Sheepnose
(*Plethobasus cyphyus*)

5-Year Review:
Summary and Evaluation

Photo: Kristen Lundh (USFWS)

5-YEAR REVIEW

U.S. Fish and Wildlife Service, Region 3
Illinois – Iowa Ecological Services Field Office
Moline, Illinois

August 27, 2020

Sheepnose mussel
(*Plethobasus cyphyus*)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office: Region 3, Laura Ragan, (612) 713-5157

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1.2 Methodology used to complete the review:

Public notice was given in the *Federal Register* (82 FR 18156) in April 2017, requesting new scientific or commercial data and information that may have a bearing on the sheepnose classification of endangered status. Pertinent data were obtained from recent reports of freshwater mussel surveys and from data submitted by U.S. Fish and Wildlife Service Field Offices and State natural resource agencies within the range of the species. A secondary data request was directed to all Fish and Wildlife Service, Ecological Services Field Offices, in coordination with their respective State partners, within the species' range in October 2019. Additionally, a search of the U.S. Fish and Wildlife Service's Environmental Conservation Online System (ECOS) was performed to identify

information regarding Section 7 Consultation-issued Biological Opinions and authorized take of the species since listing (USFWS 2020). The focus of this 5-year review is to summarize new information regarding the status of the sheepnose mussel since its listing in March 2012. This review was completed by Sara Schmuecker, Fish and Wildlife Biologist, with the Illinois-Iowa Ecological Services Field Office.

1.3 Background

1.3.1 FR Notice citation announcing initiation of this review:

82 FR 18156 (April 17, 2017) – Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of Eight Endangered Animal Species: Iowa Pleistocene snail (*Discus macclintocki*), Karner blue butterfly (*Lycaeides melissa samuelis*), Kirtland's warbler (*Setophaga kirtlandii* [=*Dendroica kirtlandii*]), Ozark hellbender (*Cryptobranchus alleganiensis bishop*), rayed bean (*Villosa fabalis*), sheepnose (*Plethobasus cyphyus*), snuffbox (*Epioblasma triquetra*), and spectaclecase (*Cumberlandia monodonta*).

1.3.2 Listing history

Original Listing
FR notice: 77 FR 14914
Date listed: March 13, 2012
Entity listed: Sheepnose (*Plethobasus cyphyus*); Species
Classification: Endangered

1.3.3 Associated rulemakings: None

1.3.4 Review History: None

1.3.5 Species' Recovery Priority Number at start of 5-year review:

A Recovery Priority Number was not set for sheepnose prior to this 5-Year Review. Refer to Section 3.1 for further discussion.

1.3.6 Recovery Plan: None.

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

No. The species is an invertebrate; therefore, the DPS policy is not applicable to this listing.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria? No.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history since the time of listing:

Biology and Life History

Hove et al. (2015) conducted a study within the Chippewa River, WI between 2007 and 2011, to investigate the brooding behavior of the sheepnose mussel. Brooding sheepnose specimens were observed between the timeframe of mid-May through early August (Hove et al. 2015, p. 4), with gravid individuals ranging in age from approximately 5 to 26 years (Hove et al. 2015, p. 5). Similar to the findings of previous studies (Watters et al. 2009, p. 221), Hove et al. (2015) identified sheepnose individuals with an approximate life span reaching 30 years.

Within the Chippewa River, sheepnose animals were observed to brood glochidia in outer gills (Hove et al. 2015, p. 4). In this study, gill colors varied, with cream and white-colored gills more often containing mature glochidia (Hove et al. 2015, p. 4). Further, Hove et al. (2015, p. 6) found that the number of juvenile mussel releases from cyprinid hosts increased when held at warmer temperatures (22-25˚C).

Host Fish

Previously, the sauger (*Sander canadensis*) was identified as a natural host fish for the sheepnose mussel (Surber 1913, p. 110), with successful laboratory transformations on a few additional species (Watters et al. 2005, p. 11). Identified host fish for sheepnose have since expanded to 30 species (Jones et al. 2019, p. 205).

Laboratory-based host trials conducted by Hove et al. (2015) found the sheepnose to be a cyprinid host specialist (Hove et al. 2015, p. 12). Specifically, Hove et al. (2015, p 6-8), Wolf et al. (2012, p 7), and Guenther et al. (2009, p. 20), collectively identified 30 native species of minnows and topminnows as suitable host fish. Of the 30 species, Hove et al. (2015) found 11 species to have a higher production of sheepnose juveniles (denoted with a "*"): Central stoneroller

(*Campostoma anomalum)*,* largescale stoneroller (*Campostoma oligolepis*), southern redbelly dace (*Chrosomus erythrogaster*), whitetail shiner (*Cyprinella galactura*)*, red shiner (*Cyprinella lutrensis*), spotfin shiner (*Cyprinella spiloptera*)*, blacktail shiner (*Cyprinella venusta*)*, steelcolor shiner (*Cyprinella whipplei*), brassy minnow (*Hybognathus hankinsoni*), Mississippi silvery minnow (*Hybognathus nuchalis*), common shiner (*Luxilus cornutus*)*, bleeding shiner (*Luxilus zonatus*), silver chub (*Macrhybopsis storeriana*)*, Allegheny pearl dace (*Margariscus margarita*), hornyhead chub (*Nocomis biguttatus*), golden shiner (*Notemigonus crysoleucas*)*, emerald shiner (*Notropis atherinoides*), river shiner (*Notropis blennius*), spottail shiner (*Notropis hudsonius*), Ozark minnow (*Notropis nubilus*)*, Topeka shiner (*Notropis topeka*)*, mimic shiner (*Notropis volucellus*), suckermouth minnow (*Phenacobius mirabilis*), bluntnose minnow (*Pimephales notatus*), fathead minnow (*Pimephales promelas*), bullhead minnow (*Pimephales vigilax*), eastern blacknose dace (*Rhinichthys atratulus*), longnose dace (*Rhinichthys cataractae*)*, creek chub (*Semotilus atromaculatus*)*, and striped shiner (*Luxilus chrysocephalus)*. Hove et al. (2015) further identified six non-cyprinid hosts; however, these species produced low numbers of sheepnose juveniles (Hove et al 2015, p. 6-12,). The identified non-cyprinid host fish species include the banded killifish (*Fundulus diaphanous*), blackspotted topminnow (*Fundulus olivaceus*), mosquitofish (*Gambusia affinis*), brook stickleback (*Culaea inconstans*), common molly (*Poecilia sphenops*), and black crappie (*Pomoxis nigromaculatus*).

It is important to note, that although these fish species successfully transformed sheepnose glochidia in a laboratory setting, differing habitat requirements often prevent or result in infrequent sheepnose interactions with many of these fish species in their natural environment.

Genetics

A genetics study conducted by S. Schwarz and K. Roe (2018) assessed population dynamics across seven sample sites within a portion of the species' range. Specifically, this study considered seven of the 25 streams where sheepnose is considered to be extant, including the Allegheny, Chippewa, Meramec, Mississippi, Tippecanoe, Tennessee, and Wisconsin Rivers (Schwarz and Roe 2018, p. 15). This study identified these seven sample sites as falling within two distinct sheepnose populations: an Upper Mississippi River (UMR) Basin population and an Ohio River Basin population. In this study, the Chippewa, Wisconsin, Mississippi, and Meramec Rivers are considered part of the UMR Basin population, and the Allegheny, Tippecanoe, and Tennessee Rivers are considered part of the Ohio River Basin population. It is important to note, these population genetics-based basin definitions differ slightly from the watershed-based basins (HUC2), as presented in Table 1 (Appendix), with the Tennessee River falling within the Ohio River and Tennessee River Basins, respectively.

