the Mid-Atlantic region) 9<br>Similar (Many of the climatic conditions are similar to those of Maryland/the Mid-Atlantic region) 6<br>Somewhat similar (Few of the climatic conditions are similar to those of Maryland/the Mid-Atlantic region) 3 | 9 |
|----|--------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                             |        |   |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|--------|---|
|            | ranges of this species to those in Maryland/the Mid-Atlantic region?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Not similar<br>Unknown                                                                                      | 0<br>U |   |
| Notes      | Using the Climatch model (Australian Bureau of Rural Sciences 2010) for both <i>M. albus</i> and <i>A. cuchia</i> , the climate of Maryland is determined to be a high match for the climate of these species in established and native ranges. Climate match scores for both species in Maryland are 1.0, the highest score possible (Australian Bureau of Rural Sciences 2010).                                                                                                                                                                                                         |                                                                                                             |        |   |
| References | Australian Bureau of Rural Sciences 2010                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                             |        |   |
| 8)         | How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in Maryland/the Mid-Atlantic?                                                                                                                                                                                                                                                                                                                             | Very similar (These factors are practically identical to those of Maryland/the Mid-Atlantic region)         | 9      | 6 |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Similar (Many of these factors are similar to those of Maryland/the Mid-Atlantic region)                    | 6      |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Somewhat similar (Few of these factors are similar to those of Maryland/the Mid-Atlantic region)            | 3      |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Not similar                                                                                                 | 0      |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Unknown                                                                                                     | U      |   |
| Notes      | Swamp eels are tolerant to a wide range of water quality conditions - including high ammonia concentrations (Miah et al. 2015) and moderate levels of salinity in the 14-16 ppt range (Schofield and Nico 2007). Swamp eels appear to be tolerant to low dissolved oxygen concentrations and are physiologically suited for man-made impoundments, stormwater ponds, canals, and disturbed systems like agricultural rice fields (Shafland et al. 2010; Fuller et al. 2021). Conditions within many Maryland habitats are similar to those reported in the native range of these species. |                                                                                                             |        |   |
| References | Schofield and Nico 2007; Shafland et al. 2010; Miah et al. 2015; Fuller et al. 2021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                             |        |   |
| 9)         | How abundant are habitats suitable for the survival, development, and reproduction of this species in Maryland/the Mid-Atlantic area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?                                                                                                                                                                                                                                                                                                                                                                            | Abundant (Suitable habitats can be easily found and readily available)                                      | 9      | 9 |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present) | 6      |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Somewhat scarce (Suitable habitats can be found occasionally)                                               | 3      |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Scarce (Suitable habitats are rarely found)                                                                 | 0      |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Unknown                                                                                                     | U      |   |

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Notes      | Based on the Climatch model (Australian Bureau of Rural Sciences 2010), the current climatic conditions throughout most of Maryland are suitable for establishment of swamp eels. There are many slow-water habitats in Maryland that would likely provide suitable habitat for survival, development, and reproduction of these species.                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |
| References | Australian Bureau of Rural Sciences 2010                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |
| <b>10)</b> | How likely is this species to adapt to or to benefit from the predicted effects of climate change on Maryland/the Mid-Atlantic freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?                                                                                                                                                             | <p>Likely (Most of the effects described above make Maryland/the Mid-Atlantic a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances) 9</p> <p>Somewhat likely (Several of the effects described above could make Maryland/the Mid-Atlantic a better environment for establishment and spread of this species) 6</p> <p>Somewhat unlikely (Few of the effects described above would make Maryland/the Mid-Atlantic a better environment for establishment and spread of this species) 3</p> <p>Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of Maryland/the Mid-Atlantic unsuitable) 0</p> <p>Unknown U</p> | 6 |
| Notes      | Based on the Climatch model (Australian Bureau of Rural Sciences 2010), the current climatic conditions throughout most of Maryland are suitable for establishment of swamp eels already. Impacts of climate change (warming conditions) may potentially reduce winter mortality of newly introduced populations in Maryland in future climate scenarios, potentially increasing the probability of establishment overall to the state. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |
| References | Australian Bureau of Rural Sciences 2010                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |   |
| <b>11)</b> | How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?                                                                                                                                                                                                                                                 | <p>Likely (All possible nutritive food items—including species in Maryland/the Mid-Atlantic that may be considered potential food items—are highly abundant and/or easily found) 9</p> <p>Somewhat likely (Some nutritive food items—including species in Maryland/the Mid-Atlantic that may be considered potential food items—are abundant and/or search time is low to moderate) 6</p> <p>Somewhat unlikely (Few nutritive food items—including species in Maryland/the Mid-Atlantic that may be considered potential food items—are abundant and/or search time is moderate to high) 3</p> <p>Unlikely (All possible nutritive food items—including species in Maryland/the Mid-Atlantic that may be considered potential food items—are relatively scarce and/or search time is high) 0</p> <p>Unknown U</p>   | 9 |

