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BIOLOGY OF THE ALABAMA SHAD IN NORTHWEST FLORIDA

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BIOLOGY OF THE ALABAMA SHAD IN NORTHWEST FLORIDA

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Florida Department of Natural Resources Marine Research Laboratory*

ABSTRACT

Biology of Alabama shad, *Alosa alabamae*, in the Apalachicola River was studied from June 1968 to April 1971. Adults enter the river in February and spawn in April. Spawning occurs at 19-22°C in moderate currents over bottom of coarse sand and gravel. Fecundity ranges from 61,238 to 257,655. Gonads of shad entering the river were in ripe condition with stage IV oocytes averaging 1159 μ in diameter. The 1969 collection contained 38.3% repeat spawners while the 1970 collection contained 6.3%. Mean fecundity increased 25.8%, although repeat spawners decreased 32%. Adult males enter the river in larger numbers than females at water temperatures below 17°C. Adult shad do not feed during the spawning run. One, two, and three year old shad make the spawning run. Female mean length and weight were 394 mm (TL) and 737 g while male mean length and weight were 349 mm (TL) and 474 g. Length frequency analysis of juveniles indicate progeny of three spawning groups, their origins being the Chipola River, the Chattahoochee-Flint River, and the Jim Woodruff Dam. Most juvenile shad grew 30 mm per month. Juveniles emigrate from the river at 125 mm (FL) or in December. Sport fishing potential is good since catch frequency is estimated as one shad per rod every 29.72 minutes.

*Contribution No. 190

This study was conducted in cooperation with the U.S. Department of Commerce, NOAA, National Marine Fisheries Service, under PL 89-304 (Project No. AFS3-3).

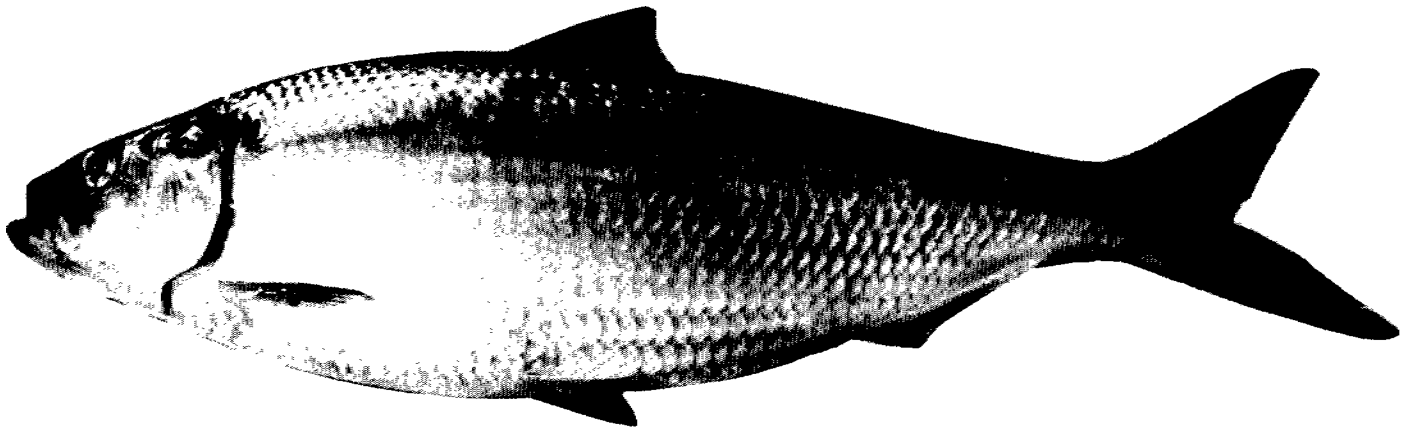

Figure 1. Alabama shad, *Alosa alabamae*.

INTRODUCTION

The Alabama shad, *Alosa alabamae* (Jordan and Evermann), (Figure 1), is a native clupeid of the Gulf of Mexico. The species was first noticed ascending river drainages of the Gulf around 1850 (Daniel, 1872) and was described as being distinct from American shad, *Alosa sapidissima* (Wilson), by Jordan and Evermann in 1896.

Alabama shad is reported in most major drainages of the Gulf Coast from the Suwannee River in Florida to the Washita River in Arkansas (Laurence and Yerger, 1967). In Florida, shad is the most abundant anadromous fish of the Gulf Coast.

Alabama shad is smaller than American shad and has never been an important food fish although its flavor compares to that of American shad. According to the former U.S. Fish Commission, 6,955 lb were landed in 1889 and 150 lb in 1902. No commercial landings have been reported since (Hildebrand, 1963). Adults ascend Gulf rivers from January through March and spawn between April and July; juveniles descend the river to salt water at the end of their first summer (Hildebrand, 1963; Laurence and Yerger, 1967).

