

An Illinois
Species Status Assessment
For
Higgins Eye



Illinois Department of Natural Resources

June 2022

Section 1. Species Description and Conservation Status

Taxonomy

The Higgins Eye mussel (*Lampsilis higginsii*) was described in 1857 by Lea. An alternative common name for the species is Higgins Eye Pearlymussel. A synonymous, but outdated scientific name is *Lampsilis higginsii* (NatureServe Explorer 2022).

The current classification for the species is (NatureServe Explorer 2022):

Phylum: Mollusca

Class: Bivalvia

Order: Unionoida

Family: Unionidae

Genus: *Lampsilis*

Species: *Lampsilis higginsii* (Lea 1857)

Physical Characteristics

The Higgins Eye is a mussel 4-6 inches in length with a rounded to slightly elongate, thick, smooth, and inflated shell. The anterior end is rounded, and the posterior end is bluntly pointed (males) or truncated (females, Illinois Natural History Survey 2022). The shell is yellow, yellowish-green, or brown with green rays. The pseudo cardinal teeth are triangular and thick, while the lateral teeth are fairly long, moderately heavy, and straight. The beak cavity is deep, and the nacre is white, often tinged with cream or salmon and sometimes iridescent (NatureServe Explorer 2022).



Figure 1. Higgins Eye Mussel (U.S. Fish and Wildlife Service 2022)

Habitat

The Higgins Eye is considered a large river species and is usually found in deep water with moderate currents and stable substrates that vary from sand to boulders. The species is found buried in the

substrate of rivers with just the edge of their partially opened shells exposed (United States Fish and Wildlife Service 2022). They are often found in mussel beds that contain anywhere from at least five (United States Fish and Wildlife Service 2022) to 15 species (NatureServe Explorer 2022) mussel species.

Feeding and Diet

It is likely Higgins Eye follow the feeding mechanisms of unionid mussels. Unionid mussels are filter feeders; they mainly eat phytoplankton, zooplankton, and bacteria suspended in the water. By drawing water inside their shells through a siphon, their gills filter out food and take in oxygen (Illinois Natural History Survey 2022).

Life History and Reproduction

Reproduction requires stable, undisturbed habitat and a sufficient population of fish hosts to complete the mussel's larval development. When the male discharges sperm into the current, females downstream siphon in the sperm to fertilize their eggs, which they store in their gill pouches until the larvae hatch. The females then expel the larvae (glochidia). Higgins Eye is considered a bradytictic bivalve (long-term breeder), meaning they spawn in the summer, and larvae are retained in the female's marsupia through the winter until they are released into the water the following spring or summer (United States Fish and Wildlife Service 2022). Glochidia parasitize fish by attaching themselves to the gills and grow into juveniles with shells of their own. At that point, they detach from the host fish and settle into the streambed and live independently. It is noted sauger, walleye, yellow perch, largemouth bass, smallmouth bass, and freshwater drum are considered suitable hosts for Higgins Eye glochidia.

Conservation Status

Table 1 Global, federal, regional, and state conservation status of the Higgins Eye.

<u>Assessment</u>	<u>Status</u>
Global Rank (G-rank) ¹	G1 (critically imperiled)
Midwest Species of Greatest Conservation Need ²	SGCN
State Rank (S-rank) ³	S2? (imperiled)
Illinois Conservation Status ⁴	Endangered
Federal Conservation Status ¹	Endangered

1. NatureServe Explorer (2022)
2. Terwillger Consulting (2021)
3. Feng et al. (2021)
4. Illinois Endangered Species Protection Board (2020)

The Higgins Eye was federally listed as endangered in 1976. Since its listing, the species has been placed on Illinois's endangered list and Midwest Species of Greatest Conservation Need list. It also holds a global status of critically imperiled and an Illinois conservation status of imperiled (Table 1). Feng et al. (2021) conducted a review of the Illinois conservation status of Higgins Eye using the NatureServe Calculator tool and determined the species to hold an s-rank of imperiled (S2?), which is an improvement from the critically imperiled (S1) rank identified under previous ranking methods (NatureServe 2022). South Dakota, Minnesota, Iowa, Wisconsin, and Missouri state the s-rank of Higgins

eye is critically imperiled (S1; Figure 2). The US Fish and Wildlife Service completed an initial recovery plan in 1983 and a revision of the plan in 2004. Subsequently reviews of the recovery plan were completed in 2010 and 2020.