|            |                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| Notes      | “Because they are generalized predators, this species is a potential threat to native fishes, frogs, and aquatic invertebrates” (Fuller et al. 2021). Appropriate food sources (e.g., frogs, fishes, crayfishes, and aquatic invertebrates) are plentiful in most Maryland aquatic environments, so food resources would not be a limitation to swamp eels in the state. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |
| References | Fuller et al. 2021                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |
| 12)        | Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?                                                                                                                                | <p>Yes, and the critical species (or one that may provide a similar function) is common in Maryland/the Mid-Atlantic and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed 9</p> <p>Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of Maryland/the Mid-Atlantic 6</p> <p>Yes, and the critical species (or one that may provide a similar function) is relatively rare in Maryland/the Mid-Atlantic AND/OR can only be found occasionally in environments suitable for the species being assessed 3</p> <p>Yes, and the critical species (or one that may provide a similar function) is not present in Maryland/the Mid-Atlantic but is likely to be introduced 0</p> <p>Yes, but the critical species (or one that may provide a similar function) is not present in Maryland/the Mid-Atlantic and is not likely to be introduced A (-80% total points at end)</p> <p>Unknown U</p> | 0 |
| Notes      | There is no evidence in the literature that species of the family Synbranchidae require another taxon for successful reproduction or to complete its life cycle.                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |
| References |                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |   |
| 13)        | How likely is the establishment of this species to be aided by the establishment                                                                                                                                                                                                                                                                                         | <p>Likely (A non-indigenous species to Maryland/the Mid-Atlantic that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in Maryland/the Mid-Atlantic, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas) 9</p> <p>Somewhat likely (A non-indigenous species to Maryland/the Mid-Atlantic that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in Maryland/the Mid-Atlantic) 6</p>                                                                                                                                                                                                                                                                                                                                                                                                      | 0 |

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 13)        | and spread of another species already in Maryland/the Mid-Atlantic?                                                                                                                                                                                                                                                                                                                                                                     | <p>Somewhat unlikely (A non-indigenous species to Maryland/the Mid-Atlantic that facilitates the development of this species—a major host, food item, pollinator—has already established in Maryland/the Mid-Atlantic BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict) 3</p> <p>Unlikely (A non-indigenous species to Maryland/the Mid-Atlantic that facilitates the development of this species has not been established in Maryland/the Mid-Atlantic) 0</p> <p>Unknown U</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |
| Notes      | There is no evidence in the literature to suggest that introductions of species of the family Synbranchidae are associated or aided by the establishment and spread of other taxa.                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
| References |                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
| 14)        | How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in Maryland/the Mid-Atlantic and may preferentially target this species?                                                                                                                                                                                                              | <p>Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in Maryland/the Mid-Atlantic) A (-80% total points at end)</p> <p>Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in Maryland/the Mid-Atlantic) B (-60% total points at end)</p> <p>Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in Maryland/the Mid-Atlantic) C (-10% total points at end)</p> <p>Unlikely (Such a natural enemy is particularly rare or is not present in Maryland/the Mid-Atlantic) 0</p> <p>Unknown U</p> | 0 |
| Notes      | The evasive, burrowing behavior of swamp eels likely reduces their risk of predation. Although there are natural predators that would likely opportunistically consume swamp eels, it is unlikely that these predators would serve as effective control agents. Shafland et al. (2007) reported predation on swamp eels by Largemouth Bass and wading birds, however this reported predation did not prevent establishment of the eels. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
| References | Shafland et al. 2010                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |

