Minnesota Department of Natural Resources (DNR) Classification Summary for Invasive Species

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DRAFT: Minnesota Department of Natural Resources Invasive Species Program, February 2020

Classification Screening for Eastern mosquitofish, *Gambusia holbrooki*

Contents

Introduction

This document is a guide to the Minnesota DNR's authority under *Minnesota Statutes*, chapter 84D, to designate invasive species as prohibited or regulated invasive species. The conclusions and recommendations in this document are for information purposes only and do not require the DNR or any other entity to take a specific action.

More information about classifications of invasive species can be found on the DNR website (http://www.dnr.state.mn.us/invasives/laws.html) and in *Minnesota Statutes*, chapter 84D

(https://www.revisor.mn.gov/statutes/?id=84D). Prohibited, regulated, and unregulated species are listed in Minnesota Rules, chapter 6216 (https://www.revisor.mn.gov/rules/?id=6216).

How to fill out this classification screening

For more detailed guidance on completing this document, see the DNR's "Guidance for Invasive Species Classification Summaries". The following is a brief guide:

- Fill out the Species Summary section with the species name and a brief description of the species and its current regulatory status in Minnesota.
- Answer the questions in the Eligibility Screening section to determine whether the species is eligible for regulation under *Minnesota Statutes*, chapter 84D.
- If the species is eligible for regulation under *Minnesota Statutes*, chapter 84D, continue to answer the questions in the Classification Screening section and characterize the certainty of the answer for each question.
- At the end of the classification screening questions, summarize the most important points from the answers and judge the overall certainty of the screening.
- Finally, you should make a recommendation for classifying the species, based on the findings of the classification screening.
- Update the table of contents when the document is completed.

Species Summary

Common name: Eastern mosquitofish

Scientific name: *Gambusia holbrooki*

Brief description: Eastern mosquitofish were recently defined as a separate species from the Western mosquitofish (*Gambusia affinis*) in 1988. These two species were stocked in 37 states including Minnesota as mosquito population control agents (Nico and Fuller 2001). Eastern mosquitofish are small, aggressive, live-bearing fish that originates from the southeastern coast of the United States. Female mosquitofish can establish populations using stored sperm. They reproduce up to three generations in one year. It is a generalist carnivore that feeds at the surface and through the water column (GISD 2018). Eastern mosquitofish prefer slow-moving to stationary water, like vegetated shallow ponds and lakes.

Present classification in Minnesota: Unlisted nonnative species

Proposed classification: Prohibited invasive species

Current distribution of species: Their native distribution is along the coastal southeastern United States, occurring as west as southern Alabama and as north as New Jersey. Stocking of Eastern and Western mosquitofish occurred in the United States since the early 1900s (Krumholz 1948). Both species have been introduced and stocked worldwide, especially in tropical and subtropical regions, for mosquito control.

Eligibility Screening

These three questions determine whether the DNR has authority to regulate the species under *Minnesota Statutes*, chapter 84D.

1. Is the species an aquatic plant or wild animal? For the purposes of this question, "species" includes "subspecies, genotypes, cultivars, hybrids, or genera" (*Minnesota Statutes*, section 84D.04 subd. 1).
    - Choose ☒Yes or ☐No; if yes, continue.
2. Is the species a pathogen or terrestrial arthropod regulated under *Minnesota Statutes*, sections 18G.01 to 18G.15? (*Minnesota Statutes*, section 84D.14(1))
    - Choose ☐Yes or ☒No; if no, continue.
3. Is the species a mammal or bird defined as livestock in statute? (*Minnesota Statutes*, section 84D.14(1)).
    - Choose ☐Yes or ☒No; if no, continue.

Classification Screening

Is it nonnative?

To be classified as an invasive species under Minnesota Statutes, the species must be "nonnative"; that is, not "native" as defined in Minnesota Statutes, section 84D.01, subd. 11. This has two components.

1. Is the species nonnative in Minnesota?

1.1. Is the species naturally present or reproducing in Minnesota? No. Eastern mosquitofish are native to the temperate and semi-tropical southeastern coastal regions of the United States. Mosquitofish were previously stocked in Minnesota. The stocking was before the Western and

Eastern mosquitofish were distinguished as two distinct species, so it is unknown if both were present at any point. While Western mosquitofish has established in Minnesota, the Eastern mosquitofish have not been found in the state (USGS 2019b).

1.2. Does the species naturally expand from its historic range into Minnesota? No. Despite being introduced and stocked around the United States, few eastern mosquitofish have established far from their native range. The closest recorded population was recorded in Ohio in the late 1940s (USGS 2019b). This population has since been extirpated. Natural range expansion into Minnesota is not likely based on the low climate match (USFWS 2017).

