Southeastern Fishes Council Proceedings

Volume 1
Number 61 *2021*

Article 5

December 2021

Status and Relative Abundance of Alabama Shad, *Alosa alabamae*, in Alabama

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Recommended Citation

Rider, Steven J.; Powell, Travis R.; Dattilo, Jason E.; and Miles, Gregory T. (2021) "Status and Relative Abundance of Alabama Shad, *Alosa alabamae*, in Alabama," *Southeastern Fishes Council Proceedings*: No. 61.

Available at: https://trace.tennessee.edu/sfcproceedings/vol1/iss61/5

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Abstract

Alabama Shad, *Alosa alabamae*, an anadromous fish found historically from the Mississippi River basin eastward to the Suwanee River, has experienced population declines and even extirpation in some States. In Alabama, *A. alabamae* have been found in rivers of the Mobile River basin and Conecuh, Yellow, and Choctawhatchee rivers in the coastal Gulf Plain. We report on our directed and targeted efforts to assess the current status and relative abundance of *A. alabamae* in Alabama and compare our results to past *A. alabamae* surveys in Alabama. We completed 52 sampling trips and expended 129.5 hours of boat-electrofishing effort targeting *A. alabamae*. Sampling was conducted during the spring to coincide with the spring-spawning migration at historical sites and sites conducive for the collection of *A. alabamae*. No *A. alabamae* was collected from the Mobile River basin (i.e., Alabama and Tombigbee rivers) and only one *A. alabamae* was collected from the Conecuh River. We collected seven *A. alabamae* in 2011 and three in 2018 from the Choctawhatchee River. For the Choctawhatchee River population, our results indicated a precipitous decline in abundance by 71% and 98% from 1999/2000 to 2011 and 2018, respectively. In addition, our results support the extirpation of *A. alabamae* from the Mobile River basin and a severely depressed population in the Conecuh River. Although *A. alabamae* was recently denied listing under the Endangered Species Act by the National Marine Fisheries Service due to lack of apparent range-wide extinction, our results indicate what was once considered the second largest population of *A. alabamae* from the Choctawhatchee River is on the verge of extirpation. *Alosa alabamae* could become extirpated from Alabama in the near future, which is a significant portion of its range.

Keywords

Mobile River basin, Clupeidae, coastal rivers, extirpation

Cover Page Footnote

The authors wish to thank Andrew Henderson and Tom Ringenberg for field assistance. Funding for this project was provided through the Cooperative Endangered Species Conservation Fund (Section 6 of the Endangered Species Act) and the State Wildlife Grant Program to the Alabama Division of Wildlife and Freshwater Fisheries.

INTRODUCTION

Alabama Shad, *Alosa alabamae*, has been collected in large Gulf of Mexico drainages from the Mississippi River and several of its larger tributaries eastward to the Suwannee River basin in northern Florida (Lee et al. 1980; Ross 2001; Mettee and O'Neil 2003; Robins et al. 2018; Cannister and Bechler 2019). These Mississippi River tributaries include the Ouachita, White, Arkansas, Ohio, Missouri, Meramec, and Tennessee rivers (Boschung and Mayden 2004). In the Gulf Coastal Plain, these rivers include Lake Pontchartrain, Pascagoula, Pearl, Mobile, Conecuh-Escambia, Yellow, Choctawhatchee, Apalachicola, and Suwannee (Mettee et al. 1996; Ross 2001; Boschung and Mayden 2004; Robins et al. 2018). This anadromous species inhabits marine and estuarine environments most of the year. However, in the spring, adults travel long distances inland, sometimes several hundred kilometers, to spawn in fresh water (Coker 1930; Lee et al. 1980; Buchanan et al. 1999; Kreiser and Schaeffer 2009). Spawning typically occurs in moderate current near sandbars, limestone outcrops, or over sand substrate with water temperatures ranging from 19 to 23^{o}C (Laurence and Yerger 1967; Mills 1972; Mettee and O'Neil 2003).

Access to many *A. alabamae* upstream spawning sites has significantly decreased since the beginning of navigation lock and dam construction in its historic range in the last 50 to 100 years (Laurence and Yerger 1967; Barkaloo et al. 1993). In addition, siltation and dredging as a result of dam construction (Lee et al. 1980; Burr and Warren 1986; Robinson and Buchanan 2020) and water pollution (Mettee et al. 1996) have also been implicated in the decline of *A. alabamae*. As a result, declines in abundance and extirpation have been observed throughout its historic range (Gunning and Suttkus 1990; Etnier and Starnes 1993; Musik et al. 2000; Ross 2001; Mettee and O'Neil 2003; Boschung and Mayden 2004). Although sporadic reports exist of *A. alabamae* still occurring inland in the Mississippi River drainage (Burr et al. 1996; Buchannan et al. 1999; Page and Burr 2011; Robinson and Buchanan 2020), most current reports and collections occur in Gulf Coast drainages from Louisiana to Florida (Mettee and O'Neil 2003; Ely et al. 2008; Young et al. 2012; Mickle et al. 2016). Although no historical estimates of abundance are known, *A. alabamae* have been abundant enough to support recreational and commercial fisheries in the past (Evermann 1902; Coker 1930; Hildebrand 1963). However, studies conducted from the 1960s to 1990s indicated abundance of spawning *A. alabamae* were relatively low or may have already been depressed by habitat alterations and overharvest (Laurence and Yerger 1967; Mills 1972; Mettee and O'Neil 2003).