**PROPAGULE PRESSURE**

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |   |   |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|---|---|
| 15)        | On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)                                                                                                                                                                                                                                          | Frequent, large inocula                              | 9 | U |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                               | Frequent, moderate inocula                           | 6 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                               | Frequent, small inocula OR infrequent, large inocula | 3 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                               | Infrequent, small or moderate inocula                | 0 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                                                               | Unknown                                              | U |   |
| Notes      | The only known Maryland introduction of swamp eel occurred in Lake Needwood in 2014 with at least 4 individual eels sighted and/or collected (Nico et al. 2019). The origin of this introduction is unknown, but eels were sold with regularity at nearby live food markets (Kilian, J., personal observation 2016). Anecdotal reports indicate that prayer release rituals occur in Maryland, but the frequency of these rituals is unknown. |                                                      |   |   |
| References | Kilian, J., personal observation 2016; Nico et al. 2019                                                                                                                                                                                                                                                                                                                                                                                       |                                                      |   |   |

**HISTORY OF INVASION AND SPREAD**

|       |                                                                                                                                                            |                                                                                                                                                                                                       |   |   |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| 16)   | How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities? | Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)                                                                     | 9 | 6 |
|       |                                                                                                                                                            | Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)                                                                          | 6 |   |
|       |                                                                                                                                                            | Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other) | 3 |   |
|       |                                                                                                                                                            | Not extensively (no invasive populations of this species have been reported)                                                                                                                          | 0 |   |
|       |                                                                                                                                                            | Unknown                                                                                                                                                                                               | U |   |
| Notes | In the U.S. alone, swamp eels are established in New Jersey, Georgia, Florida, and Hawaii (Nico et al. 2011; USFWS 2018; Fuller et al. 2021).              |                                                                                                                                                                                                       |   |   |

|            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| References | Nico et al. 2011; USFWS 2018; Fuller et al. 2021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
| 17)        | How rapidly has this species spread by natural means or by human activities once introduced to other locations?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Rapidly (This species has a history of rapid spread in introduced ranges) 9<br>Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges) 6<br>Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges) 3<br>Slowly (This species has a history of slow to no spread in its introduced ranges) 0<br>Unknown U                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 3 |
| Notes      | Once introduced into a waterbody (likely by intentional stocking), it is not likely that swamp eels would disperse rapidly based on spread rates observed in Florida. Swamp eels are slow to increase in abundance and slow to spread to new areas - likely due to 'their slow growth, sedentary nature, and the presence of very few males that need first to mature as females'. (Shaffland et al. 2009). An introduced population in Silver Lake in New Jersey has not dispersed since 2008 to adjacent lotic habitats despite having access (Chris Smith, personal communication 2014).                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
| References | Shafland et al. 2010                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |
| 18)        | Are there any existing control measures in Maryland/the Mid-Atlantic set to prevent the establishment and/or spread of this species?                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species) A (-90% total points at end)<br>Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread) B (-50% total points at end)<br>Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread) C (-20% total points at end)<br>No control methods have been set to prevent the establishment and/or spread of this species 0<br>Unknown U | C |
| Notes      | Asian Swamp Eel ( <i>M. albus</i> ) has been prohibited from import, transport, purchase, possession, propagation, sale and release in Maryland since 2006 (COMAR 08.02.19.04). This regulation was intended to reduce the likelihood that swamp eels would be imported into the state. However, this regulation has not prevented swamp eels from being imported and sold in live food markets within the state (Nico et al. 2019). Beyond this regulation, there are no control measures that have been set in Maryland that would prevent swamp eels from becoming established or spreading if introduced to state waters. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |   |

|            |                                                            |
|------------|------------------------------------------------------------|
| References | Code of Maryland Regulations 08.02.19.04; Nico et al. 2019 |
|------------|------------------------------------------------------------|

## POTENTIAL ENVIRONMENTAL IMPACT

*NOTE: In this section, a “Not significantly” response should be selected if the species has been studied but there have been no reports of a particular impact. An Unknown” response is appropriate if the species is poorly studied.*