Each of the described populations were further found to contain isolated sub-populations. Although each of the sub-populations were determined to contain "distinct genepools," some level of connectivity remains between sub-populations within their respective basins, but not between population basins, resulting in "two genetically distinct populations" (Schwarz and Roe 2018, p. 36). Compared to current conditions, "historic migration rates indicate that significantly more migration was occurring both within and between populations in the past, although also at very low rates" (Schwarz and Roe 2018, p. 37). Additionally, high levels of genetic diversity were detected within the sub-populations; however, it is noted that this may be an artifact of the long-life span of the sheepnose mussel slowing the loss of genetic variation (Schwarz and Roe 2018, p. 38). Overall, this study indicates human influences, such as "the construction of dams, stream channelization, and other anthropogenic barriers," have altered genetic connectivity of populations; however, the effects of these alterations has yet to be fully realized (Schwarz and Roe 2018, p. 41).

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:
The May 2012 listing final rule identified 25 sheepnose populations, corresponding to each of the 25 stream systems where sheepnose is considered extant. Although populations were identified at the basin level in Section 2.3.1.1 (Schwarz and Roe 2018), genetic analyses have only been conducted for a subset of the extant stream systems. Therefore, for the purposes of this review, we continue to define each occupied (extant) stream as a population. More detailed summaries are provided in the Appendix by stream segment in instances where occupied areas within a stream population are separated by significant distances, major barriers, and/or where data are noticeably dissimilar between stream segments (Appendix, Figure 1 and Table 1).

At the time of listing, sheepnose was considered to be extant in 25 of the 76 streams comprising the species' historic range. Within the 25 streams with extant populations, the population was considered declining in 8 streams, stable in 10 streams, improving in 2 streams, and unknown in 5 streams. Currently, populations are considered to be declining in 4 streams, stable in 8 streams, stable to increasing in 2 streams, and unknown in 11 streams (Appendix, Table 1). Trends were determined by professional opinion and other gathered information, and do not necessarily represent statistically significant analyses. The population trend is considered "increasing" if there was evidence that the numbers of individuals have been on an increasing trend over the past approximately 20+ years. The population trend is considered "stable" if there was evidence that the numbers of individuals have remained relatively steady over the past 20 years, and is considered "declining" if there was evidence that the numbers of individuals have been on a decreasing trend over the past 20 years. Population

trends were categorized as "unknown" if there was insufficient evidence to estimate trends.

Twelve population trend changes were identified since listing. Seven of these changes moved the population trend to an unknown status due to the lack of new survey information or insufficient information to make a trend determination (Allegheny, Big Sunflower, Bourbeuse, Holston, Kentucky, Licking, and Tennessee Rivers). The population status improved in the Ohio River, moving the trend from stable to potentially increasing. The Walhonding River was reclassified from unknown to stable, based on newly available information. The population status has declined in the Powell River, moving the trend from stable to declining due to live specimens becoming more rare in the upper reaches without recent evidence of recruitment. The Green River was reclassified from increasing to stable/increasing due to the limited observations of recent recruitment. Additionally, the Eel River continues to decline, and is now considered potentially extirpated (refer to Section 3.2.1.4).

Collectively, the last known and/or recent survey efforts have identified recruitment in 10 of the 25 populations (Appendix, Table 1). These 10 populations include the Mississippi River, Chippewa River, Meramec River, Ohio River, Allegheny River, Kanawha River, Green River, Tippecanoe River, Walhonding River, and Clinch River. These waterbodies occur within the Upper Mississippi River Basin, Ohio River Basin, and Tennessee River Basin. Evidence of recent recruitment has not been identified from the Lower Missouri River Basin or the Lower Mississippi River Basin (last identified from the Big Sunflower River in 2003).

Since the time of listing, a larger abundance of sheepnose was identified within Pool 15 of the Mississippi River than previously known, with evidence of recent recruitment represented by one approximately four-year-old juvenile (ESI 2017, p. 10). This is the first evidence of sheepnose recruitment within the Mississippi River since 2001. Section 7 consultation was conducted for this location in 2016, for activities associated with reconstruction of the Interstate 74 (I-74) bridge and demolition of the existing bridge, including a large-scale mussel relocation. This consultation included authorized take of 856 sheepnose individuals, with 107 individuals moved to mussel beds further upstream within Pool 15 as part of the 2016 relocation (ESI 2017). With the exception of the approximately four-year-old individual, relocated individuals included one approximately 6-year-old individual, with the remaining ranging in age from nine to 20+ years in age. This is considered the species' only "extra large" site (75+ individuals observed during a 2016 survey) (Appendix, Table 1).

Additionally, recruitment has been documented above Lock and Dam 5 on the Green River (KY) and the Six Mile Dam on the Walhonding River (OH), with non-reproducing individuals identified below each of these dams (Lewis 2019;

ESII 2019, p. 6-11). Both of these dams are currently being proposed for removal, resulting in the potential for range expansion within these two systems (EnviroScience 2010, p. 5). Green River Lock and Dam 5 is slated for removal in 2020 or 2021 to address public safety concerns, in addition to providing recreational and ecosystem benefits. Removal of the dams is being coordinated by a partnership, including the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, The Nature Conservancy, Kentucky Department of Fish and Wildlife Resources, Mammoth Cave National Park, and Kentucky Waterways Alliance (Chapman 2019, Labashosky 2017). Green River Lock and Dam 6, was removed in 2017, and Green River Lock and Dam 4 failed in 1965. The Six Mile Dam on the Walhonding River is owned by the State, and removal is being considered as a restoration project through the Ohio Department of Natural Resources, with removal scheduled for fall of 2020 (EnviroScience 2010, p. 5; A. Boyer, USFWS, pers. comm. 2019).

2.3.1.3 Taxonomic classification or changes in nomenclature: Williams et al. (2017, p. 41) proposes no change to the originally assigned *Plethobasus cyphyus* (Rafinesque, 1820).

2.3.1.4 Spatial Distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species within its historical range, etc.):
Records indicate the species historically occurred in at least 76 streams, comprising portions of 14 States, including Alabama, Illinois, Indiana, Iowa, Kentucky, Minnesota, Mississippi, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin. Extant populations of the sheepnose are known from 25 streams in all 14 states of historical occurrence.

There is no known new extant populations since the publication of the final rule in 2012. However, proposed dam removals on the Green River and Walhonding River have the potential to result in sheepnose range expansion within these waterbodies. Refer to Section 2.3.1.2 for further discussion.

Two of the basins, the Lower Missouri River Basin (Osage Fork Gasconade River) and the Lower Mississippi River Basin (Big Sunflower River), have not had any new live or fresh dead specimens collected since 1999 and 2005, respectively, or recent evidence of recruitment (last known from the Big Sunflower River in 2003). The populations within the streams contained within these two basins are considered unknown due to the lack of new information. Should the populations in these two systems decline to the point of extirpation, the extant sheepnose range will be reduced from five to three occupied river basins (HUC2). Additionally, the population within the Eel River (one of five populations within the Ohio River Basin) continues to decline and is considered

as potentially extirpated by local resource managers, with the last live specimen collected in 1997 (pers. comm. Marissa Reed, USFWS, 2019). Refer to the Appendix and Table 1 for additional summary of these populations.