Populations of Alabama shad in rivers of northwest Florida, especially the Apalachicola, have a good sport fishing potential during their spawning runs. Therefore, this study was initiated with the following objectives: to delimit and characterize the spawning grounds in the Apalachicola River system; to determine weight, length, age, and fecundity of adult shad in each major spawning area; to describe the present fishery and evaluate sport fishing potential; and to describe the ecology of juveniles.

METHODS AND MATERIALS

Description of Study Area (Figure 2)

The Apalachicola River is formed by the junction of the Chattahoochee and Flint Rivers. Completion of Jim Woodruff Dam at Chattahoochee, Florida, impounded the waters of these two great tributaries and created Lake Seminole; consequently, the Apalachicola River proper originates below this dam. It flows in a bed composed of late Pleistocene marine and estuarine deposits, as do most rivers of the Florida panhandle region.

From its headwaters south to the vicinity of Dawson's Landing, the Apalachicola River is in contact on the east with the sandy, chalky

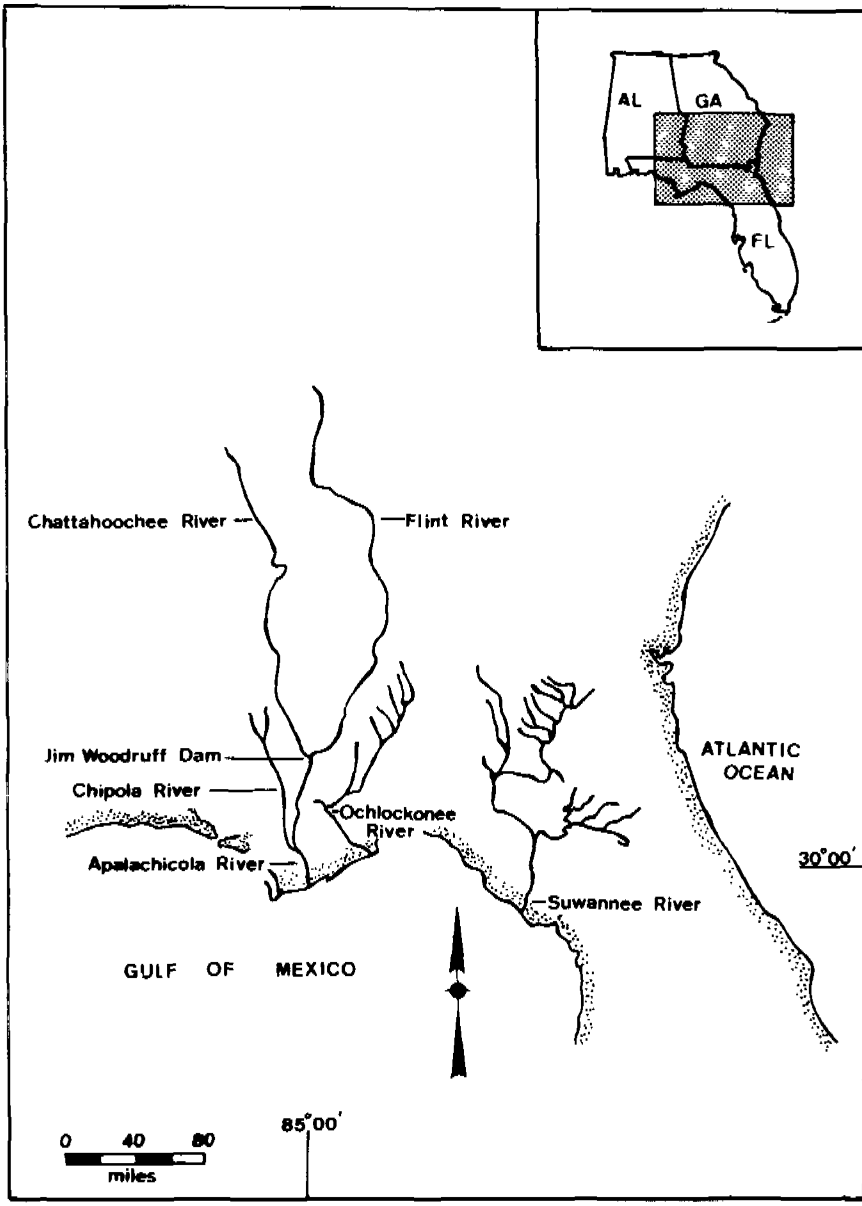

Figure 2. Map of study area.

Tampa limestone of early Miocene age. This limestone, along with the Flint River formation (chiefly sand, gravel, and mottled clay) and the Ocala limestone (chiefly calcium carbonate) underlie the basin of Lake Seminole. This reservoir exerts a major influence on the chemical and physical nature of the Apalachicola River (Cooke, 1945).