Alosa alabamae is an ecologically important species in freshwater, estuarine, and marine ecosystems. This species, along with other anadromous Clupeidae are an integral part of the food web through ecosystem functions such as nutrient and energy transfers (Freeman et al. 2003). Adults migrate into freshwater rivers in the spring to spawn. Laurence and Yerger (1967) and Mills (1972) suggested younger fish (ages 2 to 3) migrate down river after spawning to the marine environment and that older fish ($\geq$ age 4) die. However, thousands of *A. alabamae* have been tagged by fisheries biologists with the Georgia Department of Natural Resources (GADNR) from the Apalachicola River and none have been recaptured in subsequent years (T. Ingram, GADNR, unpublished data). In addition, GANDR biologists have observed large numbers of dead and dying *A. alabamae* after spawning. These observations indicate a majority of *A. alabamae* from the Apalachicola River are semelparous. This post-spawn mortality transfers nutrients from the marine to freshwater ecosystem. After hatching, *A. alabamae* larvae then juveniles form an important food link as they feed on phytoplankton and zooplankton, and in-turn are fed upon by many fish and bird species. As the juveniles mature and migrate down river into marine environments to eventually mature into adults, they become prey for many marine predators. This cycle continues once the fish mature in the marine environment to migrate upriver to spawn.

In Alabama, *A. alabamae* have historically been collected in the Mobile River basin (i.e., Tombigbee, Black Warrior, Cahaba, Coosa, and Alabama rivers) and Gulf Coastal Plain rivers (i.e., Conecuh, Yellow, and Choctawhatchee rivers) (Smith-Vaniz 1968; Mettee et al. 1996; Mettee and O'Neil 2003; Boschung and Mayden 2004). Based on historical records the Tombigbee, Cahaba, and Alabama rivers supported larger numbers of *A. alabamae* than the Coosa or Black Warrior rivers (Mettee et al. 1996; Boschung and Mayden 2004; FishNet 2021). Nonetheless, only five *A. alabamae* have been collected in the Mobile River basin since 1994.

In the Alabama River, only five *A. alabamae* have been collected in the last 26 years. One was collected in 1994 and one in 2001 below Claiborne Lock and Dam (O'Neil et al 2000; Mettee et al. 2006). Two more specimens were collected below Miller's Ferry Lock and Dam in 1995 and 1997 (O'Neil et al. 2000). Another specimen was collected from the Mobile River basin came from the Black Warrior River below Seldon Lock and Dam in 1998. This was the first specimen collected from this system in over 100 years (Mettee and O'Neil 2003). Only four other specimens have ever been collected from the Black Warrior River (Evermann 1896). This species has not been collected nor observed from the Tombigbee River since the late 1950's (Mettee et al. 1987; FishNet 2021). Only one *A. alabamae* is known from the Coosa River, collected in 1878 approximately 16 km upriver of the confluence with the Tallapoosa River (FMNH 2021). No records exist for the occurrence of *A. alabamae* in the Tallapoosa River. Nearly 800 *A. alabamae* adult and juvenile specimens were documented from the Cahaba River from 1954 to 1965 with the last specimen collected in 1968 (Pierson et al. 1989; FishNet 2021).

For the Gulf Coastal Plain rivers of Alabama, records exist for the Yellow, Conecuh, and Choctawhatchee. Five specimens have been collected from the Yellow River of Alabama; three in 1961 and two in 1971 (FishNet 2021). Another 13 specimens were collected in the Yellow River of Florida from 1961 to 1977 (FishNet 2021). General faunal surveys conducted in the Conecuh-Escambia River have collected relatively few *A. alabamae*, albeit mainly juveniles. Prior to the recent millennium 12 (1957), 113 (1958), 1 (1976), 1 (1988), and 1 (1993) specimen(s) were collected (FishNet 2021). Afterwards, at total of 10 were caught combined from 2003 (1), 2006 (2), and 2015 (7) (FishNet 2021). A targeted *A. alabamae* survey yielded 11 adult fish between 1992 to 1995 (Mettee et al. 1995). Based on previous targeted studies for *A. alabamae*, the Choctawhatchee River was considered to have the second largest population behind the Apalachicola River population as 400 fish were collected from 1994 to 2001 (Mettee and O'Neil 2003). Based on the first targeted collection efforts for *A. alabamae* in the Choctawhatchee and Conecuh rivers, these small populations were deemed self-sustaining (Mette and O'Neil 2003).

Alosa alabamae is listed by the Alabama Division of Wildlife and Freshwater Fisheries (ALDWFF) on the State's Nongame Species Regulation (220-2-.92). This regulation functions as the State of Alabama's rare and endangered species list. In addition, *A. alabamae* has been designated as a species of highest conservation concern from high conservation concern during the recent Alabama Nongame Symposium (Rider 2017). This increase in imperilment acknowledgment is the result of most of this species upriver spawning habitat being blocked or eliminated by locks and dams and recent surveys documenting a decline in *A. alabamae* abundance in Alabama (Rider et al. 2010; Rider 2011; Rider et al. 2012; Rider and Powell 2013). Although a petition to list this species under the Endangered Species Act has been denied by the National Oceanic and Atmospheric Administration (NOAA 2011), current status and relative abundance in Alabama is lacking.

We initiated a multi-year project to assess the status of *A. alabamae* with targeted sampling effort in the major river systems of its historical occurrence in Alabama. Numerous fish studies have reported on the lack of *A. alabamae* specimens; however, these have been general faunal surveys not targeting *A. alabamae* at the appropriate time, location, or using the appropriate sampling gear (Freeman et al. 2005; Pierson et al. 1989; Onorato et al. 2000). This paper summarizes and compiles these recent surveys and compares to past targeted *A. alabamae* surveys in Alabama. The objectives of this paper are to 1) determine the current status; 2) relative abundance; 3) distribution; and 4) provide additional life-history data of *A. alabamae* in Alabama.

METHODS

Study Sites

Sampling was conducted at historical sites and rivers where there was a higher likelihood of collecting specimens during the spring-spawning migration (Figure 1). These areas included the Alabama (2009) and Tombigbee (2012) rivers (Mobile River basin), Conecuh (2010) and Choctawhatchee (2011 and 2018) rivers of Alabama (Rider et al. 2010; 2011; 2012; Rider and Powell 2013). In the Tombigbee River, sampling was conducted below Coffeeville Lock and Dam at approximately Tombigbee River kilometer 187.5. Seven transects were established below Coffeeville lock and sampled each sampling date. In the Alabama River, sampling was conducted below Robert F. Henry, Millers Ferry, and Claiborne locks and dams on the Alabama River at approximately Alabama River kilometer 379.8, 213.2, and 116.7, respectively. Below Robert F. Henry, Millers Ferry and Claiborne locks and dams, five, seven, and seven transects were sampled each sampling date, respectively.