How certain are these answers? Very certain, supported by peer-reviewed literature.

Likelihood of introduction

This is a criterion for classification of an invasive species under Minnesota Statutes, section 84D.04, subd. 2(1). The terms "introduce" and "introduction" are defined in Minnesota Statutes, section 84D.01.

2. Is the species likely to be introduced to Minnesota if it is allowed to enter or exist in the state? Eastern mosquitofish could be introduced to Minnesota by the following pathways:

- Fishing: Eastern mosquitofish are occasionally sold in bait stores. A baitfish wholesaler was fined for selling mosquitofish to a bait shop in Vermont (VFWD 2018). The wholesaler had imported the mosquitofish from a fish farm in Arkansas (VFWD 2018). Instances like this could potentially occur in Minnesota leading to accidental introduction by anglers.

- Aquaria: Eastern mosquitofish could potentially enter Minnesota through aquarium trade. It is used as a feeder fish in aquariums and as a biological control for mosquito populations in water gardens or ponds (CABI 2018). Though the World Health Organization no longer suggests the use of eastern mosquito fish as a biocontrol, people still acquire them for this purpose. People have asked the Minnesota DNR about owning Eastern mosquitofish (Nick Frohnauer, personal communication, May 10th, 2019) and because there is no regulation stopping their entry, they could potentially enter through this pathway.

- Aquaculture: There is likely aquaculture interest in Eastern mosquitofish for baitfish and aquaria. This interest could lead to the intentional introduction of mosquitofish. Evidence from Australia and Europe suggests that this fish can easily escape and disperse through flood events as well (Chapman et al. 2006). Furthermore, Eastern mosquitofish can disperse through waters as shallow as 3 millimeters (Alemadi & Jenkins 2007). This ability further increases the likelihood that Eastern mosquitofish could escape into Minnesota waters.

- Food market: Eastern mosquitofish are not likely to enter Minnesota through food markets. Annual summaries of U.S. fishery imports and exports does not show that mosquitofish were shipped for food markets. These fish were primarily stocked worldwide as biological controls for mosquitos, not for human consumption.

How certain is this answer? Reasonably certain; supported by peer-reviewed and "grey" literature.

Likelihood of survival

This is a criterion for classification of an invasive species under Minnesota Statutes, section 84D.04, subd. 2(2). The term "naturalize" is defined in Minnesota Statutes, section 84D.01 as "to establish a self-sustaining population…in the wild."

3. **Is the species likely to naturalize in Minnesota if it were introduced?** Possibly. While Eastern mosquitofish could potentially survive in the state, Minnesota's cold climate may hinder establishment in the northern portion of Minnesota. Sanders et al. (2014) Risk Assessment Mapping Program (RAMP) climate match reported that Minnesota and its neighboring states have a climate that is a mid to low level match for eastern mosquitofish (Figure 1). Mosquitofish were previously stocked in Minnesota but like many populations stocked north of 40 degrees northern latitude, their establishment was unsuccessful unless stocked in geothermally or artificially heated bodies of water (Vooren 1972; USGS 2019b).

   Experiments and observations have shown that mosquitofish are able to acclimate and survive in water temperatures below 5 degrees Celsius (Otto 1973). In winter, water temperature is about 4 degrees Celsius when there is a layer of ice on top. River-fed waters and waters near power plants can be warmer, potentially allowing for a greater chance of Eastern mosquitofish survival during Minnesota's winter. If they do survive the winter into late spring and summer, they can rapidly reproduce and restore a larger population size. A single female with stored sperm could potentially repopulate during the summer and spring. Minnesota lakes also reach the mosquitofish's preferred water temperature of 31-35 degrees Celsius during the summer (Winkler 1979; Cherry et al. 1976). Additionally, Eastern mosquitofish can tolerate high salinity, low oxygen, and disturbed habitats (CABI 2018). Mosquitofish could potentially naturalize in Minnesota if they were given time to acclimate and were near warmer waters that don't freeze during the winter.

   How certain is this answer? Moderately certain, previous peer-reviewed studies do not differentiate Eastern and Western mosquitofish. Previous studies also do not understand the mechanism for mosquitofish survival in cold habitats as some seem to die off quickly and others are able to survive.