The five-year review of the Higgins Eye released in 2020 states populations in the Cordova Essential Habitat Area (EHA) have increased since 2005, but have been fluctuating since 2010. The [REDACTED] EHA population has been stable since 2014 (United States Fish and Wildlife Service 2020).

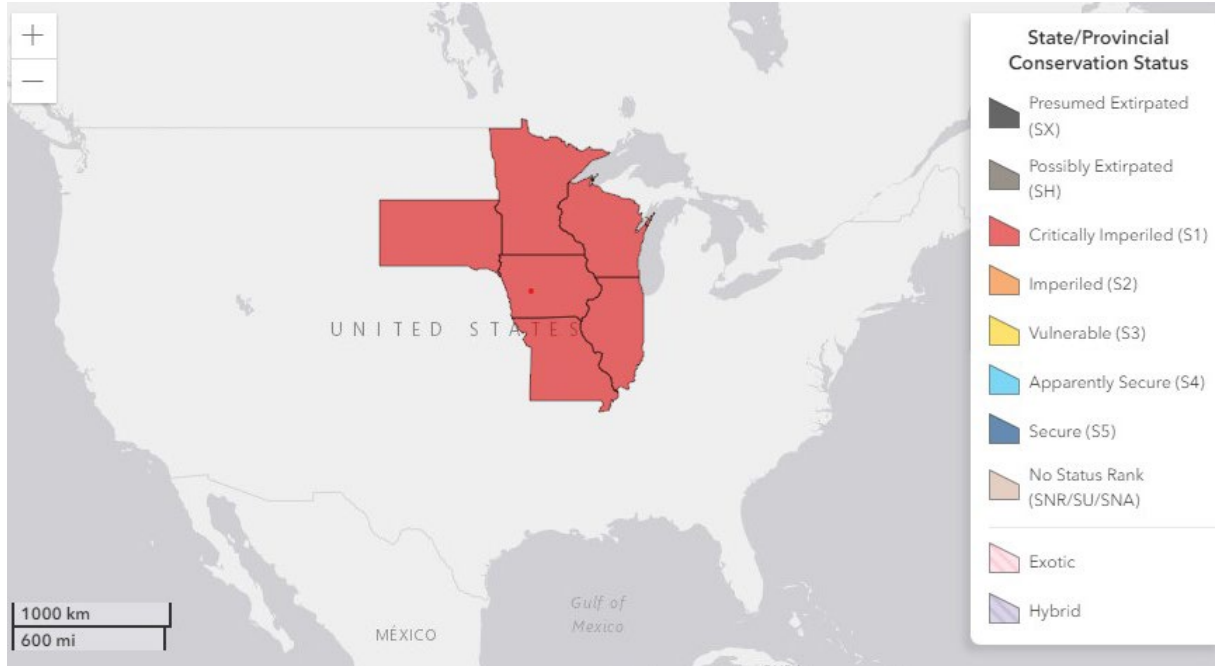


Figure 2. State-ranks (S-ranks) for Higgins Eye (NatureServe 2022). The Illinois S-rank in this figure was assessed prior to Feng et al. (2021) using alternative methodologies.

Section 2. Distribution Estimate

Historic Range (North America)

Historically, Higgins Eye occurred in 12 drainages throughout the United States, including the main stem of the Mississippi River from just north of St. Louis, Missouri, to just south of St. Paul, Minnesota; in the Illinois, Sangamon, and Rock Rivers in Illinois; in the Iowa, Cedar, and Wapsipinicon Rivers in Iowa; in the Wisconsin and St. Croix rivers in Wisconsin; and, in the Minnesota River in Minnesota (United States Fish and Wildlife Service 2004, Miller and Payne 2007; Figure 3). An examination of Higgins Eye distribution maps in Miller and Payne (2007) suggests that the species declined substantially after 1965. By 2014 the species' range had decreased 83% in the United States (Douglass and Stodola 2014).

Historic Range (Illinois)

Historic ranges of the Higgins Eye in Illinois occurred in the Illinois, Sangamon, Mississippi, and Rock River drainages in Illinois; however, most of the individuals were recorded in the Mississippi River (Douglas and Stodola 2014; Figure 4).