The reservoir covers approximately 37,500 acres and reaches a depth of over 50 feet immediately behind the dam. The lake receives drainage from approximately 17,100 square miles of primarily agricultural Georgia and Alabama land. This use of the sandy, clayey soil of the basin accounts for the turbidity of the Apalachicola River.

The river bed itself is primarily the remnants of Pleistocene deposits. Such formations as the Brandywine, Coharie, Sunderland, Wicomico, Fenholloway, Talbot, and Pamlico are chiefly sand to coarse gravel (Cooke, 1945), giving the river its characteristic bottom.

This sand and gravel bottom is constantly in motion and the intervening spaces are continually being filled by sedimentation of the finely divided clays carried in suspension by the river. As a result of the movement of the loose bottom, bars become established in the river and the U.S. Corps of Engineers must frequently dredge to maintain a nine foot channel from the Gulf of Mexico to the navigation lock at Jim Woodruff Dam. This dredging creates extensive spoil piles at the river edge and these sands and clays eventually become resuspended in the river water, adding to existing turbidity.

The U.S. Corps of Engineers further maintains the river by removing logs and other obstructions, while the Coast Guard maintains the buoys marking the channel from Apalachicola, Florida north.

Main commercial use of the river is transportation of oil and logs by barge. Other commercial users include Florida Gravel Co. at river mile 106 in Gadsden County; Gulf Power Corp. (steam power electric plant) between river mile 103 and 104 in Jackson County; Neal Lumber Co. and Farmers Mill and Elevator Inc. of Calhoun County at river mile 78.5; and Fish Meal Co. and Bloodworth Concrete Co. in Franklin County at river mile 5.

Station Description

Thirteen permanent stations were established along the Apalachicola River from Jim Woodruff Dam to Apalachicola, Florida, at approximately equal distances.

Station 1 is on the east bank in Gadsden County just below Jim Woodruff Dam across from buoy N-232 at river mile 107. The bank is lined with cypress, oak, weeping willow, and sweet gum trees. The bottom is gravel and coarse and fine sand without vegetation.

Station 2 is on the east bank in Gadsden County at river mile 102.5, across from the dikes, downstream from buoy N-216. The bank is lined with cypress, bamboo, saw-palmetto, hickory, short leaf pine, and sweet gum trees. The bottom is gravel and coarse and fine sand.

Station 3 is on the east bank at buoy C-181, river mile 94 in Liberty County. The bank is lined with short leaf pine, cypress, oak, sweet gum, and weeping willow trees. The bottom is coarse and fine sand and gravel.

Station 4 is on the east bank downstream from buoy 156 at river mile 64 in Liberty County. The bank is lined with growth of cypress, oak, weeping willow, short leaf pine, and sweet gum trees. Open pasture land is east of this thin line of trees. The bottom is coarse sand and gravel. In August 1970 the U.S. Corps of Engineers constructed dikes, causing discontinuance of this station.

Station 5 is on the east bank downstream from buoy N-134, river mile 75 at west Wynnton Bend. Old River enters at river mile 78 and exits at mile 74; the Blountstown gauge, McNeal's Lumber Co. and Farmers Mill and Elevator, Inc. are at river mile 78.5, Sutton's Lake at mile 79.5, all in Liberty County. The bank is lined with oak, sweet gum, and sycamore trees. The bottom is coarse and fine sand.

Station 6 is on the east bank just below buoy N-98 at river mile 63.7. Poloway Cutoff is at river mile 72.2, Bakers Branch at river mile 71.5, and Outside Lake at mile 65, all in Liberty County. The bank is lined with sweet gum and weeping willow trees. The bottom is coarse and fine sand.

Station 7 is on the east bank 1.5 miles below buoy N-92 at river mile 54.4. Hagerman's Ditch leading out of Lamonia Lake and Honey Pond enters above the station at river mile 56.8 in Liberty County. The bank is lined with sweet gum and weeping willow trees. The bottom is fine sand and silt.

Station 8 is on the east bank at buoy 84, river mile 44.5, just upstream from the mouth of the Florida River in Liberty County. Above the station at river mile 53 is Equiloxic Creek. At mile 50.7 is the entrance to Brown Lake in Calhoun County. The bank is lined with weeping willows. The bottom is fine sand and silt.

Station 9 is on the east bank just below buoy 61 at river mile 37.5 in Liberty County. The Chipola Cutoff is at mile 42.5 in Gulf County. The bank is lined with weeping willows. The bottom is coarse and fine sand.