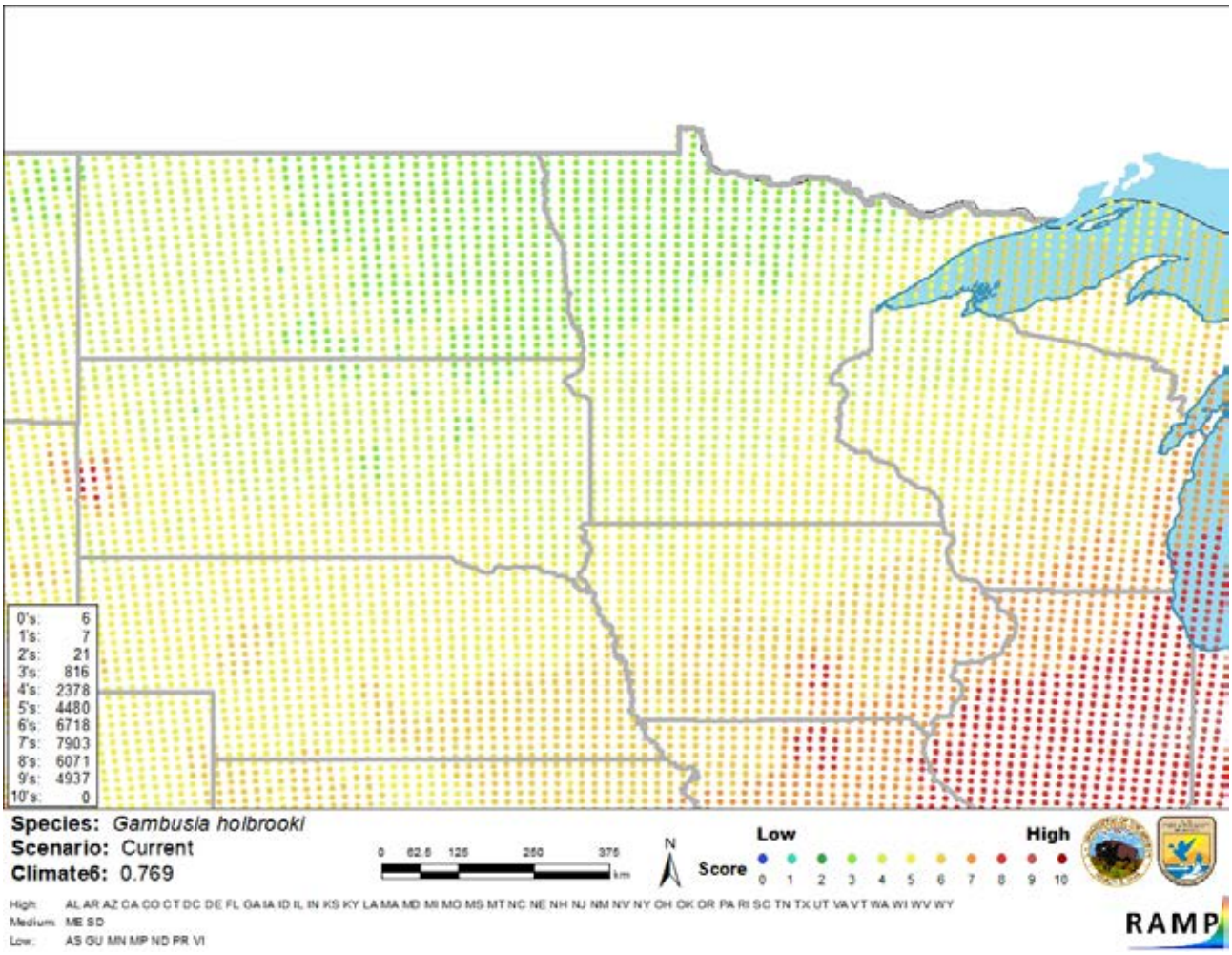

Figure 1. Risk Assessment Mapping Program (RAMP; Sanders et al. 2014) climate risk assessment for *Gambusia holbrooki* in Minnesota and neighboring states. Assessment was conducted in 2019 using GBIF data, USGS NAS Database (Nico et al. 2019), and literature sources. 0 = Lowest Match, 10 = Highest match.

Potential negative impacts

For a nonnative species to be defined as "invasive" under Minnesota Statutes, section 84D.01, subd. 9a, the species must: cause, or have the potential to cause economic or environmental harm, harm to human health; or threaten or have the potential to threaten the use of natural resources in the state. This question has four components: economic, environmental, health, and natural resources.

4. Is the nonnative species an invasive species as defined under Minnesota law?

4.1. Does the species cause, or may it cause, economic harm? No. Eastern mosquitofish are sometimes used as feeder fish in the aquarium business, but are not popular due to their aggressive behavior towards other fishes, and their poor appearance (CABI 2018). Eastern mosquitofish have been used in the past as a cheap form of mosquito control. However in recent experiments, they were not shown to be more effective than native fish at decreasing mosquito populations, and the World Health Organization no longer recommends them for mosquito control (GISD 2018).