In the Conecuh River, sampling was conducted from the Alabama-Florida state line to the Covington County Road 42 bridge, an approximate distance of 100 km. We attempted to sample 10 identified sites and one site in Murder Creek, a tributary of the Conecuh River, each sampling date. However, due to low water were unable to sample all sites for each sampling event. We sampled 2 to 3 transects per site per date, depending on the river width. For the Choctawhatchee River, 4 sites were located from the Alabama-Florida border to the confluence with the Pea River and one site in the lower Pea River. At each site we sampled a minimum of four transects per sampling date. We followed *A. alabamae* sampling protocols established by Mettee and O'Neil (2003). That is, if *A. alabamae* were encountered then we increased the number of times sampled for a particular site in the Choctawhatchee and Conecuh rivers.

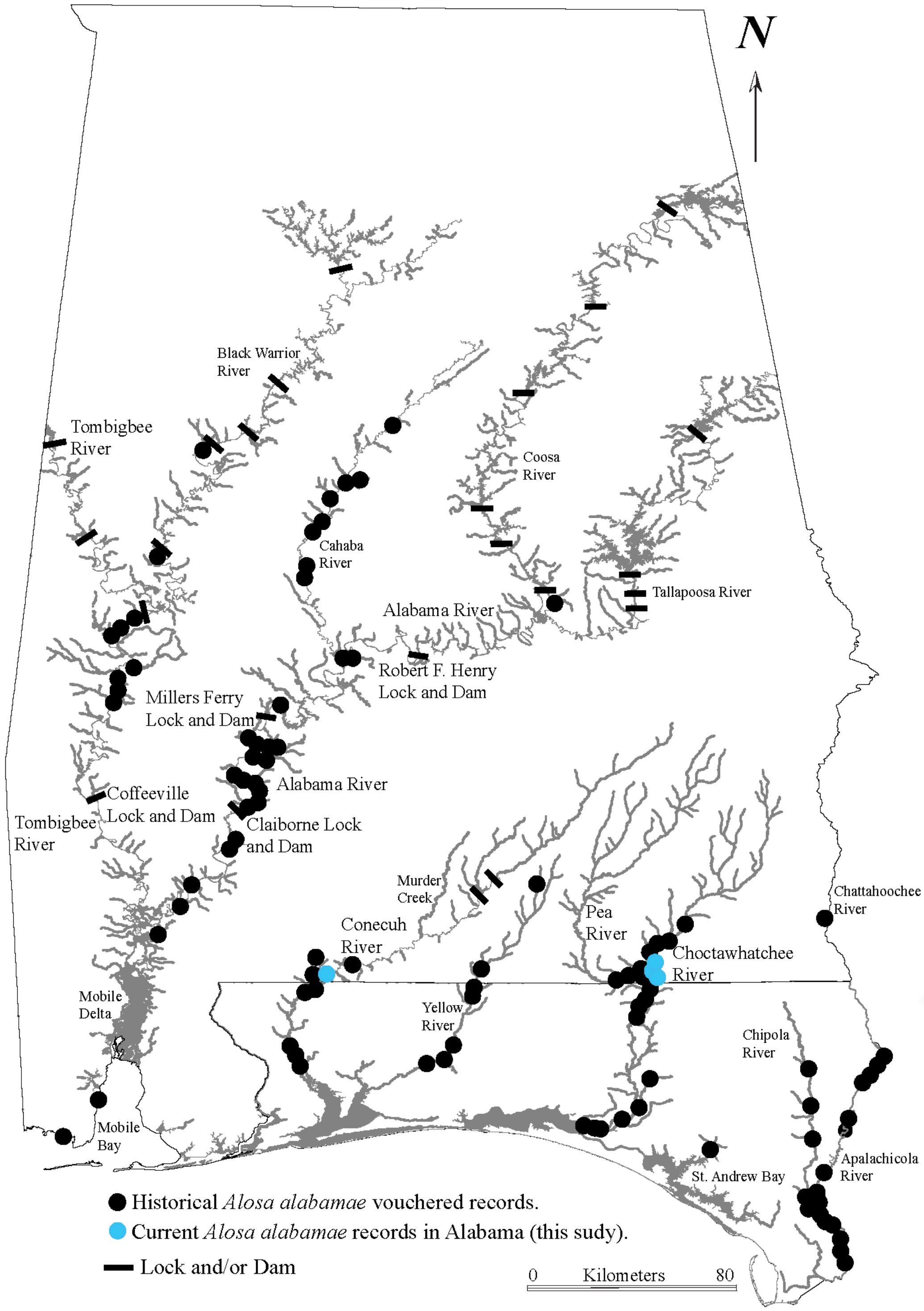

Figure 1. Historical and current *Alosa alabamae* records in Alabama and northwest Florida (Mettee et al. 1996; Boschung and Mayden 2004; Robins et al. 2018).

Fish Sampling

Fish sampling was conducted with a boom-mounted electrofishing boat using a Smith-Root 7.5 GPP generator powered pulsator control set with pulsed-direct current. Sampling was conducted for 10 minutes at each transect by going downriver (i.e., with the flow) with one fish dipper on the bow of the boat. For sampling in the Alabama and Tombigbee rivers, each transect began approximately 200 to 300 m below each dam and was equidistant apart across the river.

All fishes collected, except *A. alabamae*, were identified, enumerated, and released near point of capture. All *A. alabamae* were retained to provide additional biological data. Total length (nearest mm), weight (nearest gram), gonad weight (nearest tenth of a gram), and sex were recorded for each *A. alabamae* collected. The sagittal otoliths were excised from each fish for age determination. The gonadosomatic index (GSI) was calculated for each individual to determine reproductive maturity by the following equation: GSI = 100 x gonad weight (g)/body weight (g) (Crim and Glebe 1990). Catch-Per-Unit-Effort was calculated as the number of fish collected per hour (fish/hour) of electrofishing effort.