Historic records represented by the collection of dead shells were identified from two additional waterbodies not previously identified in the final rule (2012). Two weathered dead shells were collected from the Skunk River in Henry and Washington Counties, Iowa in 2002, and one weathered dead shell was collected from the Cottonwood River in Brown County, Minnesota in 2011 (Illinois Natural History Survey Mollusk Collection No. 44096, 44103, 79002). Although records of live specimens have not been identified from these waterbodies, these records may indicate a larger historical range within the Upper Mississippi River Basin than previously known.

2.3.2 New Information on threats, conservation measures, and regulatory mechanisms since the time of listing

Large-river habitat throughout most of the sheepnose's range has been impounded, leaving short, isolated patches of habitat in areas between dams. These conditions result in population fragmentation, isolation, and other genetic-related concerns. Other previously-identified threats include, channelization, chemical contaminants, mining, sedimentation, disease or predation, inadequacy of existing regulatory mechanisms, invasive species, oil and gas development, temperature, climate change, and overutilization for commercial, recreational, scientific, or educational purposes. These threats are exacerbated as a result of the small size and isolation of remaining populations. Refer to the 2012 final rule (77 FR 14914) and 2002 Status Assessment (Butler 2002) for a detailed discussion of these factors. We have not identified new information since listing regarding the impact of these threats and stressors on the species. These threats are still significant and impact the species with reduced survival and fragmented populations.

A mass mortality (of unknown cause) of freshwater mussels in the Clinch River, Tennessee, has been ongoing since 2016 (Richard 2016, 22. 2-16). Approximately 280 fresh dead shells, including juveniles, were collected from the Clinch River shoals in Tennessee associated with the event in 2016 (R. Agbalog, USFWS, pers.comm. 2019). Although impacted sheepnose specimens have been identified as a result of this die-off, regular survey efforts conducted by Virginia Tech between 2004-2019, have identified a persisting sheepnose population across multiple sites within the Clinch River with relatively stable densities and recent evidence of recruitment (Anthony Ford, USFWS, pers. comm. 2020; Hubbs 2019, p. 7). Studies regarding this event are ongoing. At the time of this review, no other significant die-off events of unknown cause have been identified to be impacting sheepnose populations throughout the species' range.

The Service has issued 17 Biological Opinions through ESA section 7 consultation since the time of listing (USFWS 2020). An additional two section 7 consultations and one section 10 Habitat Conservation Plan (HCP) were completed for the species prior to 2012. Consultations since listing have collectively authorized the take of approximately 999 sheepnose individuals from the Tennessee (n=93), Ohio (n=35), Kanawha (n=5), Muskingum (n=10), and Mississippi (n=856) Rivers. This information is an indicator of the level of impact were such activities to occur in the future without the protections of the ESA.

Conservation Measures:

The recent removal of Green River Lock and Dam 6 (KY) along with the planned removal of Lock and Dam 5 on the Green River (KY) and the Six Mile Dam on the Walhonding River (OH) may provide for range expansion within these systems (ESI 2017, p. 10; ESII 2019, p. 6-11; A. Boyer, USFWS, pers. comm. 2020). Additionally, these dam removals will likely facilitate movement of the sheepnose's native host fish species. Refer to Section 2.3.1.2 for additional discussion.

Section 7 consultation was completed in 2016, for activities associated with the construction of a new I-74 bridge within Pool 15 of the Mississippi River and demolition of the existing bridge, including a large-scale mussel relocation (refer to Section 2.3.1.2). As part of the mussel relocation, long-term studies are being conducted to assess the success of sheepnose mussel relocations, including individual survival, growth and movement post-relocation (ESI, 2018, p. 22). The first monitoring events of the relocation sites within Pool 15 of the Upper Mississippi River took place in 2017 and 2018. Monitoring of the relocation areas will continue in the years 2020, 2023, and 2026. The results of this study may help improve and inform and increase survival of future sheepnose relocation, translocation, stocking, and reintroduction efforts.

The identification of additional host fish species and ideal propagation conditions through laboratory trials, including fish holding temperatures and techniques for identifying the reproductive condition of gravid sheepnose females, will help promote increased juvenile production through propagation efforts (Hove et al. 2015).

New knowledge regarding the identification of genetically isolated sheepnose populations, genetic diversity within sheepnose populations and sub-populations and the gene flow in-between suggests management efforts should focus on reestablishing connections between sub-populations to increase and maintain genetic diversity (Schwartz and Roe 2018, p. 39). The maintenance of genetic variability within populations and sub-populations may be further supported

through propagation and reintroduction efforts throughout the species' current and historical range (Schwartz and Roe 2018, p. 39).

The Service will be cooperating with state, federal, and local agencies, universities, and other partners, beginning in 2020-2021, to develop and implement a propagation and reintroduction plan for this species in order to comply with the Service's controlled propagation policy. As such, we will be using the International Union for Conservation of Nature (IUCN) guidelines to facilitate our assessment of ecological, social, and economic risks, and to aid development of collection, release, and monitoring strategies. Reintroducing populations to former parts of the species' historical range has the potential to increase redundancy by adding new populations and will help to mediate the effects of habitat fragmentation. For example, the Illinois River (extirpated) provides a linkage between the Kankakee and Mississippi River populations and has experienced water quality and biological condition improvements since enactment of the Clean Water Act (1972), resulting in this stream being a potential candidate for reintroduction following further assessment. Dispersing to new locations may also help mediate effects of zebra mussels, particularly if reintroductions take place in areas where the threat of zebra mussels or other invasive species are low. Augmenting existing populations will make populations more resilient to stochastic events and may help address the threat of small population genetics.

2.4 Synthesis

The sheepnose is a federally listed endangered species with records indicating the species historically occurred in at least 76 streams in 14 states, including Alabama, Illinois, Indiana, Iowa, Kentucky, Minnesota, Mississippi, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin. The May 2012 final rule identified extant populations to include 25 streams in all 14 states of historical occurrence. At the time of listing, the sheepnose was considered to be improving in 2 streams, stable in 10 streams, declining in 8 streams, and unknown in 5 streams. Currently, populations are considered to be stable to increasing in 2 streams, stable in 8 streams, declining in 4 streams, and unknown in 11 streams. Collectively, the last known and/or recent survey efforts have identified juvenile specimens in 10 of the 25 populations, from three of the five extant river basins (Appendix, Table 1).

Two of the extant basins, the Lower Missouri River Basin (Osage Fork Gasconade River) and the Lower Mississippi River Basin (Big Sunflower River), have not reported any new live or fresh dead specimens collected since 1999 and 2005, respectively, or recent evidence of recruitment (last known from the Big Sunflower River in 2003). The populations within these two basins are considered unknown due to the lack of new information. Should the populations in these two systems decline to the point of extirpation, the extant sheepnose range will be reduced from five to three occupied river basins (HUC2).

Since the time of listing, a larger abundance of sheepnose was identified within Pool 15 of the Mississippi River than previously known, representing the species' only "extra large" population, with evidence of recent recruitment (ESI 2017, p. 10). This is the first evidence of sheepnose recruitment within the Mississippi River since 2001.

Reproducing populations have been documented above Lock and Dam 5 on the Green River (KY) and the Six Mile Dam on the Walhonding River (OH), with adult specimens identified below each of the dams (Lewis 2019; ESII 2019, p. 6-11). Both of these dams are currently being proposed for removal, resulting in the potential for range expansion within these two systems.

In addition to the sauger, 30 native host fish species have now been identified for the species, with indications that the sheepnose is a cyprinid specialist (Hove et al. 2015). Refer to Section 2.3.1.1 for a full list of identified host fish species. The identification of new host fish species and ideal propagation conditions, including fish holding temperatures and techniques for identifying the reproductive condition of gravid sheepnose females, improves our understanding of sheepnose life history and will help promote increased juvenile production through propagation efforts (Hove et al. 2015).