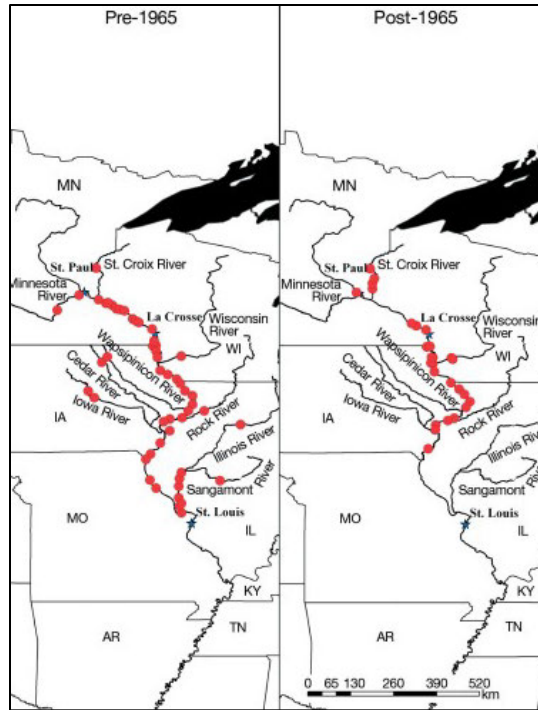


Figure 3. Pre- and post-1965 distribution of Higgins Eye (Miller and Payne 2007).

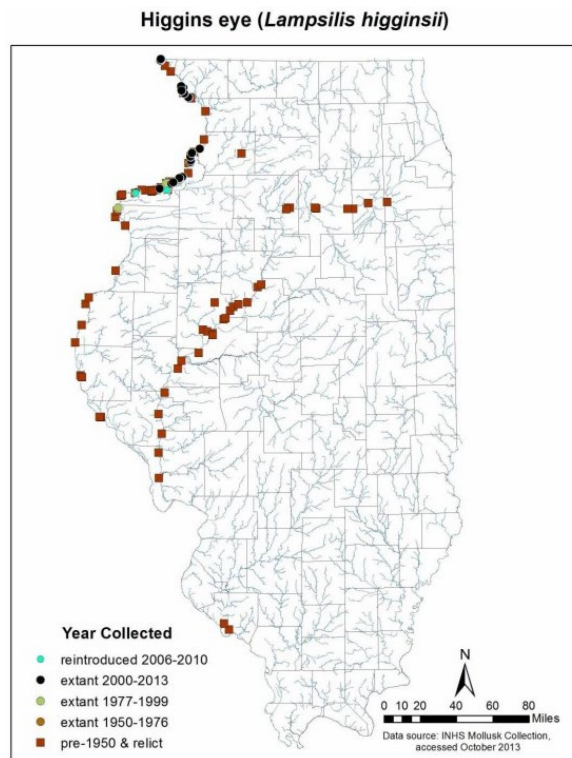


Figure 4. INHS Higgins Eye collection locations before 2013 and reintroduction sites from 2006-2010 (Douglass and Stodola 2014).

Current Distribution (North America)

The species is currently found in the upper Mississippi River between La Crosse, Wisconsin and Muscatine, Iowa as well as three tributaries, the St. Croix River between Minnesota and Wisconsin, the lower Wisconsin River in Wisconsin and the lower Rock River in Illinois (United States Fish and Wildlife Service 2022; Figure 3). The 1983 Federal Higgins Eye recovery plan identified six locations in the upper Mississippi River and one in the St. Croix River that were labeled as 'essential habitats' because they supported viable populations (United States Fish and Wildlife Service 1983). It has been concluded Higgins Eye are slightly more abundant in the center than in the periphery of its range. It is likely that *L. higginsii* populations were always smaller at the northern and southern edge of its range because the river is slightly more erosional and less suitable for mussels at the two edges (Miller and Payne 2007).

Current Distribution (Illinois)

Recent occurrences (2000-2013) of this mussel species are from the Mississippi River in five counties (Jo Daviess, Carroll, Whiteside, Rock Island, and Henderson) and the species has declined in distribution in Illinois in between each record period (Figure 4). Illinois hosts a significant proportion of the species' global population (Douglass and Stodola 2014). SWG Project T-82 also states that increased knowledge has allowed us to believe invasive species, competitors, dispersal, and infrastructure impact the species more than previously thought. These stressors, along with others, have led to the change in the historic to current range (Douglass and Stodola 2014).

Available Survey Data and Limitations

Starting in 2000 Higgins Eye propagation efforts were conducted at Genoa National Fish Hatchery and juveniles and host fish were released throughout the upper Mississippi (Douglass and Stodola, 2014). Efforts to reintroduce the Higgins Eye to the Rock River near the mouth of the Mississippi River have occurred. Surveys conducted in 2014 revealed two live individuals in the Rock River.