Station 10 is on the east bank just below buoy N-56A and the dikes in Franklin County. Across the river is the mouth of the Brickyard Cutoff at mile 20.6 in Gulf County. The River Styx at mile 36, Double Points at mile 32-33, Brushy Creek at mile 24, Scott Creek at mile 23.3, all in Liberty County, and Owl Creek at mile 22.3 in Franklin County enter the river near this station. Brickyard Creek enters at mile 20.5 just below the station. The bank is lined with weeping willows backed by cypress on the Brickyard Creek side. The bottom is fine sand and silt.

Station 11 is on the west bank at buoy 49, river mile 14.7, across from Bloody Bluff Landing in Franklin County. Fort Gadsden Creek at mile 19.5 and Smith Creek at mile 17.7 enter the river above this station. The bank is lined by weeping willows and cypress trees. The bottom is coarse and fine sand. In May 1970 the U.S. Corps of Engineers constructed dikes, causing discontinuance of this station.

Station 12 is on the east bank in Franklin County at river mile 7.8, buoy N-32. East River at mile 14, Brothers River at mile 12, the St. Marks River at mile 10.2, and Hoffman Creek at mile 8 enter the river above this station. The bank is lined with cypress, oak, cabbage palmetto, sweet bay, magnolia, and saw-palmetto trees. The bottom is silt and coarse and fine sand.

Station 13 is on the west bank at buoy C-19, river mile 4.1, in Franklin County. Saul's Creek Cutoff at mile 6, Grassy Creek at mile 4.5, Jackson River at mile 5.8, and Acorn Lake Creek at mile 4.4 enter above this station. The bank is lined with cabbage palmetto, sweet bay, and cypress trees. The bottom is silt and coarse and fine sand.

The Chipola River originates in Houston County, Alabama, and drains 1206 square miles into its 84.3 mile length. It drops from 85 feet above sea level to 5 feet at its merger with the Apalachicola River for an average gradient of 0.9 feet per mile. The Chipola parallels the Apalachicola River and consequently shares much the same geological characteristics. The most notable difference occurs in the area of Wewahitchka, Florida, with the formation of the Dead Lakes by a retention dam. This lake, with its comparatively still water, allows the settling of suspended materials and the water becomes clear until it mixes with the Apalachicola River water introduced at the Chipola Cutoff.

Station 1 on the Chipola River is just below the Dead Lakes Dam, Wewahitchka, Florida. The bank is lined with cypress and oak trees. The bottom is coarse and fine sand.

Station 2 is above the Dead Lakes at Highway 71 on the Chipola River. The bank is lined with oak, cypress, and pine trees. The bottom is coarse and fine sand.

Sampling Schedule

Systematic sampling was established on a monthly basis at each permanent station for 30 months in the Apalachicola River. At each station fish and water samples were taken. Other sampling was done biweekly but varied with the purpose of the sample.

Investigation of Physical and Chemical Characteristics

Water temperature was measured on bottom samples with a precision grade Centigrade thermometer calibrated in 0.1°C. Water transparency was measured while drifting with a 20 cm Secchi disk lowered on a chain marked off in feet.

Current was measured using a T. S. Flow Meter which measures revolutions per second (R) and is converted to meters by the formula:

Velocity = (0.159 R)-0.016

Range: 0.26 to 2.64 m/sec.

Water chemistry was determined in the field with a Hach Wildlife Kit, Model CA-24-WR which tests for dissolved oxygen, carbon dioxide, hydrogen ion concentration (pH), and hardness. Water samples were obtained using a Van Dorn water sampler.

Collection and Treatment of Specimens

Adult Alabama shad were collected weekly when present in the Apalachicola River. A 6.5 ft Heddon rod, Zebco 800 reel, and 1/10 oz baby Glow-Jig were the primary sampling equipment. A dip net was used at Jim Woodruff Dam when collections could not be made with rod and reel. Three gill nets (250 ft x 11 ft, made of 139 monofilament nylon) — 1½ in., 2½ in., and 3¼ in. stretched mesh were used in Apalachicola Bay.

In the field, adult Alabama shad were weighed by spring scale to the nearest ounce and measured to standard, fork, and total length (SL, FL, TL). Twenty scales were removed and placed in scale envelopes marked with date, location of collection, length, weight, sex and development, collector, location from which scale was obtained, and collection number. Gonads were removed from females and preserved in 10% formalin solution for fecundity estimates. Stomachs were examined and contents preserved in 10% formalin.

A 24 ft x 4 ft x ½ in. mesh seine with a center panel of ¼ in. mesh material was used to collect early juveniles. A 50 ft x 8 ft x ¾ in. mesh seine with a 4 ft x 4 ft bag of ½ in. mesh was used for larger juveniles. A 15 ft nylon shrimp trawl, ¾ in. mesh, was used to collect juveniles in

Apalachicola Bay. Juveniles were measured (SL, FL, TL) and preserved in 10% formalin.

