



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

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Classification Screening for walking catfish, Clariidae family

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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) (<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) (<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: walking catfish

Scientific name: Clariidae family, including any future Clariidae genera and all 15 genera at the time of proposal (*Bathyclarias*, *Channallabes*, *Clariallabes*, *Clarias*, *Dinotopterus*, *Dolichallabes*, *Encheloclarias*, *Gymnallabes*, *Heterobranchus*, *Horaglanis*, *Platyallabes*, *Platyclarias*, *Tanganikallabes*, *Uegitglanis*, *Xenoclarias*)

Brief description: Clariidae is a family of catfish known for the ability to breathe air and "walk" or wriggle short distances over land. Clariidae catfish are opportunistic omnivores, feeding on aquatic vegetation, invertebrates, and other fish, with much of their diets reflecting the food abundance of their habitat (Weyl et al 2016). Clariidae are used in aquaculture for food, biological controls, bait, and for the aquaria trade. Clariidae can inhabit a range of habitats such as rivers, swamps, floodplains, ponds (Robins, 2017), caves (*Uegitglanis zammaranoi*, *Horaglanis* spp.; Froese & Pauly 2019c; Babu 2012) and deep lake waters (*Dinotopterus cunningtoni*, *Xenoclarias eupogon*, *Bathyclarias* spp.; Froese

& Pauly 2019b; Agnese & Teugels 2005). Reproductive processes are unknown in most of the genera. In *Clarias* spp. it appears that mass spawning is dominant, with catfish then laying eggs into a nest or aquatic vegetation and guarding fry for about three days.

Present classification in Minnesota: Unlisted nonnative species

Proposed classification: Prohibited invasive species

Current distribution of species: The majority of Clariidae genera distribution is in Africa. *Bathyclarias*, *Channallabes*, *Clariallabes*, *Clarias*, *Dinotopterus*, *Dolichallabes*, *Gymnallabes*, *Heterobranchus*, *Platyallabes*, *Platyclarias*, *Tanganikallabes*, *Uegitglanis*, and *Xenoclarias* are all native to Africa (Devaere et al. 2007; Teugels 1986).

- Many Clariidae genera are endemic to certain parts of Africa. *Bathyclarias* are endemic to Lake Malawi (Anseaume & Teugels 1999), *Channallabes* are found in the Congo River Basin (Devaere et al. 2007), *Dinotopterus* and *Tanganikallabes* are endemic to Lake Tanganyika (Anseaume & Teugels 1999), *Platyallabes* is endemic to the Malebo Pool, *Uegitglanis* are found in caves near the Uegit and Uebi Scebeli rivers in Somalia, and *Xenoclarias* are found in the deep waters of Lake Victoria (Teugels 1986; Devaere et al. 2005).
- Some Clariidae species are found in South, Southeast, and East Asia. *Encheloclarias* are endemic to peninsular Malaysia, Indonesia, and Borneo (Ng et al. 1994; Ng & Tan 2000; Ng 2012). *Horaglanis* are endemic to Kerala, India (Froese & Pauly 2019).
- *Clarias* are the most widespread genus of the Clariidae family. *Clarias* are widespread and common throughout Africa, Southeast Asia, and East Asia.
- Trade has transported *Clarias gariepinus* from Africa to the Americas where it has established in Brazil (Alves et al. 1999) and Cuba (Garcia and del Valle 2006).
- In the United States, *Clarias batrachus* has established reproducing populations in Florida and *Clarias fuscus* in Hawai'i.

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 Clariidae species are naturally present or reproducing in Minnesota.

1.2. Does the species naturally expand from its historic range into Minnesota? No, Clariidae species will not naturally expand from their historic range into Minnesota. Their historic range in the United States has been Florida, California, Connecticut, Massachusetts, and Nevada (Nico et al. 2019). Clariidae have only established in Florida and Hawai’i and it is unlikely for them to naturally expand their range from these areas to Minnesota.

How certain are these answers? Reasonably certain, supported by peer-reviewed literature; however, a majority of this literature focuses on genera with commercial importance such as *Clarias* and *Heterobranchus*. There is little peer-reviewed information on the distribution of species in other genera.

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?