Past research and surveys have identified information regarding habitat characteristics such as substrate, stream flow, and water quality. However, there are gaps in water quality data, specific contaminants, and their impacts on various life stages (United States Fish and Wildlife Service, 2004).

The five-year review conducted by the USFWS in 2020 gave updated information on the biology, habitat, threats, and conservation measures used since the previous five-year review. Population trends were analyzed, a genetic-barcoding technique was used to identify newly transformed juveniles, and toxic chemical spills and invasive species have been identified to kill individuals throughout their range based on surveys and research conducted (United States Fish and Wildlife Service 2020).

Section 3. Abundance Estimate

One hundred and thirty-one source features have been recorded for Higgins Eye in Illinois. Search effort was not documented in source feature information; however, abundance often was recorded. One-hundred and thirty-one source features include abundance information, and the range of recorded abundances per source feature is 0 to 748 with a mean of 16.8 and median of 2. All but two years (2016 and 2017) yielded fewer than 200 individuals among all source features. Eighty-three percent of all years had a mean number of individuals per sample that was 14 or lower (Figure 5). Occasionally a larger

abundance was observed at a single source feature a single time. In 2016, 1666 individuals were recorded among all source features.

At four source features, mussels were removed for relocation and relocated at eight source feature sites (Table 2). After a removal event occurred, low presence of Higgins Eye was observed or surveys have yet to be conducted at source features, except for Source Feature ID: 9611. After a relocation event occurred, ratios of 7:1-16:1 (abundance of relocated individuals to abundance of individuals observed in subsequent surveys at same location) were shown. The USFWS outlined the total amount of Higgins Eye released in the Mississippi River from 2000-2019 (Table 3).

The five-year review of the Higgins eye released in 2020 outlined three Essential Habitat Areas (EHAs) in Illinois within the Mississippi River drainage and the percentage of Higgins Eye they contain. ██████ holds 2.9%, ██████ was undetermined, and ██████ holds 0.22% of Higgins Eye. ██████ is not considered an EHA currently but may be considered one in the future and holds 0.30% of Higgins Eye (United States Fish and Wildlife Service 2020).

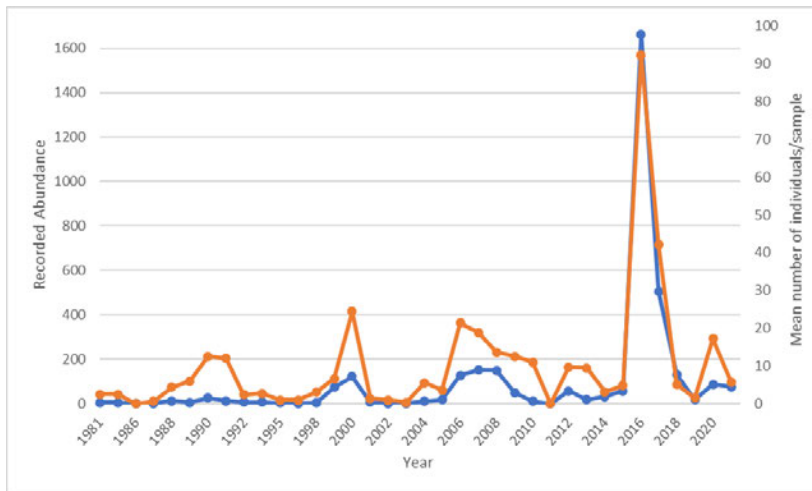


Figure 5. Total recorded abundance at all source features (blue) and mean number of individuals per sample (orange) of Higgins Eye.

Table 2. Removal and relocation information of Higgins Eye at applicable source features

<u>Source Feature ID</u>	<u>Nearest Town</u>	<u>Total Removed/Relocated</u>	<u>Additional Information</u>
9611	██████	111 removed	Removal occurred in 2000; subsequent surveys in 2006, 2007, 2008, and 2009 showed 48 or more live species
9612	██████	111 relocated	Relocation occurred in 2000; subsequent surveys in 2014 and 2018 showed 3 and 6 live respectively
14952	██████	21 relocated	Relocation occurred in 1999; two subsequent surveys in 2018 showed 1 and 2 live