Table 1. Summary of sampling sites and effort for targeted *Alosa alabamae* sampling in Alabama, 2009-2018.

River System	Sampling Site	Sampling Dates	No. Transects Sampled	Sampling Effort (hours)	Water Temperature (ºC)
Alabama River	R. F. Henry Lock and Dam	12 February - 23 April 2009	35	5.8	12.1 - 21.3
Alabama River	Miller's Ferry Lock and Dam	12 February - 23 April 2009	40	6.7	12.1 - 21.3
Alabama River	Claiborne Lock and Dam	11 February - 22 April 2009	35	5.8	12.0 - 21.3
Conecuh River	Alabama-Florida state line to HWY 42 bridge crossing	1 April - 22 July 2010	66	10.5	16.1 - 30.0
Choctawhatchee River (Pea River)	Alabama-Florida state line to Pea River confluence	14 February - 6 May 2011	295	45.5	10.1 - 25.6
Tombigbee River	Coffeeville Lock and Dam	10 April - 7 May 2012	30	11.7	17.3 - 22.5
Choctawhatchee River (Pea River)	Alabama-Florida state line to Pea River confluence	12 March - 4 May 2018	260	43.5	14.0 - 24.4
TOTAL			761	129.5	

We completed 52 sampling trips, sampled 761 transects, and expended a total of 129.5 hours of electrofishing effort targeting *A. alabamae* (Table 1). A total of 21 electrofishing trips (seven below each lock and dam) were conducted in the Alabama River (Figure 1; Table 1). These 21 trips comprised 110 transects with 18.3 hours of electrofishing expended. A total of fivesampling trips comprised 30 transects with 11.7 hours of electrofishing expended in the Tombigbee River (Figure 1; Table 1). We completed seven *A. alabamae* sampling trips from April 1 to July 22, 2010, in the Conecuh River, Alabama (Figure 1; Table 1). Seven sampling trips comprised 66 transects with 10.5 hours of electrofishing expended (Table 1). A total of 12 *A. alabamae* sampling trips were completed from February 14 to May 6, 2011, in the ChoctawhatcheeRiver, Alabama (Figure 1; Table 1). Twelve sampling trips comprised 295 transects, with 45.5 hours of electrofishing expended (Table 1). In 2018, we completed seven *A. alabamae* sampling trips from March 12 to May 4, in the Choctawhatchee River (Table 1). These sampling trips comprised 260 transects, with 43.5 hours of electrofishing effort.

RESULTS

Alabama River

We collected a total of 13,501 fishes from 13 families and 34 species from the Alabama River (Table 2). Threadfin Shad, *Dorosoma petenense*, Gizzard Shad, *Dorosoma cepedianum*, Emerald Shiner, *Notropis athernoides*, Smallmouth Buffalo, *Ictiobus bubalus*, Paddlefish, *Polyodon spathula*, and Longnose Gar, *Lepisosteus osseus* dominated and composed 93% of the total catch. The percent composition for 27 of the 28 remaining species was less than 1.0% by species for the total catch. We did not collect nor observe any *A. alabamae* from the Alabama River.

Tombigbee River

Our sampling efforts yielded 2,393 fishes from 11 families and 27 species from the Tombigbee River (Table 2). *Dorosoma petenense* (74.5%), *I. bubalus*, (4.1%), *D. cepedianum* (3.9%), carpsuckers, *Carpiodes* spp., (3.2%), and Striped Mullet, *Mugil cephalus*, (2.5%) composed 88.2% of the catch. As with the Alabama River, we did not collect any *A. alabamae* from the Tombigbee River.

Conecuh River

In the Conecuh River, a total of 1,976 fishes from 15 families and 39 species were collected (Table 2). *Carpiodes* spp., Blacktail Shiner, *Cyprinella venusta*, and Weed Shiner, *Notropis texanus*, composed 60.4% of the catch. Only one adult *A. alabamae* was collected from the Conecuh River; however, we observed 3 additional specimens on the same date (14 April 2010) and location (Alabama-Florida state line) but were unable to net these specimens. The collected specimen was an age-2 female with a total length of 246 mm, weight of 135 g, gonad weight of 5.0 g, and a gonadosomatic index (GSI) of 3.7.

Choctawhatchee River

In 2011, we collected a total of 3,053 fishes from 17 families and 39 species from the Choctawhatchee River (Table 3). *Carpiodes* spp. (34.9%) and *C. venusta* (15.8%) composed 50.7% of the catch. A total of seven *A. alabamae* was collected (Table 4). Only one of the seven collected was a female, which was 2 years old with a GSI of 10.7 (Table 5). The six males collected ranged in total length from 273 to 374 mm and ages 1 to 3 years old (Table 5), respectively. During 2011, weekly CPUE ranged from 0 to 0.47 fish/hour each sampling week (Table 5). The mean CPUE was 0.22 for the 2011 sampling season.

From the Choctawhatchee River in 2018, we collected a total of 3,031 fishes from 17 families and 41 species (Table 3). *Notropis texanus*, *C. venusta, D. petenense, M. cephalus, L. oculatus*, and *Carpiodes* spp. composed 78.31% of the catch. We collected a total of three *A. alabamae* in 2018 (Table 4). Two of the specimens were large gravid females with GSIs of 11.6 and 11.8 and ages of 3 and 4 years. The single male was 2 years old with a GSI of 5.1. In 2018, weekly CPUE ranged from 0 to 0.30 fish/hour with a mean CPUE of 0.07 fish/hour (Table 5). Water temperatures ranged from 21.9 to 24.7^{o}C when *A. alabamae* were collected.