A recent genetics study investigating 7 of the 25 extant streams within the species' range has identified the Upper Mississippi River Basin and the Ohio River Basin as genetically isolated populations, each containing sub-populations, as defined in the study (Schwarz and Roe 2018, p. 36). New knowledge regarding the identification of genetically isolated sheepnose populations, genetic diversity within sheepnose populations and sub-populations and the gene flow in-between suggests management efforts should focus on reestablishing connections between sub-populations (Schwartz and Roe 2018, p. 39) to increase and maintain genetic diversity. The maintenance of genetic variability within populations and sub-populations may be further supported through propagation and reintroduction efforts throughout the species' current and historical range (Schwartz and Roe 2018, p. 39).

The sheepnose should remain listed as endangered because the species has not improved since listing and threats have not been ameliorated. Threats persist for the remaining sheepnose populations, including habitat degradation and the effects of climate change. In summary, the species' status has not significantly changed since the time of listing.

3.0 RESULTS

3.1 Recommended Classification:

___ Downlist to Threatened

___ Uplist to Endangered

___ Delist

_X_ No change is needed

New Recovery Priority Number: A Recovery Priority Number (RPN) was not assigned to the species prior to this 5-year review. Following this review, we recommend a RPN of 11 on a scale of 1(C) (highest) to 18 (lowest). A RPN of 11 indicates this species faces a moderate degree of threat, and is considered to have a low (to moderate) recovery potential. The moderate degree of threat is based on the fact that although threats are numerous, long-standing, and ongoing, they and their management techniques are fairly well understood. The decline of the sheepnose (described by Butler 2002 and 77 FR 14914) is primarily the result of habitat loss and degradation (Neves 1991, p. 252) due to impoundments, channelization, chemical contaminants, mining, and sedimentation, among other stressors (Neves 1991, p. 252, Neves 1993, pp. 4 - 6, Williams et al. 1993, pp. 7 - 9, Neves et al. 1997, pp. 60, 63 - 75, Watters 2000, pp. 262-267). These stressors have had profound impacts on sheepnose populations and their habitat for decades. Although we have a general understanding of these threats and stressors and their associated management approaches, the recovery potential of the species is considered to be moderate to low due to the limited ability to reduce impacts from some prominent threats. For example, the reconnection of some isolated populations through the removal of impoundments is impeded as a result of the necessity to maintain navigable waters. Further, many applicable management and conservation techniques would require long-term and intensive management.

4.0 RECOMMENDATIONS FOR NEAR TERM-ACTIONS

- Develop a recovery plan for the species.
- Perform surveys in known streams to assess the status of known populations and search for additional populations in appropriate habitat to evaluate their potential role in the recovery strategy.
- Continue genetics research (for example, expansion of the Schwarz and Roe (2018) study, Section 2.3.1.1) to further assess and refine population structures within the remaining occupied streams throughout the species' range and inform recovery planning.
- Rear juveniles (head-starting) in captivity using host fish and in-vitro techniques for future augmentation and reintroductions and develop a captive propagation, genetics management, and reintroduction plan to inform recovery efforts.
- Investigate potential sites for future augmentation or reintroduction of captivity reared/head-started juveniles and/or adults.
- Develop and implement a monitoring program to evaluate conservation efforts, monitor population levels and habitat conditions, and assess the long-term viability of extant, newly discovered, augmented, and reintroduced sheepnose populations.
- Maintain and increase vegetated riparian buffers of streams throughout the range of the species.
- Initiate watershed-level, community based riparian habitat restoration projects in rivers with sheepnose or upstream in the watersheds harboring the sheepnose.
- Investigate U.S. Environmental Protection Agency's water quality criteria for pollutants to determine levels that would be protective of sheepnose and other mussels.

5.0 REFERENCES

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of Sheepnose (*Plethobasus cyphyus*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

__ Downlist to Threatened

__ Uplist to Endangered

__ Delist

X No change needed

New Recovery Priority Number: 11.

Brief Rationale: A Recovery Priority Number (RPN) was not assigned to the species prior to this 5-year review. Following this review, we recommend a RPN of 11 on a scale of 1(C) (highest) to 18 (lowest). A RPN of 11 indicates this species faces a moderate degree of threat and has a low recovery potential. Refer to Section 3.1 for further discussion.

Appropriate Delisting Priority Number: N/A

Review Conducted By: Sara Schmuecker, Fish and Wildlife Biologist

REGIONAL OFFICE APPROVAL:

Lead Assistant Regional Director, Ecological Services, Fish and Wildlife Service

Approve LORI NORDSTROM Digitally signed by LORI NORDSTROM Date: 2020.08.28 14:50:56 -05'00' Date_____