Catfish could be introduced to Minnesota by the following pathways:

- **Fishing:** Clariidae are not likely to be introduced to Minnesota waters through fishing. Many Clariidae are fished commercially and for subsistence within their native range (Robins, 2017). Despite the popularity of catfish fishing around the world, a majority of the United States catfish fishing interest is concentrated in the southeastern United States. The Clariidae catfish *C. fuscus* was originally introduced to Hawai'i in the late 1800s for fishing and as a food source (Maciolek 1984). An introduction like this may be less likely to occur now because the Lacey Act prohibits importation of Clariidae catfish into the U.S.
- **Aquaria:** Clariidae could be illegally introduced to Minnesota through aquaria. Some Clariidae species are considered ornamental aquarium fish and are popular fish to keep in Asia, particularly the *Clarias* (CABI 2019). *C. batrachus* was introduced to the United States and United Kingdom via the aquarium trade. *C. batrachus* was introduced to Florida when mature fish escaped an aquarium and/or the transport truck (Courtenay et al. 1986). Besides Florida, *C. batrachus* has been reported in California, Georgia, Massachusetts, and Nevada. These populations did not establish and are likely related to accidental or intentional aquaria release. Despite their invasive status in the United States, there is a small community interested in owning Clariidae species. It is possible to illegally buy Clariidae species online or at live markets despite being listed as federal injurious wildlife, making their importation to the U.S. illegal, in 1970.
- **Aquaculture:** Despite the popularity of some Clariidae species in African and Asian aquaculture, it is unlikely for Clariidae to be introduced to Minnesota through aquaculture. Two popular genera that are widely used in Asian and African aquaculture are *Clarias* spp. and *Heterobranchus* spp. In Africa several species of catfish are cultivated for food, bait, and biological controls (FAO Fisheries and Aquaculture Department 2010). In Asia, catfish are produced for primarily food markets.

Clarias gariepinus and *Clarias batrachus* are two species that have been spread globally for aquaculture and are noted for their invasiveness in some countries they have been introduced to. *C. gariepinus* has been introduced to Netherlands, Hungary, and Italy where it is now produced in aquaculture. These two species can be densely stocked because they are able to survive in hypoxic conditions, resulting in high yield from a smaller area (Welcomme 1988). However, outside of tropical to sub-tropical Africa and Asia, artificial heating is needed to support breeding and the additional heating costs may discourage some aquaculturists (FAO Fisheries and Aquaculture Department 2010).

- **Food markets:** Clariidae could potentially be introduced to Minnesota through food markets. Popular in Asian and African markets, Clariidae are locally sold live, fresh, and frozen. Several species of *Clarias* spp. have entered international markets. *C. gariepinus* is cultivated in Africa, Europe, and Brazil. *C. batrachus*, *C. fuscus*, and *C. macrocephalus* are important fish in some Asian cuisines (Froese & Pauly 2011).

How certain is this answer? Reasonably uncertain, peer-reviewed data focuses on economically important species and genera. There are few studies on the uses of genera beyond *Clarias* spp. and *Heterobranchus* spp.

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?** Possible, but unlikely. There is potential for some members of the Clariidae family to naturalize in Minnesota if introduced. Due to the family originating from tropical to sub-tropical areas, the Clariidae species likely need warmer waters to survive. Shafland and Pestrack (1982) tested 14 invasive tropical fish in Florida for lower lethal temperatures and the average temperature over all species was 9.53° C.

Artificially heated waters could provide habitat for Clariidae over the winter. Two recorded lethal temperatures for *C. gairepinus* and *C. batrachus* are 8-10 degrees Celsius (Klyszejko et al. 1993) and 9.4-12.8 degrees Celsius (Robins 2017) (46.4-50 and 48.2-55.0 degrees Fahrenheit, respectively). Additionally, *C. batrachus* is reported to bury itself in mud for short periods to avoid lethal cold snaps (Robins 2017). As opportunistic omnivorous, capable of feeding on land (Van Wassenbergh et al. 2006), surviving in turbid, hypoxic environments, and short overland migration, many of the Clariidae species, particularly *Clarias* spp., have the potential of successful invaders.

Of the two species already established in the United States, *C. fuscus* has low-climate match to the central and southern portion of Minnesota and *C. batrachus* has a very low-climate match for all of Minnesota (Sanders et al. 2014). Climate match scores increase for both in southern Minnesota, with *C. fuscus* matching with the central and southeastern part of the U.S. and *C. batrachus* matching primarily with the southeast U.S. Despite the high climate match with all of Florida, *C. batrachus* population die-offs are reported during cold spells, indicating a low tolerance for cold temperatures and potentially restricted northward movement. We also conducted climate matches using the Risk Assessment Mapping Program (RAMP) on each genus of the Clariidae family,

however we chose to only display the genus with the most data, *Clarias*. Figure 1 shows that Minnesota and its neighboring states have a mid to low climate match for *Clarias* catfish to establish.