DISCUSSION

Our targeted sampling efforts suggest the historical distribution and relative abundance of *A. alabamae* in Alabama have decreased drastically. Mettee and O'Neil (2003) specified the historical range of *A. ala*bamae in Alabama had been fragmented coinciding with a possible negative population trend. However, they cautioned this observation may be due in part to "insufficient sampling during spring spawning migrations with appropriate sampling gear." To account for this potential bias, we sampled during months of the spring spawning migration that if *A. alabamae* were present then we would have a higher likelihood of collecting specimens. Although we were unable to sample during February and March in the Tombigbee River due to high water, we did sample in April and May and if *A. alabamae* were present, they should have been susceptible to our sampling gear. In the Alabama River, were able to sample from early February to late May, again the time frame that has been shown to be the most conducive period for collecting *A. alabamae* and none were captured. When present, *A. alabamae* are typically collected from February to May in the Apalachicola and Choctawhatchee rivers using boat-electrofishing gear, similar to our sampling gear (Mettee and O'Neil 2003; Ely et al. 2008; Rider et al. 2012). Our targeted surveys conducted after 2001 support the assertion that *A. alabamae* is extirpated from the Mobile River basin. Additionally, recent sampling efforts since 2009 in both the Tombigbee and Alabama rivers with boat electrofishers have not collected or observed any *A. alabamae* (Dattilo 2017; S. Rider, ADWFF, unpublished data).

Boat electrofishing is considered to be the most effective method to collecting spring spawning *A. alabamae*. Since the early 1990s, boat electrofishing has been used to collect *A. alabamae* in numerous river systems (Mettee et al. 1995; Mettee and O'Neil 2003; Ingram 2007; Ely et al. 2008; Rider et al. 2010; Rider 2011; Rider et al. 2012; Young et al. 2012; Rider and Powell 2013; Kern et al. 2017). As with any sampling gear there are limitations as the efficiency of electrofishing is based on fish and habitat characteristics, along with operating conditions (Reynolds 1983). Pelagic fishes such as clupeids can be difficult to collect with electrofishing gear

Table 2. Number (N) and percent composition (PC) of fishes by species collected from the Alabama River in 2009, Conecuh River in 2010, and Tombigbee River in 2012 during *Alosa alabamae* sampling.

				Alabama River 2009		Conecuh River 2010		Tombigbee River 2012		Total	
FAMILY	GENUS	SPECIES	COMMON NAME	N	PC	N	PC	N	PC	N	PC
Acipenseridae	*Acipenser*	*oxyrinchus desotoi*	Gulf Sturgeon	0	0.0	2	0.1	0	0.0	2	0.0
Polyodontidae	*Polyodon*	*spathula*	Paddlefish	301	2.2	0	0.0	35	1.5	336	1.9
Lepisosteidae	*Lepisosteus*	*oculatus*	Spotted Gar	87	0.6	21	1.1	4	0.2	112	0.6
	Lepisosteus	*osseus*	Longnose Gar	172	1.3	69	3.5	48	2.0	289	1.6
Amiidae	*Amia*	*calva*	Bowfin	3	<0.1	7	0.4	0	0.0	10	<0.1
Anguillidae	*Anguilla*	*rostrata*	American Eel	1	<0.1	18	0.9	0	0.0	19	0.1
Clupeidae	***Alosa***	***alabamae***	**Alabama Shad**	0	0.0	1	<0.1	0	0.0	1	<0.1
	Alosa	*chrysochloris*	Skipjack Herring	18	0.1	0	0.0	6	0.3	24	0.1
	Breevortia	*patronus*	Gulf Menhaden	0	0.0	0	0.0	1	<0.1	1	<0.1
	Dorosoma	*cepedianum*	Gizzard Shad	279	2.1	11	0.6	93	3.9	383	2.1
	Dorosoma	*petenense*	Threadfin Shad	10,092	74.8	137	6.9	1,782	74.5	12,011	67.2
Cyprinidae	*Ctenopharyngodon*	*idella*	Grass Carp	3	<0.1	3	0.2	6	0.3	12	<0.1
	Cyprinella	*venusta*	Blacktail Shiner	30	0.2	355	18.0	0	0.0	385	2.2
	Cyprinus	*carp*	Common Carp	22	0.2	1	<0.1	0	0.0	23	0.1
	Hybognathus	*nuchalis*	Mississippi Silvery Minnow	0	0.0	0	0.0	23	1.0	23	0.1
	Notropis	*atherinoides*	Emerald Shiner	1,392	10.3	0	0.0	2	<0.1	1,394	7.8
	Notropis	*buccatus*	Silverjaw Minnow	0	0.0	2	0.1	0	0.0	2	<0.1
	Notropis	*longirostris*	Longnose Shiner	0	0.0	96	4.9	0	0.0	96	0.5
	Notropis	*texanus*	Weed Shiner	0	0.0	139	7.0	0	0.0	139	0.8
Catostomidae	*Carpiodes*	*cyprinus*	Quillback	15	0.1	496	25.1	63	2.6	574	3.2
	Carpiodes	*velifer*	Highfin Carpsucker	3	<0.1	246	12.4	13	0.5	262	1.5
	Cycleptus	*meridionalis*	Southeastern Blue Sucker	0	0.0	0	0.0	3	0.1	3	<0.1
	Hypentelium	*etowanum*	Alabama Hog Sucker	1	<0.1	0	0.0	0	0.0	1	<0.1
	Ictiobus	*bubalus*	Smallmouth Buffalo	306	2.3	0	0.0	97	4.1	403	2.3
	Minytrema	*melanops*	Spotted Sucker	1	<0.1	7	0.4	0	0.0	8	<0.1
	Moxostoma	*carinatum*	River Redhorse	0	0.0	4	0.2	1	<0.1	5	<0.1
	Moxostoma	*poecilurum*	Blacktail Redhorse	14	0.1	62	3.1	0	0.0	76	0.4
Ictaluridae	*Ameiurus*	*natalis*	Yellow Bullhead	0	0.0	1	<0.1	0	0.0	1	<0.1
	Ictalurus	*furcatus*	Blue Catfish	5	<0.1	0	0.0	4	0.2	9	<0.1
	Ictalurus	*punctatus*	Channel Catfish	17	0.1	20	1.0	30	1.3	67	0.4

Table 2. Continued.