19830		31 relocated	Relocation occurred in 1999; subsequent surveys in 2000, 2003, 2006, 2009, and 2017 showed 1, 0, 0, 0, and 1 live species respectively
27219		5 removed	Removal occurred in 2018; subsequent surveys in 2019 and 2021 showed 0 and 1 live species respectively
27483		63 relocated	Relocation occurred in 2017; no subsequent surveys have been conducted
28248		12 relocated	Relocation occurred in 2016; no subsequent surveys have been conducted
28249		12 removed	Removal occurred in 2016; subsequent surveys in 2018 and 2020 showed 0 and 1 live mussel respectively
31511		5 relocated	Relocation occurred in 2018; subsequent survey in 2021 showed no live mussels
32330		43 removed	Removal occurred in 2017; no subsequent surveys have been conducted
32331		79 relocated	Relocation occurred in 2017; no subsequent surveys have been conducted
31332		14 relocated	Relocation occurred in 2017; no subsequent surveys have been conducted

Table 3. Numbers of Higgins eye released in the Mississippi River as adults, sub-adults, or via free release of infested host fish (juv-free) or in cages (juv-cage) as reported by MNDNR. Italicized numbers indicate a slight discrepancy in numbers between MNDNR data and the data presented in EcoAnalysts, Inc.

Drainage										
Location	Hidden Falls	Upper Pool 2		Lower Pool 2		Pool 3		Pool 4 - Goose Lake	Pool 4 - 4th Cut	Pool 16 - Fairpt.
Year Placed	Sub-adults	Adults	Sub-adults	Adults	Sub-adults	Adults	Sub-adults	Sub-adults	Sub-adults	Sub-adults
2000		100				101				
2001		271								
2002										
2003							196	349		
2004			5		845			577	605	
2005					800		1400	500	500	
2006			1679		-301		744			
2007			5260				2260			4779
2008			521				1092	270	30	2061
2009										
2010			1900				1631	1473	1473	
2011	2									164
2012	826		759				160			47
2013	525		520							
2014	1341									1300
2015	833									
2016	0									
2017	0									
2018	0									
2019	17									
TOTAL	3,544	371	10,644	-	1,344	101	7,483	3,169	2,608	8,351

Section 4. Population Identification and Viability

Element Occurrences (EOs), or occurrence records grouped by proximity, can be used as surrogates for populations. EOs for Higgins Eye were ranked using the guidance in Hammerson et al. (2020). The Natural Heritage database identifies twenty-one Higgins Eye EOs. Of these ten are ranked D (poor viability), three are ranked CD (poor/fair viability), two are ranked AB (good/excellent viability), and six are historic (no records within 10 years, but unknown status; Table 4, Figure 5).

Table 4. Element Occurrence (EO) Ranks for Higgins Eye (A= Excellent viability, B= Good viability, C= Fair viability, D= Poor viability, H=Historical; Hammerson et al. 2020).

<u>EO ID</u>	<u>EO Number</u>	<u>EO Name</u>	<u>Most Recent Record</u>	<u>EO Rank</u>	<u>Justification</u>
899	9	[REDACTED]	1984	H	Unknown status of record. Unknown if additional surveys have occurred.
900	10	[REDACTED]	1981	H	Unknown status of record. Unknown if additional surveys have occurred.
2543	2	[REDACTED]	1992	H	Unknown status of record. Unknown if additional surveys have occurred.
3798	11	[REDACTED]	1988	H	Unknown status of record. Unknown if additional surveys have occurred. Juveniles have been recorded at this EO.
3947	6	[REDACTED]	1984	H	Unknown status of record. Unknown if additional surveys have occurred.
4453	1	[REDACTED]	2021	AB	This EO had two sites with mussels removed for relocation and four sites that received relocated mussels. Between 1 and 748 individuals recorded per source feature.
4789	3	[REDACTED]	2009	H	Unknown status of record. Unknown if additional surveys have occurred.
4940	13	[REDACTED]	2021	AB	This EO had two sites with mussels removed for relocation and two sites that received relocated mussels. Juveniles have been recorded at this EO. Between 1 and 325 individuals recorded per source feature.
6239	19	[REDACTED]	2018	D	One individual recorded per source feature.
6704	20	[REDACTED]	2019	D	Between 1 and 20 individuals recorded per source feature. More than 60% of occurrences are historic.
6807	21	[REDACTED]	2018	D	Between 1 and 10 individuals recorded per source feature.