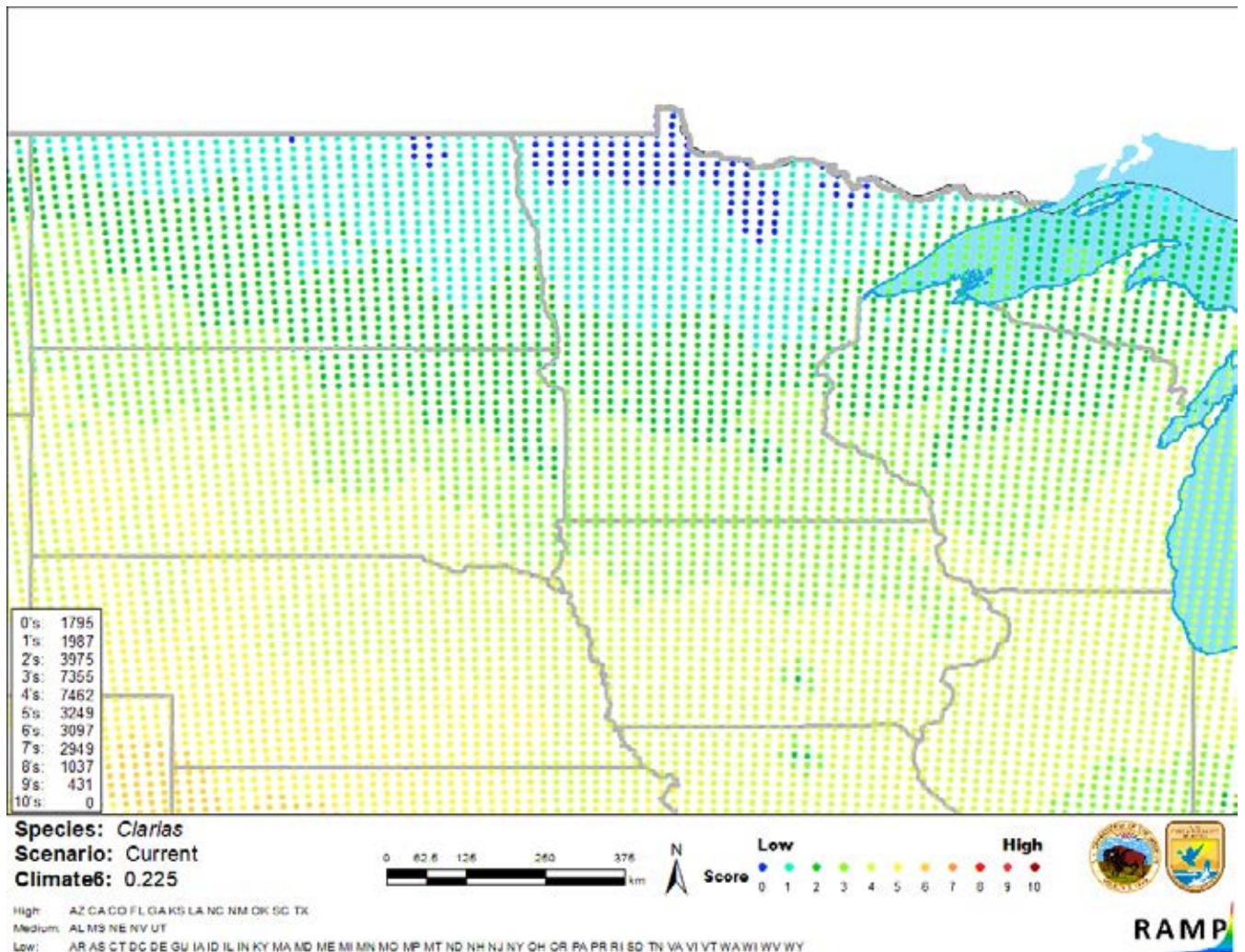


Figure 1. Risk Assessment Mapping Program (RAMP; Sanders et al. 2014) climate risk assessment for the Clariidae genus *Clarias* in Minnesota and neighboring states. Assessment was conducted in 2019 using GBIF data, USGS NAS Database (Nico et al. 2019), and literature sources. 0 = Lowest Match, 10 = Highest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

How certain is this answer? Reasonably uncertain, there are few studies reporting thermal tolerances unless the species is important for aquaculture.

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? Yes. In Florida, *C. batrachus* is known to invade commercial aquaculture ponds and feed on the fish stock (Nico et al. 2017). This has been associated with the costs of buying and installing aquaculture pond fencing. If introduced to Minnesota during the late spring to early fall, *Clarias* species could use flooding events and rainy days to travel to and invade aquaculture ponds.