Appendix

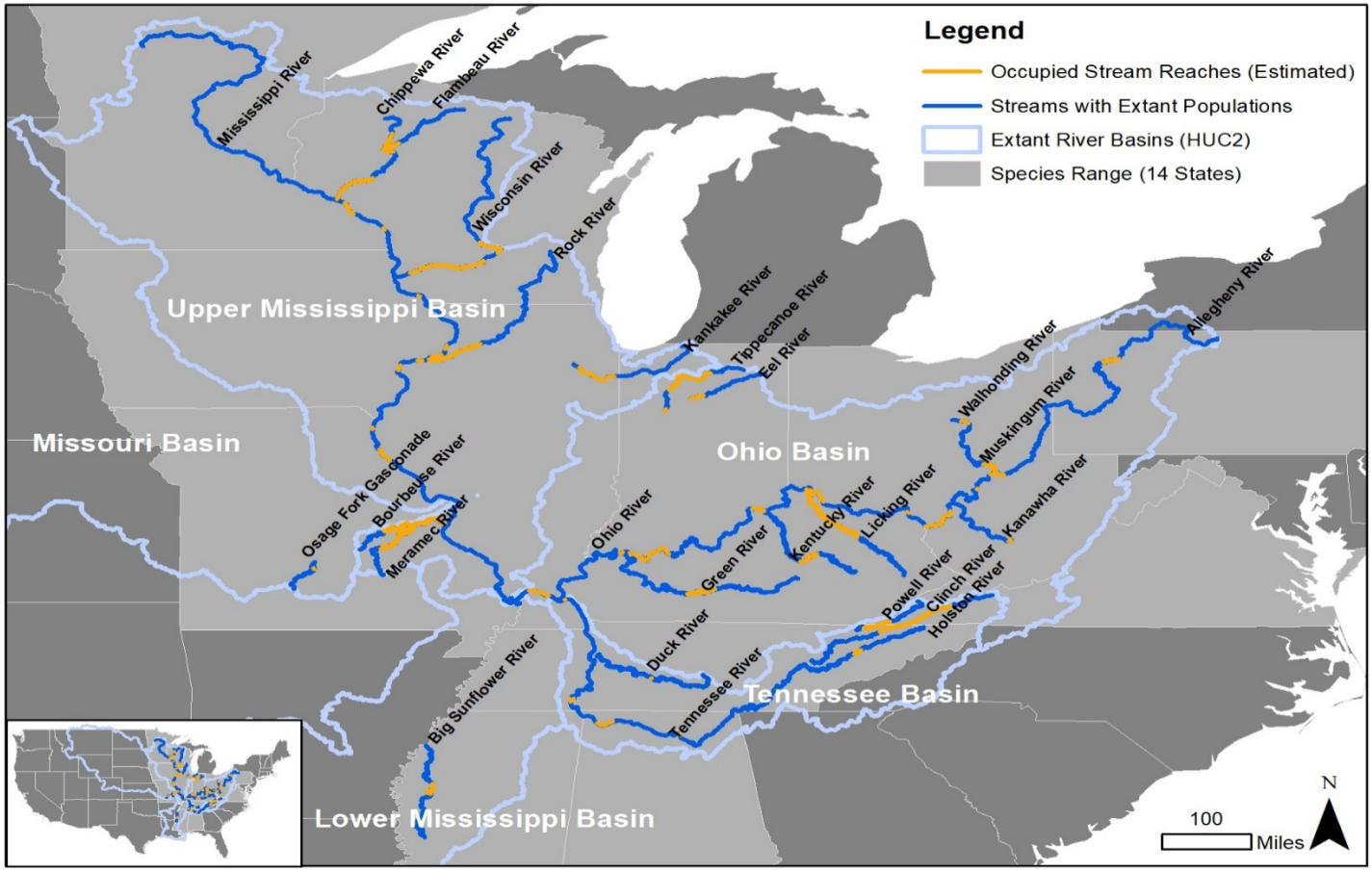

Figure 1. Current sheepnose distribution map.

Table 1. Sheepnose extant population summary by stream of occurrence.

Stream	Year of Last Live or Fresh Dead Observ-ation	Year of Last Known Survey	Evidence of juveniles ≤ 5 yrs	Size (# of individuals)	Estimated number of occupied river miles	Population Trend at time of Listing (2012)	Current Population Trend	Notes
Upper Mississippi River Basin								
Mississippi River (MN, WI, IA, IL, MO)	2018	2019	Yes	Extra Large	30+ mi	Declining	Declining	
Pool 3 (MN, WI)	2000-2001	Unknown	Unknown	Unknown	Unknown		Unknown	Downstream of St. Croix River
Pool 4 (MN, WI)	2008	2008	No	Small	< 1 mi		Declining	This population likely continues to decline, but has not been confirmed through surveys.
Pool 5 (MN, WI)	2017	2019	No	Small	10-20 mi		Declining	2017: One 17 year old (approx.) individual. Only live specimen found since 2007/2008.
Pool 7 (MN, WI)	2001	2018	Yes (2001)	Small	5-10 mi		Unknown	Live juvenile found in 2001 (estimated 3 yrs, 3.3cm)
Pool 11 (IA, WI)	2012	2019	No	Small	1-5 mi		Unknown	
Pool 14 (IA, IL)	2006-2007	2017	No	Small	1-5 mi		Declining	
Pool 15 (IA, IL)	2018	2018	Yes (2016)	Extra Large	20-30 mi	N/A	Stable to Declining	107 individuals relocated upstream in 2016 due to bridge reconstruction project. One 4-year-old individual found as part of the relocation was first evidence of recent recruitment. Other relocated specimens included one approximately 6-year-old, with the remaining ranging in age from 9 to 20+ years in age. Evidence of gravid females in 2017.
Pool 16 (IA, IL)	2014	Unknown	Unknown	Small	1-5 mi		Unknown	
Pool 17 (IA, IL)	2010	Unknown	Unknown	Unknown	1-5 miles		Unknown	
Pool 20 (IA, IL, MO)	1992	2000	No	Small	Unknown		Declining, Possibly Extirpated	
Pool 22 (MO, IL)	1988	2008	No	Small	10-20 mi		Declining, Possibly Extirpated	Last known live record from MO portion of Mississippi River
Pool 24 (MO, IL)	1999	Unknown	No	Small	Unknown		Declining, Declining, Possibly Extirpated	

Chippewa River (WI)	2017	2017	Yes	Medium	30+ mi	Stable	Stable	
Confluence to Eau Claire	2016	2016	Yes (2016)	Medium	30+ mi	N/A	Stable	Densities reaching 0.5 individuals per square meter. A 41mm individual was collected in 2016.
Upstream of Holcomb Flowage	2017	2017	No	Small	30+ mi		Stable	
Flambeau River (WI)	2017	2017	No	Medium	10-20 mi	Stable	Stable	Below lowest dam, near confluence. 9 specimens collected (2017).
Wisconsin River (WI)	2017	2018	No	Medium	30+ mi	Declining	Declining	
Above Lake Wisconsin	2017	2018	No	Small to Medium	20-30 mi	N/A	Declining	Five adults collected (2017)
Below Lake Wisconsin	2012	2018	No	Small to Medium	30+ mi		Declining	One fresh dead collected (2012).
Rock River (IL)	2007	Unknown	No	Unknown	Unknown	Unknown	Unknown	One live specimen collected in last 50-60 years. Assumed near extirpation, but has not been confirmed through systemic survey.
Kankakee River (IL)	2019	2019	Unknown	Small to Medium	20-30 mi	Stable	Stable	Recruitment last reported in 2012. Primarily constricted to downstream of Kanakakee, IL – last found upstream in 2010.
Meramec River (MO)	2019	2019	Yes	Large	30+ mi	Stable	Stable	Best population in Missouri
Bourbeuse River (MO)	2018	2018	Unknown	Medium	30+ mi	Declining	Unknown	
Lower Missouri River Basin								
Osage Fork Gasconade River (MO)	1999	1999	Unknown	Small	< 1 mi	Unknown	Unknown	Only live specimen collected from Gasconade River drainage for >30 years. Assumed near extirpation, but has not been confirmed through systemic survey.
Ohio River Basin								
Ohio River (IL, KY, OH, WV)	2019	2019	Yes	Small - Large	30+ mi	Stable	Stable to Increasing	
Olmsted (IL, KY)	2015	2018	Unknown	Small	10-20 mi	N/A	Unknown	
J.T. Myers (IN, KY)	2017	2017	No	Small	1-5 mi		Unknown	
Newburgh (IN, KY)	2019	2019	No	Small	30+ mi		Increasing	Gravid females collected in 2017 and 2018
McAlpine (IN, KY)	2019	2019	No	Small	1-5 mi		Increasing	
Markland (OH, KY)	2017	2017	Yes (2014)	Small - Large	20-30 mi		Stable to Increasing	Recruitment last observed in 2014. 48 individuals collected in 2014 survey.
Meldahl (OH, KY)	2019	2019	Unknown	Small	<1 mi		Unknown	
Greenup (OH, WV)	2019	2019	Unknown	Small	30+ mi		Stable	
Racine (OH, WV)	2000	Unknown	Unknown	Small	<1 mi		Unknown	3 live individuals
Belleville (OH, WV)	2019	2019	Unknown	Small	10-20 mi		Stable	Population could be expanding downstream following die-off event in 1999 resulting from a purported release from a ferro-alloy manufacturing facility.