7966	27	Mississippi River-Albany	2016	CD	Thirty-five individuals recorded at one source feature. Historic and current visit records to this source feature show gravid females.
9444	29	[REDACTED]	2016	D	Between 1 and 2 individuals recorded per source feature.
10523	30	[REDACTED]	2019	D	Two individuals recorded per source feature.
10534	31	[REDACTED]	2018	D	Between 2 and 4 individuals recorded per source feature.
11210	33	[REDACTED]	2021	D	One individual recorded per source feature.
11635	35	[REDACTED]	2018	CD	One individual recorded per source feature. Few individuals recorded at each source feature, but recent gravid females were documented.
11894	36	[REDACTED]	2019	D	Six individuals recorded per source feature.
12303	38	[REDACTED]	2021	D	One individual recorded per source feature.
12578	39	[REDACTED]	2021	D	One individual recorded per source feature.
12628	40	[REDACTED]	2021	CD	Twelve individuals recorded per source feature in 2021.

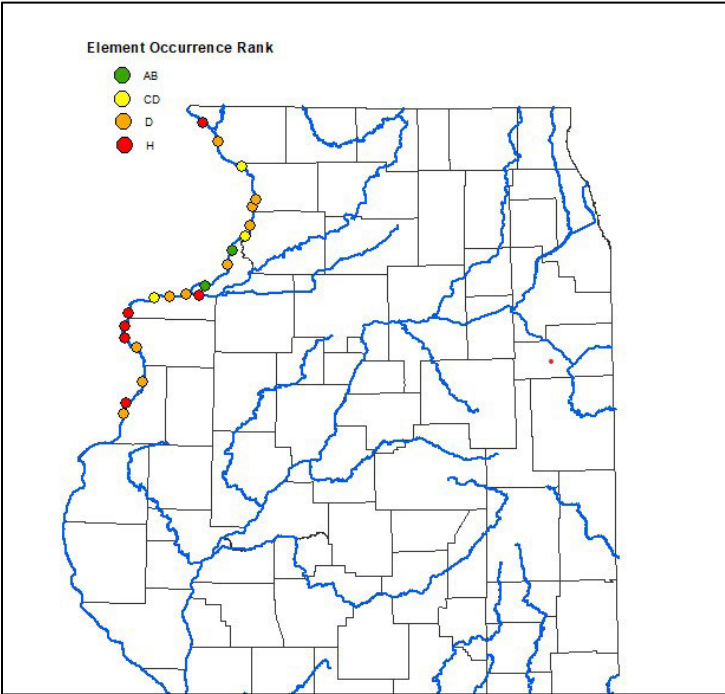


Figure 5. Higgins Eye Element Occurrence (EO) Ranks.

Juveniles were recorded at three source features. Age and sex were not recorded for observed juveniles. One juvenile was observed NE of Burlington, IL and six were observed northeast of Princeton, IL (Table 5).

Table 5. Juvenile Higgins Eye recorded at applicable source features

<u>Source Feature</u>	<u>Location Description</u>	<u>Year</u>	<u>Abundance of Juveniles</u>
13782	[REDACTED]	1981	1
14943	[REDACTED]	2018	1
14951	[REDACTED]	1999	5

Section 5. Ongoing Research and Monitoring

The largest population of Higgins Eye is shown to be in the Mississippi River at [REDACTED]. Annually, biologists collect and clean the species of invasive species. Beginning in 2000, state and federal entities have cooperated to reintroduce Higgins eye into areas of its historic range from which it has been extirpated. In 2000 and 2001, biologists relocated 471 adult Higgins eye from the Mississippi River at [REDACTED], and [REDACTED], Illinois, where zebra mussels posed an imminent risk to the populations. These relocated animals were taken to two sites in pools 2 and 3 of the Mississippi River where zebra mussel densities are below threatening levels (United States Fish and Wildlife Service 2006a).

Biologist have released cage-reared juveniles and fish infested with Higgins eye glochidia into the species’ historic range. In 2006 at the Genoa National Fish Hatchery largemouth bass and walleye were selected as hosts. A total of 7,175 largemouth bass and walleye were inoculated and released during spring 2006 (United States Fish and Wildlife Service 2006b). Since 2000, the USFWS has estimated 37,615 total Higgins Eye has been released into the Mississippi River (United States Fish and Wildlife Service 2020).

The USFWS’ major activities that have occurred since the last five- year review in 2006 include monitoring and captive propagation and release. Monitoring of Higgins eye locations, including zebra mussel monitoring has occurred for several years at multiple locations. Approximately 55,000 Higgins eye adults and subadults have been released into four rivers (Mississippi, Rock, Wisconsin, and Chippewa) and fish infested with millions of glochidia have been released into additional locations (Wisconsin, Iowa, Cedar, and Wapsipinicon; United States Fish and Wildlife Service 2020).

Section 6. References

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