|            |                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                            |   |   |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| E1)        | Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?                                                                                                                                                           | Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease                                                    | 6 | 0 |
|            |                                                                                                                                                                                                                                                                                                                                        | Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)                                                               | 1 |   |
|            |                                                                                                                                                                                                                                                                                                                                        | Not significantly                                                                                                                                                                                                                          | 0 |   |
|            |                                                                                                                                                                                                                                                                                                                                        | Unknown                                                                                                                                                                                                                                    | U |   |
| Notes      | Specimens obtained from live food markets and from the wild (introduced populations in Florida) contained a high parasite load including nematodes, acanthocephalans, and digenean parasites (Nico et al. 2011). However, it is unclear if these parasites are new to North American waters or if they pose a threat to native fishes. |                                                                                                                                                                                                                                            |   |   |
| References | Nico et al. 2011                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                            |   |   |
| E2)        | Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?                                                                                                                                                                                                                                    | Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations | 6 | 0 |
|            |                                                                                                                                                                                                                                                                                                                                        | Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population                                                                                              | 1 |   |
|            |                                                                                                                                                                                                                                                                                                                                        | Not significantly                                                                                                                                                                                                                          | 0 |   |
|            |                                                                                                                                                                                                                                                                                                                                        | Unknown                                                                                                                                                                                                                                    | U |   |
| Notes      | There is no reported evidence that introduced swamp eels outcompete native taxa. As generalist predators, swamp eels likely serve as significant predators to native taxa in invaded areas. However, impacts associated with direct competition for resources has not been demonstrated in the published literature.                   |                                                                                                                                                                                                                                            |   |   |

|            |                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                       |   |   |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| References |                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                       |   |   |
| E3)        | Does it alter predator-prey relationships?                                                                                                                                                                                                        | Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)                                      | 6 | 0 |
|            |                                                                                                                                                                                                                                                   | Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe | 1 |   |
|            |                                                                                                                                                                                                                                                   | Not significantly                                                                                                                                                                                                                                                                                     | 0 |   |
|            |                                                                                                                                                                                                                                                   | Unknown                                                                                                                                                                                                                                                                                               | U |   |
| Notes      | Although it is speculated that swamp eels, as generalized predators, pose a potential threat to native fishes, frogs, invertebrates, etc. (USFWS 2018), there is no research-derived evidence of swamp eels altering predator-prey relationships. |                                                                                                                                                                                                                                                                                                       |   |   |
| References | USFWS 2018                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                       |   |   |
| E4)        | Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?                                                                                                                              | Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)                                                                                                            | 6 | 0 |
|            |                                                                                                                                                                                                                                                   | Yes, some genetic effects have been observed, but consequences have been limited to the individual level                                                                                                                                                                                              | 1 |   |
|            |                                                                                                                                                                                                                                                   | Not significantly                                                                                                                                                                                                                                                                                     | 0 |   |
|            |                                                                                                                                                                                                                                                   | Unknown                                                                                                                                                                                                                                                                                               | U |   |

|            |                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                              |   |   |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| Notes      | There are no published reports of genetic impacts to native taxa from swamp eel introductions (USFWS 2018; Fuller et al. 2021). There are no native congeners or fishes in the Family Synbranchidae in Maryland. Therefore, hybridization with native fishes is highly unlikely.                                                                                      |                                                                                                                                                                                              |   |   |
| References | USFWS 2018; Fuller et al. 2021                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                              |   |   |
| E5)        | Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?                                                                                                                                                                                                                            | Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species | 6 | 0 |
|            |                                                                                                                                                                                                                                                                                                                                                                       | Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)                    | 1 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                       | Not significantly                                                                                                                                                                            | 0 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                       | Unknown                                                                                                                                                                                      | U |   |
| Notes      | There are no published reports of water quality impacts associated with swamp eel introductions. These species exhibit burrowing behavior - excavating burrows in soft bottom sediments (Schofield and Nico 2007). This behavior could cause local impacts to water clarity and distribution of sediments, but these impacts (if any) are likely acute and localized. |                                                                                                                                                                                              |   |   |
| References | Schofield and Nico 2007                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                              |   |   |

|            |                                                                                                                                                                                                                   |                                                                                                                                                                                                       |   |   |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| E6)        | Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)? | Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species | 6 | 1 |
|            |                                                                                                                                                                                                                   | Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild                                                                          | 1 |   |
|            |                                                                                                                                                                                                                   | Not significantly                                                                                                                                                                                     | 0 |   |
|            |                                                                                                                                                                                                                   | Unknown                                                                                                                                                                                               | U |   |
| Notes      | The burrowing behavior of swamp eels can alter habitat within ponds and swamps. Burrowing can alter hydrology and accelerate drying in invaded habitats (Aguirre and Poss 1999; USFWS 2018).                      |                                                                                                                                                                                                       |   |   |
| References | Aguirre and Poss 1999; USFWS 2018                                                                                                                                                                                 |                                                                                                                                                                                                       |   |   |