Allegheny River (PA)	2008	Unknown	Yes (2008)	Small	10-20 mi	Increasing	Unknown	Considered stable to increasing at time of listing, with ample evidence of recruitment in 2006-2008. The Service did not receive new survey records as part of this 5-Year Review, but is considered to still be small.
Kanawha River (WV)	2019	2019	Yes	Medium	5-10 mi	Stable	Stable	Limited to unimpounded portion of river
Licking River (KY)	2007	Unknown	No	Unknown	Unknown	Declining	Unknown	Known from five sites in the middle Licking River
Green River (KY)	2019	2019	Yes (2019)	Medium	20-30 mi	Increasing	Stable to Increasing	Potential for range expansion following dam removal
Tippecanoe River (IN)	2018	2018	Yes	Small	30+ mi	Stable	Stable	
upstream of Lake Freeman	2018	2018	Yes (2018)	Small	30+ mi	N/A	Stable	
downstream of Lake Freeman	2013	Unknown	No	Small	1-5 mi		Stable	No live specimens collected since 2013.
Kentucky River (KY)	1996	Unknown	Unknown	Small	Unknown	Declining	Unknown	Palisades Region
Eel River (IN)	1997	Unknown	Unknown	Small	<1 mi	Declining	Declining, Likely Extirpated	Lower mainstem, Cass County. No live specimens collected in >20 years. Assumed near extirpation, but has not been confirmed through systemic survey.
Muskingum River (OH)	2011	2011	Unknown	Small	10-20 mi	Unknown	Unknown	One individual (16-20 years old) collected below Devola dam
Walhonding River (OH)	2019	2019	Yes (2019)	Large	5-10 mi	Unknown	Stable	Potential for range expansion following dam removal
Tennessee River Basin								
Tennessee River (AL, KY, TN)	2018	2018	Unknown	Small - Medium	30+ mi	Stable	Unknown, Likely Declining	Recruitment last document in 1997. Insufficient recent information to determine trend.
Kentucky Dam tailwaters (KY)	2017	2017	No	Medium	1-5 mi	N/A	Unknown	10 adult individuals collected (2017)
Pickwick Dam tailwaters (TN)	2017	2017	No	Small	1-5 mi		Unknown	One adult individual (estimated 9 years old)
Wilson Dam tailwaters (AL)	2018	2018	No	Small	10-20 mi		Unknown	Four adults relocated to georeferenced locations within Buck Island Chute (TRM 249)
Guntersville Dam tailwaters (AL)	2004	Unknown	Unknown	Medium	1-5 mi		Unknown	No live specimens collected since 2004
Holston River (TN)	2007	Unknown	No	Medium	10-20 mi	Declining	Unknown	No live specimens collected since 2007. Collections since 2002 have consisted of all extremely old individuals. This population likely continues to decline, but has not been confirmed through surveys.

Clinch River (TN, VA)	2019	2019	Yes	Medium	30+ mi	Stable	Stable	Four specimens relocated go TWRA C-RAC for propagation (2019). Three propagated individuals released near Cleveland, VA (2016). Live specimens becoming more rare in upstream (VA) reach. On-going mussel die-off event with 280 fresh dead shells collected in 2016, cause unknown, assessments on-going.
Powell River (TN, VA)	2013	Unknown	No	Small	30+ mi	Stable	Declining	Live specimens becoming more rare in upstream (VA) reach.
Duck River (TN)	2003	Unknown	No	Unknown	Unknown	Unknown	Unknown	A single adult (10+ years old) collected in 2003.
Lower Mississippi River Basin								
Big Sunflower River (MS)	2005	2018	No	Unknown	10-20 mi	Declining	Unknown	Shell of fresh dead juvenile found in 2003. Population assumed to be extant, but has not been confirmed through extant survey.

Stream: Extant populations by stream are presented in bold, with information further summarized for individual occupied stream segments (non-bold text), where applicable (for example, (e.g., if data were notably dissimilar in different stream segments).

Year of Last Known Survey: Estimated based on available information.

Evidence of Juveniles: Evidence of individuals ≤ 5 years old during last survey.

Size: We categorized the extant populations (typically, occupying distinct river segments) trends into four groups.

Small: 5 or fewer individuals observed during most recent surveys.

Medium: 6-29 individuals observed during most recent surveys.

Large: 30-74 or more individuals observed during most recent surveys.

Extra Large: 75 or more individuals observed during most recent surveys.

Unknown: Insufficient evidence to place population into a size category.

Estimated number of occupied river miles: Derived from communication with local resource professionals or applying an approximately one-river mile buffer to the up- and downstream most collection records.

Current Population Trend: Trends were determined by professional opinion and other gathered information, and do not necessarily represent statistically significant analyses.

Increasing: Evidence that the numbers of individuals have been on a significantly increasing trend over the past 20 years or more.

Stable: Evidence that the numbers of individuals has remained relatively stable over the past 20 years.

Declining: Evidence that the numbers of individuals have been on a significantly decreasing trend over the past 20 years or more.

Unknown: Insufficient evidence to estimate trends.

Extant Sheepnose Population Summaries (2020)

Extant populations of the sheepnose are known from 25 streams in all 14 States of historical occurrence.

Upper Mississippi River Sub-basin

Sheepnose is known to be extant within the Mississippi River mainstem and six tributary rivers of the Upper Mississippi River basin, in addition to one tributary of the Illinois River (Kankakee River).

Mississippi River mainstem (IA, IL, MN, MO, WI)

The final rule (2012) identified occupied stream reaches in Pools 4, 5, 7, 11, 14, 15, 16, 17, 20, and 24 of the Mississippi River mainstem. Additional records for Pools 3 and 22 were presented in a 2002 Status Assessment (Bulter 2002). Since the species was listed in 2012, new records have been reported from Mississippi River Pools (MRP) 5 (2017), 11 (2012), 15 (2018), and 16 (2014) (A. Scheunemann, Minnesota Department of Natural Resources, pers. comm. 2020; USACE 2012, p.3; ESI 2017, p. 10; Illinois Department of Natural Resources (DNR) Natural Heritage Database, received November 20, 2019). Subsequent surveys were conducted in Pools 5 and 11 in 2019, with no findings of live or fresh dead specimens. Overall, the population size within the Mississippi River is considered small, with less than five specimens collected in recent surveys and no known evidence of recruitment, with the exception of Pool 15.

Large numbers of sheepnose have recently been found in Pool 15 (IL/IA) within the Quad Cities area during surveys associated with the reconstruction of the Interstate 74 (I-74) bridge, including one approximately four year old juvenile, documenting the first evidence of recruitment in the Mississippi River since an approximately 3-year-old individual was collected in Pool 7 in 2001 (ESI 2017, p. 10). Section 7 consultation was completed in 2016, for activities associated with reconstruction of the I-74 bridge and demolition of the existing bridge, including the large-scale mussel relocation. This consultation included authorized take of 856 sheepnose individuals, with 107 individuals moved to mussel beds further upstream within Pool 15 as part of the relocation (ESI 2017). In addition to the 4-year-old individual, other relocated individuals included one approximately 6-year-old, with the remaining ranging in age from 9 to ≥20. Evidence of gravid females were reported in 2017. The Mississippi River is the only "extra large" population, based on the abundance in Pool 15 (Table 1).

Chippewa and Flambeau Rivers (WI)

Two occupied stream segments are present within the Chippewa. The downstream segment extends from the Mississippi River confluence upstream to Eau Claire, WI and is the larger of the two with sheepnose densities reaching 0.5 individuals per square meter (Eckert et al. 2017, p 3.). A 2016 sampling effort found specimens of multiple age classes, ranging in length from 41 to 115 mm (Eckert et al. 2017, p.3). Additional live specimens have been identified in 2012, 2014, and 2015 (L. Kitchell, Wisconsin DNR, pers. comm. 2020). The segment located upstream of the Holcombe Flowage is smaller with specimens most recently identified in 2017 (L. Kitchell, Wisconsin DNR, pers. comm. 2020). The Chippewa River population remains

stable and has been the subject of recent brooding and host fish studies, as described in Section 2.3.1 (Hove et al. 2015).

The Flambeau River, a tributary to the Chippewa River, has been known to support a population below its lowest dam, near its confluence with the Chippewa River. Nine live specimens were collected in 2017 by J. Weinzinger (L. Kitchell, Wisconsin DNR, pers. comm. 2020). Evidence of recent recruitment has not been documented.