FAMILY	GENUS	SPECIES	COMMON NAME	Alabama River 2009 N	Alabama River 2009 PC	Conecuh River 2010 N	Conecuh River 2010 PC	Tombigbee River 2012 N	Tombigbee River 2012 PC	Total N	Total PC
	Noturus	*leptacanthus*	Speckled Madtom	0	0.0	4	0.2	0	0.0	4	<0.1
	Pylodictis	*olivaris*	Flathead Catfish	0	0.0	1	<0.1	5	0.2	6	<0.1
Esocidae	*Esox*	*americanus*	Redfin Pickerel	0	0.0	1	<0.1	0	0.0	1	<0.1
	Esox	*niger*	Chain Pickerel	0	0.0	2	0.1	0	0.0	2	<0.1
Belonidae	*Strongylura*	*marinus*	Atlantic Needlefish	113	0.8	3	0.2	18	0.8	134	0.7
Moronidae	*Morone*	*chrysops*	White Bass	27	0.2	0	0.0	14	0.6	41	0.2
	Morone	*saxatilis*	Striped Bass	15	0.1	0	0.0	2	<0.1	17	<0.1
	Morone	*mississippiensis*	Yellow Bass	1	<0.1	0	0.0	0	0.0	1	<0.1
	Morone	*chrysops x saxatilis*	Palmetto Bass	50	0.4	1	<0.1	0	0.0	51	0.3
Centrarchidae	*Ambloplites*	*ariommus*	Shadow Bass	0	0.0	2	0.1	0	0.0	2	<0.1
	Lepomis	*gulosus*	Warmouth	1	<0.1	0	0.0	0	0.0	1	<0.1
	Lepomis	*macrochirus*	Bluegill	134	1.0	41	2.1	19	0.8	194	1.1
	Lepomis	*megalotis*	Longear Sunfish	11	0.1	38	1.9	0	0.0	49	0.3
	Lepomis	*microlophus*	Redear Sunfish	5	<0.1	43	2.2	0	0.0	48	0.3
	Micropterus	*henshalli*	Alabama Bass	162	1.2	0	0.0	18	0.8	180	1.0
	Micropterus sp. cf.	*punctulatus*	Choctaw Bass	0	0.0	23	1.2	0	0.0	23	0.1
	Micropterus	*salmoides*	Largemouth Bass	97	0.7	9	0.5	4	0.2	110	0.6
	Pomoxis	*annularis*	White Crappie	9	0.1	0	0.0	2	<0.1	11	<0.1
	Pomoxis	*nigromaculatus*	Black Crappie	16	0.1	7	0.4	0	0.0	23	0.1
Percidae	*Ammocrypta*	*bifascia*	Florida Sand Darter	0	0.0	14	0.7	0	0.0	14	<0.1
	Percina	*austroperca*	Southern Logperch	0	0.0	10	0.5	0	0.0	10	<0.1
	Percina	*nigrofasciata*	Blackbanded Darter	0	0.0	6	0.3	0	0.0	6	<0.1
Sciaenidae	*Aplodinotus*	*grunniens*	Freshwater Drum	80	0.6	0	0.0	39	1.6	119	0.7
Mugilidae	*Mugil*	*cephalus*	Striped Mullet	18	0.1	69	3.5	61	2.5	148	0.8
Achiridae	*Trinectes*	*maculatus*	Hogchoker	0	0.0	4	0.2	0	0.0	4	<0.1
TOTAL				13,501	100	1,976	100	2,393	100	17,870	100

Table 3. Number (N) and percent composition (PC) of fishes by species collected from the Choctawhatchee River in 2011 and 2018 during *Alosa alabamae* sampling.

				2011		2018		Total	
FAMILY	GENUS	SPECIES	COMMON NAME	N	PC	N	PC	N	PC
Acipenseridae	*Acipenser*	*oxyrinchus desotoi*	Gulf Sturgeon	32	1.0	6	0.2	38	0.6
Lepisosteidae	*Lepisosteus*	*oculatus*	Spotted Gar	99	3.2	89	2.7	188	3.0
	Lepisosteus	*osseus*	Longnose Gar	129	4.2	151	4.6	280	4.4
Amiidae	*Amia*	*calva*	Bowfin	7	0.2	23	0.7	30	0.5
Anguillidae	*Anguilla*	*rostrata*	American Eel	10	0.3	14	0.4	24	0.4
Clupeidae	***Alosa***	***alabamae***	**Alabama Shad**	**7**	0.2	**3**	**0.1**	**10**	**0.2**
	Dorosoma	*cepedianum*	Gizzard Shad	66	2.2	35	1.1	101	1.6
	Dorosoma	*petenense*	Threadfin Shad	294	9.6	259	7.8	553	8.7
Cyprinidae	*Ctenopharyngodon*	*idella*	Grass Carp	13	0.4	4	0.1	17	0.3
	Cyprinella	*venusta*	Blacktail Shiner	484	15.9	765	23.2	1,249	19.6
	Cyprinus	*carp*	Common Carp	35	1.1	35	1.1	70	1.1
	Hypbopsis	*winchelli*	Clear Chub	7	0.2	13	0.4	20	0.3
	Notemigonus	*crysoleucas*	Golden Shiner	0	0.0	11	0.3	11	0.2
	Notropis	*longirostris*	Longnose Shiner	1	0.0	9	0.3	10	0.2
	Notropis	*texanus*	Weed Shiner	4	0.1	891	27.0	895	14.1
Catostomidae	*Carpiodes*	*cyprinus*	Quillback	375	12.3	148	4.5	523	8.2
	Carpiodes	*velifer*	Highfin carpsucker	692	22.7	148	4.5	840	13.2
	Minytrema	*melanops*	Spotted Sucker	3	0.1	13	0.4	16	0.3
	Moxostoma	*poecilurum*	Blacktail Redhorse	161	5.3	72	2.2	233	3.7
Ictaluridae	*Ictalurus*	*furcatus*	Blue Catfish	10	0.3	16	0.5	26	0.4
	Ictalurus	*punctatus*	Channel Catfish	24	0.8	26	0.8	50	0.8
	Noturus	*leptacanthus*	Speckled Madtom	1	0.0	1	0.0	2	<0.1
	Pylodictis	*olivaris*	Flathead Catfish	5	0.2	4	0.1	9	0.1
Esocidae	*Esox*	*niger*	Chain Pickerel	1	0.0	3	0.1	4	0.1
Belonidae	*Strongylura*	*marinus*	Atlantic Needlefish	13	0.4	12	0.4	25	0.4
Atherinidae	*Labidesthes*	*sicculus*	Brook Silverside	5	0.2	2	0.1	7	0.1

Table 3. Continued.