## **POTENTIAL SOCIO-ECONOMIC IMPACT**

*NOTE: In this section, a “Not significantly” response should be selected if there have been no reports of a particular impact. An “Unknown” response is appropriate if the potential for a particular impact might be inferred from a significant environmental impact but has not been explicitly reported or if there is an unresolved debate about a particular impact.*

|       |                                                                                                                                                                       |                                                                                  |   |   |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|---|---|
| S1)   | Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?         | Yes, significant effects on human health have already been observed              | 6 | 1 |
|       |                                                                                                                                                                       | Yes, but negative consequences have not been widespread, long lasting, or severe | 1 |   |
|       |                                                                                                                                                                       | Not significantly                                                                | 0 |   |
|       |                                                                                                                                                                       | Unknown                                                                          | U |   |
| Notes | Swamp eels are a common source of human gnathostomiasis, a foodborne zoonosis caused by advanced third stage larvae of Gnathostoma spp. nematodes (Cole et al. 2014). |                                                                                  |   |   |

|            |                                                                                                                                                                                                                                                  |                                                                                         |   |   |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|---|---|
| References | Cole et al. 2014                                                                                                                                                                                                                                 |                                                                                         |   |   |
| S2)        | Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?                                                                                                                     | Yes, it is known to cause significant damage                                            | 6 | 6 |
|            |                                                                                                                                                                                                                                                  | Yes, but the costs have been small and are largely repairable or preventable            | 1 |   |
|            |                                                                                                                                                                                                                                                  | Not significantly                                                                       | 0 |   |
|            |                                                                                                                                                                                                                                                  | Unknown                                                                                 | U |   |
| Notes      | The burrowing behavior of swamp eels can alter the hydrology within invaded rice fields in the Philippines - damaging dikes, altering nutrients, and causing water loss (Gonzales 2014; USFWS 2018).                                             |                                                                                         |   |   |
| References | Gonzales 2014; USFWS 2018                                                                                                                                                                                                                        |                                                                                         |   |   |
| S3)        | Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?                                                                                                                                                    | Yes, it has significantly affected water quality, and is costly or difficult to reverse | 6 | 0 |
|            |                                                                                                                                                                                                                                                  | Yes, but the effects are negligible and/or easily reversed                              | 1 |   |
|            |                                                                                                                                                                                                                                                  | Not significantly                                                                       | 0 |   |
|            |                                                                                                                                                                                                                                                  | Unknown                                                                                 | U |   |
| Notes      | Water quality impacts have not been reported in the scientific literature. Burrowing behavior may affect water clarity, but impacts would be localized. There are no reports of swamp eels affecting water quality or suitability for human use. |                                                                                         |   |   |

|            |                                                                                                                                                                       |                                                                                                      |   |   |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|---|---|
| References |                                                                                                                                                                       |                                                                                                      |   |   |
| S4)        | Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?                                                     | Yes, it has caused significant damage to one or more markets or economic sectors                     | 6 | 1 |
|            |                                                                                                                                                                       | Some damage to markets or sectors has been observed, but negative consequences have been small       | 1 |   |
|            |                                                                                                                                                                       | Not significantly                                                                                    | 0 |   |
|            |                                                                                                                                                                       | Unknown                                                                                              | U |   |
| Notes      | Agricultural impacts have been reported from the Philippines - where burrowing eels have damaged dikes in rice fields causing water loss (Gonzales 2014; USFWS 2018). |                                                                                                      |   |   |
| References | Gonzales 2014; USFWS 2018                                                                                                                                             |                                                                                                      |   |   |
| S5)        | Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?         | Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism | 6 | 0 |
|            |                                                                                                                                                                       | Yes, but negative consequences have been small                                                       | 1 |   |
|            |                                                                                                                                                                       | Not significantly                                                                                    | 0 |   |
|            |                                                                                                                                                                       | Unknown                                                                                              | U |   |
| Notes      | There are no reports of swamp eel invasions hindering recreational activities or tourism.                                                                             |                                                                                                      |   |   |