Other fishes were identified, measured (SL, TL) and released. Representatives of each species were permanently preserved and added to the fish reference collection, Florida Department of Natural Resources Marine Research Laboratory, St. Petersburg, Florida.

Eggs and larvae of Alabama shad were collected by towing and bottom sets with a 0.5 m plankton net made of 20 meshes/in. nylon netting. Specimens were preserved in 3-5% formalin.

Laboratory Procedures

Fecundity estimates were obtained by removing gonads from the 10% formalin and drying with paper towels. They were then weighed on a platform balance to the nearest 0.1 g. A small aliquot was removed with a scalpel and weighed to the nearest 0.001 g on a Mettler balance. The ova in each sample were then counted, using a binocular dissecting scope, and fecundity was calculated by

$$Eg = \frac{Es}{Ws} \times Wg$$

where: Eg is the number of ova in the gonad, Es is the number of ova in the aliquot, Ws is the weight of the aliquot, Wg is the weight of the gonad.

Gonads of 24 specimens were selected for microscopic examination. Gonads were sectioned at 6 μ and stained with Harris' hematoxylin and eosin. For each gonad, measurements were made with an ocular micrometer on stage IV oocytes sectioned through the center of the cell. Stages of oogenesis follow the descriptions in Moe (1969).

Scales were used for age determination following methods of Cating (1953), who correlated number of transverse grooves with number of annuli in American shad, Judy (1961), who validated Cating's method, and Laurence and Yerger (1967), who previously applied Cating's methods to Alabama shad.

RESULTS AND DISCUSSION

Hydrology

Table 1 presents a summary of hydrological data by station for the 30-month study. Bottom water temperature ranged from 11°C in December 1970 to 31°C in August 1970 and averaged 21.36°C. Dissolved oxygen ranged from 5-12 ppm, according to season, and averaged 7.9 ppm; pH ranged from 6.8-9.0 and averaged 7.28; hardness ranged

TABLE 1. SUMMARY OF HYDROLOGICAL DATA APALACHICOLA RIVER 1969-1970

Station	Temperature °C			Oxygen ppm			pH			Carbon Dioxide ppm			Hardness gr/gal			Turbidity in.		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1	11.6	31.0	21.0	6	12	6.3	7.0	9.0	7.6	5	10	6.2	2	5	3.1	18	36	22.9
2	11.6	29.5	20.9	6	12	7.9	6.8	8.0	7.3	5	10	7.0	2	4	2.9	12	36	22.7
3	11.6	29.3	20.9	6	10	7.8	6.8	8.5	7.3	5	15	7.4	2	4	3.0	18	36	22.3
4	11.6	29.4	21.0	6	11	7.9	6.8	8.5	7.3	5	10	7.0	2	4	2.9	12	30	21.9
5	11.6	29.6	21.3	6	11	7.9	7.0	8.5	7.3	5	10	6.8	2	4	3.0	12	24	20.5
6	11.5	29.4	21.3	6	10	7.8	7.0	8.0	7.3	5	10	7.2	2	4	2.9	12	24	19.2
7	11.5	29.4	21.3	6	10	8.0	6.8	7.8	7.2	5	10	7.2	2	4	3.0	12	30	19.4
8	11.4	29.4	21.5	6	10	8.0	6.8	8.0	7.3	5	10	7.0	2	4	3.1	12	24	17.8
9	11.4	29.4	21.5	6	10	8.0	6.8	8.0	7.3	5	10	7.0	2	4	3.0	12	24	17.3
10	11.4	28.7	21.6	5	10	7.9	6.8	8.5	7.2	5	15	7.0	2	4	3.1	12	24	17.3
11	11.0	29.1	21.7	6	10	8.0	6.8	7.5	7.1	5	15	6.8	2	4	3.0	12	30	17.0
12	11.0	29.0	21.7	6	10	8.1	6.8	7.5	7.2	5	10	6.8	2	4	2.9	12	30	17.8
13	11.0	29.0	21.8	6	10	8.1	6.8	7.5	7.2	5	10	6.8	2	8	3.9	12	30	18.1
Total			21.3			8.0			7.28			6.9			3.1			19.6