				2011		2018		Total	
FAMILY	GENUS	SPECIES	COMMON NAME	N	PC	N	PC	N	PC
Fundulidae	*Fundulus*	*escambiae*	Russetfin Topminnow	0	0.0	1	0.0	1	<0.1
	Funjdulus	*olivaceus*	Blackspotted Topminnow	0	0.0	1	0.0	1	<0.1
Moronidae	*Morone*	*saxatilis*	Striped Bass	6	0.2	7	0.2	13	0.2
	Morone	*chrysops x saxatilis*	Palmetto Bass	3	0.1	1	0.0	4	0.1
Centrarchidae	*Ambloplites*	*ariommus*	Shadow Bass	2	0.1	1	0.0	3	<0.1
	Lepomis	*auritus*	Redbreast Sunfish	30	1.0	1	0.0	31	0.5
	Lepomis	*gulosus*	Warmouth	0	0.0	5	0.2	5	0.1
	Lepomis	*macrochirus*	Bluegill	30	1.0	77	2.3	107	1.7
	Lepomis	*megalotis*	Longear Sunfish	21	0.7	83	2.5	104	1.6
	Lepomis	*microlophus*	Redear Sunfish	177	5.8	80	2.4	257	4.0
	Lepomis	*punctatus*	Spotted Sunfish	0	0.0	1	0.0	1	<0.1
	Micropterus sp. cf.	*punctulatus*	Choctaw Bass	24	0.8	19	0.6	43	0.7
	Micropterus	*salmoides*	Largemouth Bass	29	0.9	38	1.2	67	1.1
	Pomoxis	*annularis*	White Crappie	1	0.0	0	0.0	1	<0.1
	Pomoxis	*nigromaculatus*	Black Crappie	0	0.0	5	0.2	5	0.1
Percidae	*Percina*	*austroperca*	Southern Logperch	5	0.2	1	0.0	6	0.1
Sciaenidae	*Aplodinotus*	*grunniens*	Freshwater Drum	5	0.2	0	0.0	5	0.1
Mugilidae	*Mugil*	*cephalus*	Striped Mullet	224	7.3	222	6.7	446	7.0
Achiridae	*Trinectes*	*maculatus*	Hogchoker	5	0.2	5	0.2	10	0.2
TOTAL				3,053	100	3,301	100	6,341	100

Table 4. Biological data for *Alosa alabamae* collected from the Choctawhatchee River, 2011 and 2018.

Date	Total length (mm)	Total weight (g)	Gonad weight (g)	Sex	Age	Gonadosomatic Index	Water temperature (ºC)
22 Mar 2011	326	342	12.9	M	2	3.8	23.1
8 Apr 2011	361	441	15.3	M	2	3.5	19.5
20 Apr 2011	374	510	25.2	M	3	4.9	24.7
20 Apr 2011	236	94	1.5	M	1	1.6	24.7
20 Apr 2011	392	560	58.4	F	3	10.4	24.7
21 Apr 2011	360	364	13.2	M	2	3.6	23.5
21 Apr 2011	273	162	6.8	M	1	4.2	23.5
12 Mar 2018	391	743	87.9	F	3	11.8	19.9
9 Apr 2018	400	701	81.0	F	4	11.6	22.8
10 Apr 2018	290	227	11.5	M	2	5.1	22.9

Table 5. Sampling effort (hour), number collected, and catch-per-unit-hour (CPUE; number of *Alosa alabamae* per hour of sampling effort) among sampling weeks from the Choctawhatchee River, 1999-2000 (Mettee and O'Neil 2003), 2011, and 2018.

1999-2000 (Mettee and O'Neil 2003)				2011 (current study)				2018 (current study)			
Sample Week	Sampling Effort (hour)	Number Collected	CPUE	Sample Week	Sampling Effort (hour)	Number Collected	CPUE	Sample Week	Sampling Effort (hour)	Number Collected	CPUE
1-7 Mar	3.23	6	1.86	28 Feb-6 Mar	No Sampling			26 Feb-4 Mar	No Sampling		
8-14 Mar	7.19	21	2.92	7-13 Mar	3.4	0	0.00	5-11 Mar	No Sampling		
15-21 Mar	4.47	11	2.46	14-20 Mar	3.4	1	0.29	12-18 Mar	6.7	1	0.15
22-28 Mar	11.18	22	1.97	21-27 Mar	6.4	3	0.47	19-25 Mar	No Sampling		
29 Mar-4 Apr	10.66	83	7.79	28 Mar-3 Apr	No Sampling			26 Mar-1 Apr	6.7	0	0.00
5-11 Apr	12.02	38	3.16	4-10 Apr	3.4	1	0.29	2-8 Apr	6.7	0	0.00
12-18 Apr	4.85	22	4.54	11-17 Apr	No Sampling			9-15 Apr	6.7	2	0.30
19-25 Apr	6.72	6	0.89	18-24 Apr	15.4	5	0.32	16-22 Apr	3.3	0	0.00
26 Apr-2 May	No Sampling			25 Apr-1 May	6.8	0	0.00	23-29 Apr	6.7	0	0.00
3-9 May	No Sampling			2-8 May	6.7	0	0.00	30 Apr-6 May	6.7	0	0.00
TOTAL	60.32	209	3.46	TOTAL	45.5	10	0.22	TOTAL	43.5	3	0.07

since they are not associated with shallow shoreline habitats like centrarchids. However, when *A. alabamae* spring-spawning migrations are blocked and fish become concentrated below these structures, they are susceptible to capture with electrofishing gear. Gill netting below these structures during this time of year can be difficult with varying water releases and the leaves and detritus in the river which tends to clog nets. However, in unregulated systems such as the Choctawhatchee River, fish are concentrated near spawning habitat such as limestone outcrops and rocky gravel shoals. Identifying this habitat is crucial and concentrating sampling effort at these locations is paramount to collecting fish. Therefore, we concentrated our sampling efforts in the Conecuh and Choctawhatchee rivers close to these habitats. As in regulated systems, gill netting during this time of year in these systems tends to be difficult with the leaves and detritus in the water column. Electrofishing provides the best option and opportunity for collecting spring spawning *A. alabamae* in these river systems than other gears.