Parasites and pathogens from invasive Clariidae species may cause economic harm to commercial fishery ponds. In particular, *C. batrachus* can carry *Edwardsiella ictaluri* which causes enteric septicemia of catfish (ESC). ESC is already in the United States catfish industry, but further spread of *C. batrachus* puts catfish farmers at a higher economic risk as the species is known to seek out aquaculture ponds for feeding (Robins 2017).

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

4.2. Does the species cause, or may it cause, environmental harm? Yes. Several species have been researched for causing or potentially causing environmental harm. Three of those species are *C. batrachus*, *C. gariepinus*, and *C. fuscus*. These species display the invasive characteristics of opportunistic feeding, high fecundity, and tolerance to hypoxic and turbid environments (CABI 2019).

Several countries report ecological damage after the introduction of *C. batrachus*. The Philippines and Sri Lanka both report *C. batrachus* competing with endemic native species (Joshi 2006; Kotagama & Bambaradeniya 2006). In the United States, the introduction of *C. batrachus* has not lead to widespread ecological damage, but significant damage has occurred in isolated, wetland pond where the voracious omnivore quickly dominates the food web (Loftus 1988).

Both *C. batrachus* and *C. gariepinus* are able to rapidly expand into and populate new areas (Ellender et al. 2014; Robins 2017). *Clarias* spp. survival may be enhanced because of early parental care (Taylor et al. 1984) and extended reproductive cycles at consistently warm temperatures (Alves et al. 1999).

Studies on *C. gariepinus* indicate greater uptake of resources than native species, increasing competitive pressure (Alexander et al. 2014). *C. gariepinus*'s impact in India was modeled by Khan and Panikkar (2009) and found that any increase in the population would negatively impact native fish that shared its range. Anecdotally, when *C. gariepinus* was introduced in Paraná, Brazil for sport-fishing ponds, concerned local fisherman felt that catch of native species was declining (Vitule et al. 2006). Similar concern was expressed by fishermen after *C. gariepinus*' introduction to southern China (Radhakrishnan 2011).

Additionally, Clariidae species could transfer parasites and pathogens to native species. Few studies have been completed on invasive Clariidae catfish spreading parasites to native species, however Clariidae are known to carry a number of pathogens in their native range and have the potential to bring them to the United States. In particular, *C. batrachus* can carry *Edwardsiella ictaluri* which causes ESC. Native Minnesotan species like channel catfish and brown bullheads are susceptible to infection (Hawke 2015).

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

- 4.3. Does the species cause, or may it cause, harm to human health?** Possible harm to human health can occur indirectly when walking catfish are present in high abundance. Robins (2017) notes that during rainy or misty nights, *C. batrachus* would migrate across roads and ultimately get crushed by moving vehicles. Their crushed bodies left a slimy film that made the road slick and increased the hazard of driving in the rain (Robins 2017).

How certain is this answer? Reasonably uncertain, anecdotal evidence, no evidence of other potential harm.

- 4.4. Does the species threaten, or may it threaten, the use of natural resources in the state?** Yes. Clariidae species may pose a risk to Minnesota's natural resources including native species and commercial fishing. *C. batrachus* and *C. gariepinus* are previously recorded as highly invasive, opportunistic predators that both compete with and prey on local species. In Minnesota, it would likely do the same. Wetland species may be particularly threatened due to Clariidae species ability to travel short distances on land, allowing for the species to move across multiple wetland ponds. Additionally, food web alterations may lead to unforeseen ecosystem changes that could impact water quality or community structure.

How certain is this answer? Moderately certain, supported by peer-reviewed 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? Species from the Clariidae family, particularly the *Clarias* spp., would have potentially adverse impacts in Minnesota on native species. The magnitude may depend on when and where they were introduced. These species appear to be intolerant of freezing temperatures and so their impacts would likely be restricted to the warmer months or warmer waters in Minnesota. Small, interconnected seasonal wetlands would likely suffer as previously introduced Clariidae species display opportunistic feeding and heavy predation on native species (Loftus 1988). Masterson (2007) describes resident freshwater sunfish and native catfish species appearing particularly susceptible to invasive *C. batrachus*. After depleting one wetland, their ability to wiggle short distances on land would assist in their dispersal to another nearby body of water. Along with competition and predation, Clariidae species can host a number of parasites, including enteric septicemia of catfish, which could spread to native Minnesotan channel catfish and brown bullhead.