TABLE 2. COLLECTION DATES AND TEMPERATURES FOR MIGRATING ALABAMA SHAD BY SEX AND MEAN AGE, APALACHICOLA RIVER 1969-1970

Date	Males	Mean Age	Females	Mean Age	Temperature °C
2- 7-69	0	-	1	3.00	15.6
2- 8-69	5	2.00	2	2.50	15.6
2- 9-69	8	2.25	1	3.00	15.6
2-16-69	14	2.35	5	2.80	14.6
2-24-69	23	2.00	9	2.20	12.6
3- 2-69	20	2.00	15	2.20	14.2
3- 8-69	7	2.00	5	2.20	14.2
3-11-69	3	2.00	3	2.30	12.1
3 12-69	3	2.30	7	2.43	12.1
3-31-69	9	2.00	7	2.00	17.5
4- 5-69	5	2.00	10	2.10	19.2
4- 9-69	7	1.85	10	2.00	21.1
4-19-69	5	1.40	4	2.20	20.7
2-10-70	2	2.00	0	-	14.0
2-15-70	0		1	3.00	14.6
2-16-70	12	2.00	3	3.00	14.6
2-20-70	5	2.00	1	3.00	12.5
3- 2-70	0		1	2.00	16.0
3- 3-70	10	2.00	10	2.50	17.1
3- 6-70	0		2	3.00	17.4
4-10-70	13	1.07	3	2.00	22.1

from 2-28 gr/gal and averaged 3.1 gr/gal; carbon dioxide ranged from 5-15 ppm and averaged 6.9 ppm; turbidity ranged from 12-36 inches and averaged 19.6 in.

Life History

Adult Alabama shad enter the Apalachicola River to spawn as early as January and as late as March. Survey records of the Florida Game and Fresh Water Fish Commission reported earliest collections on 26 January 1960 and latest on 8 March 1961. In 1969 and 1970, no shad were collected until February. Table 2 gives collection dates and temperatures.

At lower temperatures, male shad entered the Apalachicola River in larger numbers than females. In 1969, 62%, in 1970, 76% of the collections were males at temperatures below 17°C. This phenomenon was implied by Laurence and Yerger (1967) who reported 75% of collections were males before March 1966, and by survey records of the Florida

Game and Fresh Water Fish Commission which reported 85% of collections were males prior to 24 February 1954 and 74% were males prior to 16 February 1961. At temperatures above 17°C, females outnumber males in the collections.

Alabama shad do not feed during the spawning run. Stomach analyses of 248 adults revealed only two, representing 0.8% of the collection, with stomach contents, both shad having ingested juvenile centrarchids.

Atkinson (1951) found that American shad would feed when held in ponds. He concluded that fresh water plankton was too small to be retained by the gill rakers of spawning shad.

Because of the difficulty in locating the first three annuli on the scales of American shad, Cating (1953) established the relationship between transverse groove counts and the location of these annuli. Laurence and Yerger (1967) noted that the relationship between annuli and transverse grooves was constant for Alabama shad: six to nine grooves to the first annulus, nine to twelve to the second annulus, twelve to fifteen to the third annulus, and fifteen or more to the fourth.

Using these criteria for 248 Alabama shad collected, all were less than four years old if the leading edge was counted as an annulus. The predominant age class was two year olds representing 79.8%. The remaining age classes were one and three year olds representing 5.2% and 14.9%.

Nikolskii (1962) noted that the middle-aged individuals of the spawning population possess the greatest reserve of yolk in the egg and fat in the yolk. Thus, the most viable offspring, best provided with food for the period of yolk feeding, are left by the middle-aged parents. The middle-aged Alabama shad is two years old and its dominance of the spawning population is interpreted as an adaptation to increase population density.

Analysis of length-weight relationships reveal that females are larger in every age class. Males averaged 474 g and 312 mm (FL) while females averaged 737 g and 347 mm (FL). Table 3 lists mean and range of lengths and weights by age and sex for the 1969 and 1970 collection.

Location of Spawning Grounds

Examination of gonads indicated Alabama shad spawned in April 1969 and 1970 at water temperatures of 19-22°C, but attempts to collect eggs and larvae during daylight sampling were unsuccessful.

In April 1971 eight shad eggs and 431 clupeid larvae were collected in the main river channel from Jim Woodruff Dam to river mile 102 at water temperatures of 19-23°C. Collections were made over bottom of coarse sand and gravel with a current of 0.5-1.0 m/sec. Areas sampled

TABLE 3. WEIGHT AND LENGTH OF ALABAMA SHAD BY AGE AND SEX APALACHICOLA RIVER, 1969—1970

		MALES		FEMALES		
Age	No.	Weight (oz)	Fork Length (mm)	No.	Weight (oz)	Fork Length (mm)
1969						
1	1	8	255	0		
2	65	Mean.16 Range:10-25	316 272-360	42	23.1 15-34	340 309-382
3	2	Mean:19.5 Range:19-20	334 323-350	7	30.8 18-44	356 328-400
1970						
1	12	Mean: 6.25 Range: 2-8	219 175-250	0		
2	30	Mean: 21.9 Range: 16-28	326 305-352	9	24.6 12-32	340 275-363
3	0			12	35.9 31-45	370 328-393

for eggs below river mile 102 were negative. All small larvae were collected at night and only in areas of appreciable currents.