Wisconsin River (WI)

Sheepnose are known from two stream segments of the Wisconsin River, separated by the Lake Wisconsin impoundment. The stream segment downstream of Lake Wisconsin was last surveyed in 2018; however, the species has not been found since 2012 (L. Kitchell, Wisconsin DNR, pers. comm. 2020). The stream segment upstream of Lake Wisconsin is the larger of the two. This segment was last surveyed in 2018, but sheepnose has not been collected since 2017. Recent evidence of recruitment has not been identified from either stream segment. This population is considered to be declining.

Rock River (IL)

The Illinois DNR's unpublished natural heritage database (provided November 20, 2019) and Illinois Natural History Survey's unpublished database (provided October 16, 2019) reported no new records of the species since 2007. Only one live specimen has been collected in the last 50-60 years. The Rock River population is assumed to be near extirpation; however, a systemic survey has not been conducted to assess viability.

Kankakee River (IL)

Sheepnose was last found in the Kankakee River in 2019 (Stodola 2019, p. 8). This population previously occupied approximately 30 river miles, but is now thought to be restricted to Will County, downstream of Kankakee, Illinois (J. Tiemann, Illinois Natural History Survey, pers. comm. 2020). Although the 2019 survey was indicative of a small population size, a medium-size population was found upstream from the dam in Wilmington, Illinois, near Custer Park in 2018, with a relative frequency of 0.2 percent (EnviroScience 2018, p. 8). A fish study conducted as part of this survey identified sheepnose host fish species, including bluntnose minnow, common shiner, mimic shiner, and spotfin shiner (EnviroScience 2018, p. 14); however evidence of recruitment has not been reported since listing (2012).

Meramec River (MO)

The Meramec River population was last surveyed in 2019, with evidence of recruitment (A. Roberts, U.S. Fish and Wildlife Service (USFWS), pers. comm. 2020; S. McMurray, Missouri Department of Conservation (MDC), pers. Comm. 2020). This is a large population, spanning more than 30 river miles and is considered stable.

Bourbeuse River (MO)

The Bourbeuse River population was last surveyed in 2018. This population continues to occupy an area of more than 30 river miles (A. Roberts, USFWS, pers. comm. 2020; S. McMurray, MDC, pers. Comm. 2020).

Lower Missouri River Basin

The sheepnose population in the Osage Fork Gasconade River, Missouri, is the only known population remaining in the Lower Missouri River Basin.

Osage Fork Gasconade River (MO)

New information has not been identified regarding the status of this population since the 2012 final rule (A. Roberts, USFWS, pers. comm. 2020). One sheepnose collected in 1999 is the only live specimen collected from the Gasconade River drainage for more than 30 years, with this population assumed to be near extirpation; although, a systemic survey has not been conducted to assess viability. However, two host fish species, the creek chub and central stoneroller, are known to be present within the Osage Fork (A. Roberts, USFWS, pers. comm. 2020; S. McMurray, MDC, pers. Comm. 2020).

Ohio River Basin

Sheepnose is known to be extant within the Ohio River mainstem and nine tributary streams.

Ohio River mainstem (IL, IN, KY, OH, WV)

Several occupied stream segments exist throughout the Ohio River mainstem, separated by impoundments. Sheepnose have consistently been documented throughout the Ohio River mainstem between river miles 162 – 959, with the most recent live specimens collected in 2019, from multiple reaches of the River. The upstream-most occupied segment currently spans approximate river miles 162-178 of the Belleville Pool, but could be expanding downstream towards river mile 183 (approx.) through recolonization following a mussel kill in 1999, resulting from a purported release from a ferro-allow manufacturing facility (J. Clayton, West Virginia Division of Natural Resources, pers. comm. 2020; USFWS et al 2007, p. 1).

In recent years, sheepnose have been documented on most beds surveyed, indicative of a relatively healthy population within the Ohio River mainstem; however, it is noted that this may be an artifact of more dive surveys being completed in recent years (M. Reed, USFWS, pers. comm. 2020). Although the sheepnose in most occupied stream segments within the Ohio River appear to have remained stable or be increasing since listing (2012), only one case of recruitment is known (M. Reed, USFWS, pers. comm. 2020). Evidence of recruitment was documented in a large population located between approximate river miles 442 to 46 (OH, KY) in 2014; however only adult specimens have been collected in subsequent surveys.

Allegheny River (PA)

New survey information has not been identified regarding the status of this population since the 2012 final rule. However, the population continues to be considered small with the current area

of occupation spanning from Tionesta to Oil City, Pennsylvania (Nevin Welte, Pennsylvania Fish and Boat Commission, pers. comm. 2020).

Kanawha River (WV)

Sheepnose within the Kanawha River continue to be limited to the unimpounded portion of the river near Kanawha Falls, Fayette County, West Virginia. Sheepnose was most recently documented in 2019 (J. Clayton, West Virginia DNR, pers. comm. 2020), with evidence of recruitment. This medium-sized population is considered to be stable.

Licking River (KY)

New information has not been identified regarding the status of this population since the 2012 final rule (A. Ford, USFWS, pers. comm. 2020). The current status of this population is unknown; however, lack of recent evidence of live specimens and recruitment suggests this population is likely continuing to decline.

Green River (KY)

Sheepnose was most recently identified in the Green River in 2019 (A. Ford, USFWS, pers. comm. 2019). Specimens collected above Lock and Dam 5 between the years of 2017 and 2019, comprised several age classes ranging from approximately 4 to 13 years of age, with evidence of recent recruitment (Kentucky Heritage Database, provided November 21, 2019; A. Ford, USFWS, pers. comm. 2019). A survey conducted in 2019, documented the presence of one adult sheepnose specimen downstream of Lock and Dam 5 (RM 167-168.1), with a relative abundance of 0.02 percent (Lewis 2019, p. 25). This survey was completed as part of an effort to assess the potential removal of the dam. Two dams are slated for removal on the Green River to address public safety concerns, in addition to providing recreational and ecosystem benefits. Removal of the dams is being coordinated by a partnership, including the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, The Nature Conservancy, Kentucky Department of Fish and Wildlife Resources, Mammoth Cave National Park, and Kentucky Waterways Alliance (Chapman 2019, Labashosky 2017). The first, Lock and Dam 6, was removed in 2017, and will be followed by Lock and Dam 5 in 2020 or 2021.

Tippecanoe River (IN)

Two occupied stream segments are known from the Tippecanoe River, separated by the Lake Freeman impoundment. The upstream segment was last surveyed in 2018, identifying recent recruitment (M. Reed, USFWS, pers. comm. 2019). Although this population is small, it is considered to be stable and spans more than 30 river miles. A live specimen has not been identified from the downstream segment since 2013 (M. Reed, USFWS, pers. comm. 2019).

Kentucky River (KY)

New information has not been identified regarding the status of this population for more than 20 years (A. Ford, USFWS, pers. comm. 2020). The current status of this population is unknown; however, lack of recent evidence of live specimens and recruitment suggests this population is

likely continuing to decline and may be near extirpation. A systemic survey has not been conducted to assess viability.

Eel River (IN)

New information has not been identified regarding the status of this population since the 2012 final rule (M. Reed, USFWS, pers. comm. 2019). However, the population within the Eel River is considered to be declining and potentially extirpated by local resource managers, with the last live specimen collected in 1997 (pers. comm. Marissa Reed, USFWS, 2019). A systemic survey has not been conducted to assess viability.