|            |                                                                                                            |                                                                                                                                                                                                                     |   |   |
|------------|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| References |                                                                                                            |                                                                                                                                                                                                                     |   |   |
| S6)        | Does it diminish the perceived aesthetic or natural value of the areas it inhabits?                        | Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations | 6 | 0 |
|            |                                                                                                            | Yes, but negative consequences have been small                                                                                                                                                                      | 1 |   |
|            |                                                                                                            | Not significantly                                                                                                                                                                                                   | 0 |   |
|            |                                                                                                            | Unknown                                                                                                                                                                                                             | U |   |
| Notes      | There are no reports of swamp eel invasions affecting the aesthetic or natural value of an invaded system. |                                                                                                                                                                                                                     |   |   |
| References |                                                                                                            |                                                                                                                                                                                                                     |   |   |

## **POTENTIAL BENEFICIAL EFFECT**

*NOTE: In this section, a "Not significantly" response should be selected if there have been no reports of a particular effect. An "Unknown" response is appropriate if the potential for a particular effect might be inferred but has not been explicitly reported or if there is an unresolved debate about a particular effect.*

|            |                                                                                                       |                                                                                                                   |   |   |
|------------|-------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|---|---|
| <b>B1)</b> | Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms? | Yes, it has succeeded significantly as a control agent                                                            | 6 | 0 |
|            |                                                                                                       | Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness | 1 |   |
|            |                                                                                                       | Not significantly                                                                                                 | 0 |   |
|            |                                                                                                       | Unknown                                                                                                           | U |   |

|            |                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                               |   |   |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|---|---|
| Notes      | There are no reports of swamp eels serving as a biological control agent for nonindigenous organisms.                                                                                                                                                                                                                                                                                          |                                                                                                               |   |   |
| References |                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                               |   |   |
| B2)        | Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?                                                                                                                                                                                                                                                                                           | Yes, it is economically important to at least one of these industries                                         | 6 | 0 |
|            |                                                                                                                                                                                                                                                                                                                                                                                                | Yes, but its economic contribution is small                                                                   | 1 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                | Not significantly                                                                                             | 0 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                | Unknown                                                                                                       | U |   |
| Notes      | Swamp eels including <i>A. cuchia</i> form a 'high value export fishery involving nearly 15 countries in the world' (Miah et al. 2015). Swamp eels are imported as adults into the U.S. and sold for human consumption at live food markets (Nico et al. 2019). However, there are no reports of these species becoming commercially valuable as fisheries, bait, etc. within invaded systems. |                                                                                                               |   |   |
| References | Miah et al. 2015; Nico et al. 2019                                                                                                                                                                                                                                                                                                                                                             |                                                                                                               |   |   |
| B3)        | Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?                                                                                                                                                                                                                                                                            | Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism | 6 | 0 |
|            |                                                                                                                                                                                                                                                                                                                                                                                                | It is sometimes employed recreationally, but adds little value to local communities or tourism                | 1 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                | Not significantly                                                                                             | 0 |   |
|            |                                                                                                                                                                                                                                                                                                                                                                                                | Unknown                                                                                                       | U |   |

|            |                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                               |   |   |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|
| Notes      | This species has been observed for sale in Maryland in one specialty aquarium store (Harbold, W., personal communication 20). The extent that swamp eels are sold as pets is unknown, but likely low. Therefore, their recreational value (as pets) is considered insignificant across the state. |                                                                                                                                                                               |   |   |
| References |                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                               |   |   |
| B4)        | Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?                                                                                                                                                                                     | Yes, it has significant medicinal or research value                                                                                                                           | 6 | 0 |
|            |                                                                                                                                                                                                                                                                                                   | It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied | 1 |   |
|            |                                                                                                                                                                                                                                                                                                   | Not significantly                                                                                                                                                             | 0 |   |
|            |                                                                                                                                                                                                                                                                                                   | Unknown                                                                                                                                                                       | U |   |
| Notes      | There are no reports of medicinal or research value associated with swamp eels.                                                                                                                                                                                                                   |                                                                                                                                                                               |   |   |
| References |                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                               |   |   |
| B5)        | Does the species remove toxins or pollutants from the water or otherwise increase water quality?                                                                                                                                                                                                  | Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and                                                                       | 6 | 0 |
|            |                                                                                                                                                                                                                                                                                                   | Yes, but positive impact for humans or native species is considered negligible                                                                                                | 1 |   |
|            |                                                                                                                                                                                                                                                                                                   | Not significantly                                                                                                                                                             | 0 |   |
|            |                                                                                                                                                                                                                                                                                                   | Unknown                                                                                                                                                                       | U |   |