Spawning habitat of Alabama shad is essentially the same as Godwin and Adams' (1969) description for American shad in the Altamaha River, Georgia.

Walburg (1956, 1960), Sykes (1956), and Leggett (1969) revealed that American shad suffered mass mortalities after spawning below latitudes of 35°. According to Leggett (1969), Walburg (1957), LaPoint (1957), and Sykes (1957) spawning marks on scales of American shad collected north of 35° latitude indicated 3-50% repeat spawners from the Neuse to St. John (New Brunswick) Rivers. Laurence and Yerger (1967) indicated 35% repeat spawning of Alabama shad in the Apalachicola River during 1966.

In 1969, 71 of 185 (38.3%) Alabama shad were repeat spawners and two specimens had spawned twice previously. Repeat spawners appeared earlier in the river, representing 55% of the collection before 8 March 1969 at a water temperature of 14.2°C. In 1970, 6.3% of the col-

TABLE 4. PREVIOUSLY SPAWNED ALABAMA SHAD BY AGE AND SEX, APALACHICOLA RIVER, 1969-1970

Age	Sex	1969 Total No.	1969 Previous Spawn No.	1969 %	1970 Total No.	1970 Previous Spawn No.	1970 %	Combined Total No.	Combined Previous Spawn No.	Combined %
1	M	4	0	—	12	0	—	16	0	—
	F	0	—	—	0	—	—	0	—	—
2	M	96	34	35.4	30	3	10	126	37	29.3
	F	63	19	30.1	9	0	—	72	19	26.3
3	M	8	6	75.0	0	—	—	8	6	75.0
	F	17	9	52.0	12	0	—	29	9	31.0

lection had spawning marks on their scales and one specimen had spawned twice. Table 4 lists number and percentage of repeat spawners by age and sex.

Fecundity

Fecundity estimates for 33 Alabama shad collected in 1969 and 1970 are presented in Table 5. Fecundity estimates for the 1969 collection averaged 130, 199 with a range of 61,238 to 257,655. Composition of the collection consisted of virgin spawners, average 135,730, one previous spawner, average 122,892, and two specimens that had spawned twice previously, estimated at 123,049 and 155,121.

had spawned twice previously, estimated at 123,049 and 155,121.

Fecundity estimates for the 1970 collection averaged 175,844 with a range of 138,864 to 221,707. The collection contained one specimen that had spawned twice previously, estimated at 138,864.

Leggett (1969), in comparing populations of American shad from four Atlantic coast rivers, noted considerable annual variation of intra-population fecundity. This variation was attributed to fluctuations in the percent of repeat spawners but remained constant around a long term mean.

Mean population fecundity in Alabama shad increased with a decrease in proportion of repeat spawners. A decrease in repeat spawners of 32% from the 1969 spawning run to the 1970 spawning run produced a mean fecundity increase of 25.8%.

Nikolskii (1962) noted that fish of older and middle ages are first to come to spawn in most species and that the last portions of milt contain less spermatozoa and thus possess smaller fertilizing capacity.

TABLE 5. FECUNDITY ESTIMATES FOR ALABAMA SHAD BY AGE, LENGTH, AND WEIGHT APALACHICOLA RIVER 1969-1970
(Numbers in parentheses indicate previous spawnings)

Date	Age	Total Length (mm)	Weight (oz)	Fecundity
2- 7-69	3	434	39	222,740
2- 8-69	2	400	34	257,655
2- 8-69	3	404	26	112,644 (1)
2- 9-69	3	366	23	104,617 (1)
2-16-69	3	389	26	127,224 (1)
2-16-69	3	385	25	123,049 (2)
2-16-69	3	386	24	98,531 (1)
2-16-69	2	377	21	61,238
2-16-69	3	394	19	105,002 (1)
2-24-69	2	392	25	109,696 (1)
2-24-69	2	397	28	141,627 (1)
2-24-69	2	380	22	110,088 (1)
2-24-69	3	446	41	189,763 (1)
2-24-69	3	387	27	129,726 (1)
2-24-69	2	398	26	132,115
2-24-69	2	387	22	111,532
2-24-69	2	399	27	102,727
2-24-69	2	400	25	104,819
3- 2-69	2	391	26	125,397
3- 2-69	2	391	23	117,051
3- 2-69	2	383	22	122,028
3- 2-69	3	434	33	155,121 (2)
2-15-70	3	430	38	138,864 (2)
2-16-70	3	449	45	221,707
2-16-70	3	412	31	154,339
2-16-70	3	423	33	164,323
2-20-70	3	438	41	200,530
3 - 2-70	2	380	25	156,532
3- 3-70	3	446	45	203,773
3- 3-70	2	391	28	167,267
3- 3-70	2	399	32	174,486
3- 3-70	3	403	32	173,342
3- 3-70	3	420	35	142,144

Table 2 shows a marked decrease in mean age of males in the late collections. This is due to a large number of yearling males entering the spawning population and is interpreted as an adaptive measure which could maintain high quality and quantity of spermatozoa for late spawning females.