How certain is this answer? Moderately certain, no evidence to the contrary, but also lack of available research.

4.2. Does the species cause, or may it cause, environmental harm? Yes. Previous literature has detailed the negative environmental impacts of introduced Eastern mosquitofish around the world. Eastern mosquitofish are more competitive than most native fish, and they are aggressive consumers of invertebrates, larvae, insects, plants, and other fish hatchlings (CABI 2018). They have been linked to declines in native fish and minnow populations in Australia, Arizona, Nevada, and other regions of the United States and Europe (Arthington & Lloyd 1989; Galat & Robertson 1989; Komak & Crossland 2000; Meffe 1985; and Pyke 2008). In regions of the southwestern United States, local extirpations of some species such as the Sonoran topminnow have been attributed to the introduction of Eastern mosquitofish (Meffe 1985).

Eastern mosquitofish will also target invertebrates, fry, and tadpoles as prey. Evidence suggests that Eastern mosquitofish can negatively impact populations of frogs and invertebrates by targeting their young, attacking juveniles, and eating their eggs (Pyke et al. 2000). Eastern mosquitofish have also been known to act aggressively toward other fishes, clipping fins and inflicting injuries on adults as well as consuming fry as prey (GISD 2018).

How certain is this answer? Reasonably certain, supported by peer-reviewed literature.

4.3. Does the species cause, or may it cause, harm to human health? Uncertain. Some studies suggest that by preying upon natural insect predators of mosquitos, Eastern mosquitofish actually help bolster mosquito populations, which could negatively impact outdoor human recreation and health. However, these studies are still inconclusive and require further research.

How certain is this answer? Reasonably uncertain, lack of available research on this topic.

4.4. Does the species threaten, or may it threaten, the use of natural resources in the state? Yes. Eastern mosquitofish could threaten Minnesota fisheries by preying on and outcompeting native fishes. Some studies also suggest that by preying upon certain invertebrates and

zooplankton, Eastern mosquitofish can lead to algae blooms in water bodies. (Moore et al. 2006). Such blooms could affect water recreation.

How certain is this answer? Moderately certain, supported by some peer-review literature.

Natural resource impacts

This is a criterion for classification of an invasive species under Minnesota Statutes, section 84D.04, subd. 2(3).

5. **Would the species have potential adverse impacts in Minnesota, in particular on: native species, outdoor recreation, commercial fishing, and other uses of natural resources in the state?**

- Choose ☒Yes or ☐No; if yes, continue to 5.1.

5.1. If so, what would be the magnitude of these adverse impacts? Due to their feeding habits and competitive life-history, Eastern mosquitofish could cause declines in native fish, invertebrate, and potentially amphibian populations (Arthington & Lloyd 1989, CABI 2018; GISD 2018; Meffe 1985; Webb and Joss 1997; and Pyke et al. 2000). The declines of native fish and amphibians may result in the increase of mosquitos. Their consumption of zooplankton may increase phytoplankton, allowing for algal blooms (Moore at al. 2006). Overall, these changes could adversely impact fishing, both recreational and commercial, and water recreation.

The magnitude of these impacts will depend on when and where the species is introduced. If introduced in winter, the species will not likely survive even in a heated water near power plants because it wasn't given time to adjust to colder waters. If it's introduced to the northern half of the state, the magnitude of impacts may be smaller as it can take time for eastern mosquitofish to establish and once it is winter, the population will die off from the cold temperatures. If it's introduced in the late spring to early fall, it may have a chance to establish and naturalize leading to long-term impacts like shifting aquatic community structure. In naturally or artificially heated pools, there is potential for long-term damage to the native species populations.

How certain is this answer? Reasonably certain, supported by peer-reviewed literature.

Management options

This is a criterion for classification of an invasive species under Minnesota Statutes, section 84D.04, subd. 2(4).

6. **Would we be able to eradicate, or control the spread of, the species once it is introduced in Minnesota?** Yes. While there are currently no common methods of control or eradication for Eastern mosquitofish, Minnesota's cold winter may provide a population control in the northern region. Beyond natural climate control, previously tested controls include biocontrol, chemical control, and mechanical control.

   Biocontrol has not been very effective when attempted. Beyond their native range, Eastern mosquitofish appear to have few natural predators. Indeed, most studies have assessed that the native predators where the Eastern mosquitofish has been introduced avoid preying upon this species (CABI 2018).