|            |                                                                                                                                                                                                                                                                                                    |                                                                                 |   |   |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---|---|
| Notes      | There are no reports of swamp eels effectively removing toxins or pollutants from the water or improving water quality.                                                                                                                                                                            |                                                                                 |   |   |
| References |                                                                                                                                                                                                                                                                                                    |                                                                                 |   |   |
| B6)        | Does the species have a positive ecological effect outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)? | Yes, it significantly contributes to the ecosystem in one or more of these ways | 6 | 0 |
|            |                                                                                                                                                                                                                                                                                                    | Yes, it provides some positive contribution to the ecosystem, but is not vital  | 1 |   |
|            |                                                                                                                                                                                                                                                                                                    | Not significantly                                                               | 0 |   |
|            |                                                                                                                                                                                                                                                                                                    | Unknown                                                                         | U |   |
| Notes      | There are no reports of positive ecological effects associated with swamp eel invasions.                                                                                                                                                                                                           |                                                                                 |   |   |
| References |                                                                                                                                                                                                                                                                                                    |                                                                                 |   |   |

| Vector Potential Scorecard                                                       |                   |                                      |              |                            |
|----------------------------------------------------------------------------------|-------------------|--------------------------------------|--------------|----------------------------|
| Vector                                                                           | Raw Points Scored | Multiplier                           | Total Points | Potential for Introduction |
| POTENTIAL INTRODUCTION VIA DISPERSAL                                             | 0                 | 0.25                                 | 0            | Unlikely                   |
| POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING                                   | 0                 | 0.1                                  | 0            | Unlikely                   |
| POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE                      | 100               | 0.1                                  | 10           | Low                        |
| POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE | 100               | 1                                    | 100          | High                       |
| POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE                        | 100               | 0.5                                  | 50           | Moderate                   |
| POTENTIAL INTRODUCTION VIA SHIPPING                                              | 0                 | 0                                    | 0            | Unlikely                   |
| Total Unknowns                                                                   | 0                 | Potential for Introduction (overall) |              | High                       |
|                                                                                  |                   | Confidence Level                     |              | High                       |

| Scoring              |                              |
|----------------------|------------------------------|
| Points per Vector    | Probability for Introduction |
| 80-100               | High                         |
| 40-79                | Moderate                     |
| 1-39                 | Low                          |
| 0                    | Unlikely                     |
| # Unknowns (overall) | Confidence Level             |
| 0                    | High                         |
| 1-2                  | Moderate                     |
| 3-5                  | Low                          |
| >5                   | Very Low                     |

| Establishment Potential Scorecard    |                               |                                  |           |          |
|--------------------------------------|-------------------------------|----------------------------------|-----------|----------|
| Points                               | Probability for Establishment | A. Total Points (pre-adjustment) |           | 84       |
| >100                                 | High                          | Adjustments                      |           |          |
|                                      |                               | B. Critical Species (#12)        | A*(1-__%) | 84       |
| 51-99                                | Moderate                      | C. Natural enemies (#14)         | B*(1-__%) | 84       |
|                                      |                               | Control measures (#18)           | C*(1-__%) | 67.2     |
| 0-50                                 | Low                           | Probability for Establishment    |           | Moderate |
| # of questions answered as "unknown" | Confidence Level              |                                  |           |          |
| 0-1                                  | High                          | Total # of questions unknown     |           | 1        |
| 2-5                                  | Moderate                      |                                  |           |          |
| 6-9                                  | Low                           | Confidence Level                 |           | High     |
| >9                                   | Very Low                      |                                  |           |          |

| Scoring |     |          |
|---------|-----|----------|
| Score   | # U | Impact   |
| >5      | Any | High     |
| 2-5     | Any | Moderate |
| 0       | 0-1 | Low      |
| 1       | 0   |          |
| 0       | ≥2  | Unknown  |
| 1       | ≥1  |          |

| Potential Impact Type | Score | # Unknowns | Impact |
|-----------------------|-------|------------|--------|
| Environmental         | 1     | 0          | Low    |
| Socio-Economic        | 8     | 0          | High   |
| Beneficial            | 0     | 0          | Low    |