How certain is this answer? Reasonably certain; beyond Florida, areas like the Philippines, Sri Lanka, and India indicate invasive *Clarias* spp. of the Clariidae family altering food webs and competing with native, endemic species. These are supported by grey literature and peer-reviewed articles.

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? Maybe. Clariidae are subtropical to tropical species. Two documented lethal temperatures for *Clarias* are 8° C – 10° C (Klyszejko et al. 1993) and 9.4° C – 12.8° C (Robins 2017). Many lakes, ponds, and wetlands freeze over during the winter which would likely kill Clariidae. Eradication and control would be difficult in artificially heated waters like waters near power plants.

The non-selective piscicide Rotenone was experimentally tested on *C. gariepinus* to find the minimum effective dose for 100% mortality (Jordaan et al. 2016). *C. gariepinus* showed greater tolerance to the toxin, recovery capability, and avoidance behavior. Some specimen survived relatively high concentrations of Rotenone and there was high survival variability among individuals.

Manual removal could potentially eradicate or control the spread of small populations of invasive Clariidae. In Glen Melville Reservoir, South Africa, Booth et al. 2010 describes a population of *C. gariepinus* in which abundance was low and mortality rates were high. They indicate that this population would be vulnerable to overfishing and suggested baited longlines for removal.

No other methods to eradicate or control the spread of Clariidae have been previously reported. They do have natural predators in the United States, with many larger wading birds feeding on *C. batrachus* in Florida. Some of these birds, like the great blue heron, are present in Minnesota and provide a potential population control.

How certain is this answer? Reasonably certain; supported by peer-reviewed articles. While lethal temperatures of many Clariidae species are not documented, the current known distribution of these species are mostly limited to tropical to sub-tropical habitats.

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.

Regulations in other jurisdictions:

- In 1970, the entire walking catfish family was listed as Injurious Wildlife under the Lacey Act (18 U.S.C. § 42(a)(1)), which bans the import of injurious species into the United States and its territories. A court ruling in 2017 “struck down the longstanding interpretation of the U.S. Fish and Wildlife Service (USFWS) that Title 18 also prohibited the shipment of injurious species across state lines” (Otts 2017); however, the U.S. Fish and Wildlife Service may still prohibit interstate transport of state-regulated species. Therefore, listing all walking catfish family fish species as prohibited invasive species in Minnesota will help to prevent its introduction and spread in the U.S. and to our neighboring jurisdictions.

- The walking catfish family is regulated as invasive species in nearby states: Illinois, Indiana, and Wisconsin; New York and Ohio regulate *C. batrachus* (Great Lakes Commission, Memo dated December 14, 2017).

Other considerations:

- Clarias catfish (*Clarius batrachus*) is listed as one of the Global Invasive Species Database's 100 Worst Invasive Species (GISD 2019).
- *C. batrachus* have enhanced dispersal ability because they can breathe atmospheric air and use their pectoral fins to "walk". Rainy nights and Minnesota's interconnected wetlands may assist in the dispersal of walking catfish.
- While Clariidae catfish may not be able to naturalize in Minnesota waters due to our cold winters, they could use the interconnected rivers to move southward to states where they could naturalize. For example south of Minnesota, *C. fuscus*'s climate category match raises from low to medium near Oklahoma, Kansas, and Missouri (Sanders et al. 2014).
- Due to taxonomic rearrangement, Clariidae species have moved around in genera and will likely continue to do so as more genetic analyses are conducted on species in the family.

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: Of the 15 genera of the Clariidae family, *Clarias* spp. appear to have the greatest invasive potential due to their biological characteristics and economic importance in Africa and Asia. The other genera of Clariidae are understudied and their invasive potential is less certain. Some Clariidae species may be introduced or spread through commercial fisheries, aquaculture, and aquaria. Some Clariidae

also exhibit characteristics that may make them better able to establish in new environments: opportunistic omnivory; high fecundity; ability to spread short distances over land; and tolerances to a variety of habitats, including hypoxic environments. Several countries have reported competition with native species and negative ecological impacts when *Clarias* were introduced. Many Clariidae species are not likely to enter or naturalize in Minnesota because they lack economic importance and because of the cold winter temperatures. If *Clarias*, were introduced, they could cause damage to the states natural resources for a short term likely for a single summer season.

How certain is this classification summary, overall? Moderately certain; supported by peer-reviewed literature and grey literature.

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 walking catfish family as 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](http://www.anstaskforce.gov/Documents/ANSTF_Risk_Analysis.pdf) (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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