Since 1992, only 26 *A. alabamae* specimens have been collected and/or observed from the Conecuh-Escambia River system and none since 2015. We were able to collect only one specimen in 2010. Mettee and O'Neil (2003) identified the *A. alabamae* population in the Conecuh-Escambia River system as self-sustaining, albeit with small numbers of fish. However, it appears mortality is higher than recruitment based on our results and other recent collection efforts (Mettee and O'Neil 2003) for *A. alabamae* in this system. Severe imperilment of this population is evident, and viability of a self-sustaining population is in doubt based on our collection efforts.

The Apalachicola River *A. alabamae* population has long been observed to have the highest abundance compared to all other river systems with the Choctawhatchee River to have the second largest population (Mettee and O'Neil 2003; Ely et al. 2008; Young et al. 2012). Population estimates from the Apalachicola River have ranged from 2,767 to 25,935 individuals between 2005 to 2007 (Ely et al. 2008) and from 98,469 to 122,578 individuals from 2010 to 2012 (Young et al. 2012), respectively. Although no population estimates have been conducted in the Choctawhatchee River, numbers of *A. alabamae* and relative abundance have declined in the Choctawhatchee River. That is, relative abundance (CPUE) has declined 50-fold, which translates to a decline in numbers by 98% in just over 20 years.

Ages of female *A. alabamae* (n=3) collected during this survey ranged from 3 to 4 years, with a mean gonadosomatic index (GSI) of 11.3. Females from the Apalachicola River and from the Choctawhatchee River collected by Ingram (2007) and Mettee and O'Neil (2003) had comparable GSIs to *A. alabamae* collected during our study, indicating these specimens collected were sexually mature. Unfortunately, we did not collect any females age 5 or 6, which are more fecund than the younger specimens (Mettee and O'Neil 2003; Grice et al. 2014; Ingram 2007). For males, ages ranged from 1 to 3 years, which is comparable to the Apalachicola River (Ingram 2007). However, ages ranged from 1 to 5 years for fish collected by Mettee and O'Neil (2003) in the Choctawhatchee River. No *A. alabamae* from the Apalachicola River have been aged 5 or older (T. Ingram, GADNR, unpublished data). Male GSIs were comparable to values reported by Mettee and O'Neil (2003) and that males can become sexually mature at age 1.

As with other riverine fluvial and anadromous species such as Gulf Sturgeon, *Acipenser oxyrinchus desotoi,* American Shad, *Alosa sapidissima*, and Alabama Sturgeon, *Scaphirhynchus* *suttkusi*, like *A. alabamae*, the construction of navigation locks and dams have contributed and exacerbated these population declines (Barkuloo et al. 1993; Rider and Hartfield 2007; Haro and Castro-Santos 2012; Sulak et al. 2016). In the Mobile River basin, which is the largest Gulf Coast drainage east of the Mississippi River, there are 22 hydroelectric dams and navigation locks and dams in the Alabama portion of the basin (Mettee et al. 2009). This fragmented habitat has led to at least 32 aquatic animals and plants listed under the Endangered Species Act in the Mobile River basin (USFWS 2021). Habitat fragmentation in the Mobile River basin also has been attributed to declines in the following fish species: Mooneye, *Hiodon tergisus*, Southeastern Blue Sucker, C*ycleptus meridionalis*, River Redhorse, *Moxostoma carinatum*, Frecklebelly Madtom, *Noturus munitus*, Crystal Darter *Crystallaria asprella*, and undescribed southern walleye, *Sander* sp. cf. *vitreus* (Boschung and Mayden 2004; Freeman et al. 2005; Rider 2012). However, the Choctawhatchee River is unimpounded along its 227-km length and although two small reservoirs (Point A, 243 ha; Gantt, 1,093 ha) exist in the upper reaches of the Conecuh River, it is a relatively unregulated river as 274 km of free-flowing river exists below Point A Reservoir. Thus, other factors than habitat fragmentation are involved in the decline of *A. alabamae* in these drainages. The additional life-history data from these two systems illustrates the current status of *A. alabamae* and provides a baseline for further monitoring and research efforts.

Overall, there is a range wide lack of life-history data for *A. alabamae.* For example, only data from the Apalachicola-Chattahoochee-Flint River basin were sufficient enough to perform a population viability analysis (PVA) for the recent *A. alabamae* assessment (Smith et al. 2011). Although we only collected 11 fish from the Conecuh and Choctawhatchee rivers combined, these additional data are important for these systems where a future PVA may be possible. These data are invaluable in assisting modelling efforts to estimate future population abundance and the potential risk of extinction (Coulson et al. 2001).

Inasmuch as there is a dearth of biological and ecological data on this species from the marine environment; future research should concentrate on the basic requirements for *A. alabamae* while in the marine environment and potential factors affecting their numbers. Further research in the freshwater habitats examining varying water flow conditions and water temperature fluctuations (i.e., climate change) should be examined to determine if a potential link exists to further explain the decline of *A. alabamae*. Our results indicate the current status *A. alabamae* in Alabama is one of declining and extirpated populations. Determining the abiotic and biotic factors affecting *A. alabamae* populations is paramount in understanding these declines and how to mitigate and improve life-history conditions for this species.

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