Muskingum River (OH)

Sheepnose was most recently identified in the Muskingum River in 2011 (ESI 2012, p. 7; A. Boyer, USFWS, pers. comm. 2020). This population is believed to be limited to a 10-20 mile reach from the Ohio River confluence, upstream to the Beverly Dam. The current status of this population is unknown.

Walhonding River (OH)

The sheepnose population within the Walhonding River is present within a 5 to 10 mile reach near the Six Mile Dam. A 2019 survey found 32 live specimens with shell lengths ranging in size from 44.5 to 123.5 mm, representing multiple age classes and indicating evidence of recruitment above the dam and a single adult specimen below the dam (ESII 2019, p. 6-11). Sheepnose exhibited a relative frequency of 1.13 above the dam and 0.23 below the dam (ESII 2019, p. 9). This survey was completed as part of an effort to assess the potential removal of Six Mile Dam. The Six Mile Dam on the Walhonding River is owned by the State, and removal is being considered as a restoration project through the Ohio Department of Natural Resources, with removal scheduled for fall of 2020 (EnviroScience 2010, p. 5; A. Boyer, USFWS, pers. comm. 2019). Additionally, in 2018, low water conditions stranded numerous mussels along the banks of the Walhonding River near the Six Mile Dam, including one sheepnose that was recovered and returned to the water (ESII 2019, p. 5). Overall, the sheepnose population in the Walhonding River appears to be fairly robust, although highly restricted (A. Boyer, USFWS, pers. comm. 2019).

Tennessee River Basin

Sheepnose is known to be extant within the Tennessee River mainstem and four tributary streams.

Tennessee River mainstem (AL, KY, TN)

Four occupied stream segments are known from the Tennessee River, located in the tailwaters of the Kentucky Dam (KY), Pickwick Dam (TN), Wilson Dam (AL), and Guntersville Dam (AL). The Kentucky Dam stream segment was last surveyed in 2017, finding ten adult specimens ranging in age from 8 to 13 years (A. Ford, USFWS, pers. comm. 2020; Kentucky Heritage Database, received November 21, 2019). A 2017 survey identified at least one adult specimen below the Pickwick Dam (Tennessee Heritage Database, obtained November 21, 2019; A. Ford,

USFWS, pers. comm. 2019). Sheepnose was most recently collected from the Wilson Dam tailwaters in a 2018 survey. Four live adult individuals were collected and relocated a short distance to georeferenced locations within Buck Island Chute (TRM 249) to allow for them to be found more easily in the future (Garner 2019, p. 1-2). A live specimen has not been collected from the Guntersville Dam stream segment since 2004. Overall, the status of this population is unknown, but lack of recruitment identified in recent survey efforts (last documented in 1997) suggests this population may be declining.

Holston River (TN)

New information has not been identified regarding the status of this population since the 2012 final rule (A. Ford, USFWS, pers. comm. 2019). The current status of this population is unknown; however, lack of recent evidence of live specimens and recruitment suggests this population is likely continuing to decline.

Clinch River (TN, VA)

The Clinch River population spans more than 30-river miles across the Tennessee-Virginia state-line. This population has been regularly sampled since listing (2012), with surveys completed within the last year documenting recruiting specimens from both the Tennessee and Virginia portions of the Clinch River. Surveys were conducted at nine sites across a 30-mile reach of the unimpounded portion of the Clinch River within Hancock County, Tennessee between 2018 and 2019. Twenty sheepnose specimens were collected from five of the nine sites, with a relative abundance of 1.8% (Hubbs 2019, p. 29). Evidence of recent recruitment was identified (Hubbs 2019, p. 7). Four of these individuals were transferred from Clinch River Mile 177.0 to the Tennessee Wildlife Resources Agency's Cumberland River Aquatic Center (TWRA C-RAC) for propagation (Hubbs 2019, p. 5). Live specimens are becoming more rare within the upstream reach of the population, with a 2019 survey in Clinchport, Virginia finding fewer than 10 individuals; however, densities tend to vary across years and survey locations (R. Agbalog, USFWS, pers. comm. 2019). Additionally, three propagated individuals were released near Cleveland, Virginia in 2016 (R. Agbalog, USFWS, pers. comm. 2019).

A significant mussel die-off event has been on-going in the Clinch River since 2016, downstream of the Tennessee-Virginia state line (Richard 2016, pp. 2-16). Approximately 280 fresh dead shells, including juveniles, were collected from the Clinch River shoals in Tennessee associated with the event in 2016 (R. Agbalog, USFWS, pers. comm. 2019). The cause of the die-off is currently unknown and impact assessments are on-going (Don Hubbs, TWRA Mollusk Recovery Coordinator, April 20, 2017).

Although impacted sheepnose specimens have been identified as a result of the on-going die-off event, regular survey efforts conducted by Virginia Tech between 2004 and 2019, have identified a persisting sheepnose population across multiple sites within the Clinch River with relatively stable densities and recent evidence of recruitment (Anthony Ford, USFWS, pers. comm. 2020; Hubbs 2019, p. 7). Therefore, the Clinch River population continues to be considered stable.

Powell River (VA and TN)

Sheepnose remains extant within both the Tennessee and Virginia portions of the Powell River, but is becoming increasingly rare within Virginia portion (R. Agbalog, USFWS, pers. comm. 2020; Johnson et al. 2010, p. 21; Johnson et al. 2012, p. 88-89). Sheepnose was documented in both Tennessee and Virginia across 13 of the 21 sites sampled through an extensive survey effort in 2008-2009. A total of 104 sheepnose were found during this effort with lengths ranging from 58-103 mm and no evidence of recruitment. Numbers of individuals found per site ranged from one to 33 (Johnson et al. 2012, p. 94-95). Sheepnose collected through random timed searches and systematic searches comprised 0.68 percent relative abundance and individuals collected through quantitative sampling in two locations comprised 0.34 percent relative abundance with an estimated density of 0.03 mussels per square meter (Johnson et al. 2012, p. 94-98).

Sheepnose have most recently been found within the Powell River (VA) in 2013 with three specimens found near Fletcher Ford in Virginia. Additional specimens were found near Flanary Bridge in 2012 (R. Agbalog, USFWS, pers. comm. 2020). Densities have been documented to vary depending on year and survey location. Recent surveys have identified five or fewer individuals per site. Sheepnose have been found in higher densities in the Powell River within Tennessee. Overall, the population appears to be declining. River contamination resulting from historic mining operations is an on-going threat specific to the Powell River population (R. Agbalog, USFWS, pers. comm. 2020; Johnson et al 2012, p. 88-89).

Duck River (TN)

New information has not been identified regarding the status of this population since the 2012 final rule (A. Ford, USFWS, pers. comm. 2020). A single adult (10+ years old) individual was last collected just downstream from the old Columbia Dam in the Duck River (TN) in 2003 (Ahlstedt et al 2017, p. 63). The current status of the Duck River population is unknown.

Lower Mississippi River Basin

The sheepnose population in the Big Sunflower River, Mississippi, is the only known population remaining in the Lower Mississippi River Basin.

Big Sunflower River (MS)

The Big Sunflower River population is believed to be limited to an approximately 10 to 20 mile reach upstream of Indianola in Sunflower County, Mississippi (Jones et al, 2019). Sheepnose was last identified in the Big Sunflower River in 2005 (MMNS unpublished records, obtained on October 16, 2019). This population was last surveyed in 2018, with no individuals found. There has been no evidence of recruitment since the shell of a freshly dead juvenile was found in 2003 (Jones et al. 2019). Although the population is still assumed to be extant, there is insufficient information to determine population size and trend.

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