   Chemicals such as the fish poison rotenone have been attempted as a means of diminishing or eradicating Eastern mosquitofish. However, Pyke (2005) found that Eastern mosquitofish were often more tolerant of rotenone and other chemicals than native species, so chemical control methods were likely to have a greater negative impact on native populations.

   Mechanical methods of control such as draining standing water bodies and cutting off pathways of spread have also been attempted. However, Eastern mosquitofish tend to spread quickly enough that cutting off pathways is not always effective. If all potential pathways from the body of water are closed, draining could be a potential solution.

   How certain is this answer? Moderately certain, supported by peer-reviewed literature.

Other relevant information

This is a criterion for classification of an invasive species under Minnesota Statutes, section 84D.04, subd. 2(5). Information that may be included here includes, but is not limited to: economic impacts; regulations in other jurisdictions; and ongoing monitoring programs.

7. **Are there other criteria the DNR commissioner deems appropriate? If so, discuss.**

   - Western mosquitofish (*Gambusia affinis*) is currently listed as a prohibited invasive species in Minnesota. Western mosquitofish and Eastern mosquito fish share similar biology, appearance, and are closely related (Pyke, 2005). Moore et al. (2005) notes that while Eastern mosquitofish may be slower to disperse and establish than western mosquitofish, their similar biology indicates similar impacts on native species.

   - Western mosquitofish are listed on the IUCN's '100 Worst Invasive Species' list and denotes that because of the biological similarities, Eastern mosquitofish poses a similar threat (GISD 2019).

- In Wisconsin, Eastern mosquitofish are a Restricted Species (WDNR 2015), meaning one cannot transport, transfer, or introduce without a permit.

Summary

Summarize the findings of the screening form, including whether the species is nonnative and invasive as defined by Minnesota Statutes, chapter 84D, and characterize the overall certainty of the answers provided above.

Note that certain answers in the screening form may indicate that the species is not a good candidate for designating as a prohibited or regulated invasive species under *Minnesota Statutes*, chapter 84D:

- If you answered "Yes" to **either** 1a or 1b, the species is not "nonnative" as defined under *Minnesota Statutes*, chapter 84D; consider regulation under other authorities.
- If you answered "No" to **all** of 4a, 4b, 4c, and 4d, then the species is nonnative but may not be "invasive" as defined under *Minnesota Statutes*, chapter 84D; consider whether proposed introductions of this species should follow *Minnesota Rules*, part 6216.0290.

Summary: Originating in the southeastern United States, Eastern mosquitofish have been introduced all around the world and beyond their native United States range as a means of mosquito control. In regions around the world, high densities of eastern mosquitofish have been linked to native fish, invertebrate, and amphibian declines via competition and predation. They are tolerant of a wide range of environmental pressures like temperature, pH, and salinity. They are considered a threat by a number of states and countries, and cited under the IUCN's 100 Worst Invasive Species list. Minnesota has a low climate match for Eastern mosquitofish, however their temperature tolerance could allow for their survival and establishment. Their establishment would likely lead to long-term environmental harm and harm to Minnesota's natural resources. Finally, if allowed in Minnesota, this species has the potential to spread to nearby and downriver states and cause significant damage as most of the United States has a mid- to high-climate match for eastern mosquito fish.

How certain is this classification summary, overall? Reasonably certain, there is a large body of literature regarding *Gambusia* species and Eastern mosquitofish.

Recommendation

The DNR may choose to recommend whether to designate the species as a prohibited invasive species, a regulated invasive species, or whether the species should be an unlisted nonnative species (Minnesota Statutes, section 84D.06). Briefly justify this recommendation and include any additional information

such as recommended deadlines for updating this screening form and revisiting this decision and gaps in our knowledge that could be addressed by researchers.

Recommendation: Designate as a prohibited invasive species.

Appendix

Qualitative uncertainty ratings

Uncertainty rating	Description	Abbreviation
Very certain	As certain as I am going to get	VC
Reasonably certain	Reasonably certain	RC
Moderately certain	More certain than not	MC
Reasonably uncertain	Reasonably uncertain	RU
Very uncertain	A guess	VU

Uncertainty ratings from: "Generic Nonindigenous Aquatic Organisms Risk Analysis Review Process", Risk Assessment and Management Committee report to the Aquatic Nuisance Species Task Force, 1996. Available online (www.anstaskforce.gov/Documents/ANSTF_Risk_Analysis.pdf; accessed February 14, 2020).

Version notes

References to Minnesota Statutes are to the 2019 version.

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