There is considerable variation in fecundity for Alabama shad of

TABLE 6. MEAN STAGE IV OOCYTE DIAMETERS (μ) AND CONFIDENCE LEVELS FOR ALABAMA SHAD BY AGE, SPAWNING HISTORY, AND MONTH OF COLLECTION, 1969 AND 1970
(10% of oocytes counted in each gonad were measured)

Classification	No. Fish	No. Oocytes Counted	$\bar{X}$ μ	Confidence Level
Age II	13	138	1151.63	±198.06
Age III	11	120	1167.50	±215.11
Ages combined	24	258	1159.01	±145.43
Virgin spawners				
Age II	10	100	1141.75	±231.24
Age III	6	60	1138.33	±298.02
Ages combined	16	160	1140.46	±182.12
Previous spawners				
Age I	5	58	1190.51	±316.50
Age II	3	40	1185.62	±381.32
Ages combined	8	98	1188.52	±242.28
Collection month				
February	11	110	1186.59	±228.32
March	8	98	1135.45	±232.36
April	5	50	1144.50	±328.32

given size or weight. Such variation is common among fish, having been reported for American shad by Leggett (1969) and for herring by Bridger (1961).

Fecundity of Alabama shad approximates that of American shad in the latter's northern range but is considerably less than that of southern populations. Leggett (1969) indicated a mean fecundity of 155,000 for American shad in the St. John River (New Brunswick). Walburg (1960) reported fecundity of American shad in the St. Johns River (Florida) ranged from 277,000 to 659,000.

Microscopic examination of gonads revealed that most oocytes were stage IV with an occasional stage III. Little variation in development was apparent between ages, between virgins and previous spawners, or between months of collection.

Table 6 lists mean stage IV oocyte diameters and confidence levels by age, spawning history, and month of collection. Stage IV oocyte diameters of the combined data averaged 1159.01 μ ±145.43.

No significant differences in mean stage IV oocyte diameters were

TABLE 7. SIZE RANGE OF JUVENILE ALABAMA SHAD BY DATE AND RIVER MILE, 1969

Date	No.	Range FL (mm)	Mean FL (mm)	River Mile	Temperature °C
5-28-69	18	29-49	37.9	107	26.5
7-31-69	3	89-142	107.3	48	27.4
8- 6-69	14	69-142	105.1	48-7.8	28.1
9-11-69	11	44-109	84.4	42.5-7.8	27.5
10- 8-69	5	78-95	87.4	37.5-7.8	25.6
11- 5-69	1	74	74.0	20.6	18.4
12- 8-69	4	66-90	79.0	7.8	13.3

found between virgin spawners vs. previous spawners ($t = 1.597$, d.f. $= 256$) or between first vs. second previous spawners ($t = 0.151$, d.f. $= 96$).

Juvenile Migration and Growth

During the 30 month survey period, 1,125 juvenile Alabama shad (25-142 mm FL) were collected in the Apalachicola River in June through December.

One 128 mm FL Alabama shad was collected on 20 March 1969. Although the specimen was within the typical size range of juveniles, it had mature gonads and thus was considered part of the spawning population. Aside from this atypical occurrence, no juveniles were collected from January through May.

Migration and growth of juveniles were monitored by systematic sampling and concentrated sampling in all types of habitat. Juveniles were never collected in areas of still or back waters. Table 7 lists collection dates, range, and water temperatures for 1969.

Length frequency progressions of juveniles in the Apalachicola River for 1970 (Figure 3) indicate that progeny of three separate spawning populations may be encountered between July and November. The first, spawned between river mile 102-107, appeared in July when a prominent mode (No. 1) occurred at 75 mm. During August this mode reached 105 mm but had become much less prominent, indicating that some emigration from the river had occurred.

The second group, represented by a prominent mode (No. 2) of 65 mm in August, and 95 mm in September, were probably spawned in the Chipola River. The previously described retention dam is low enough to permit passage of adult shad during periods of high water. On 18 February 1970 a mature male shad was collected above the retention dam.

Spawning probably occurs north of Marianna, Florida in late April or May. Lower water temperatures, caused by numerous springs feeding into the Chipola River, allow spawning to occur after the Jim Woodruff group. Absence of a mode (No. 2) in October indicates emigration from the river.

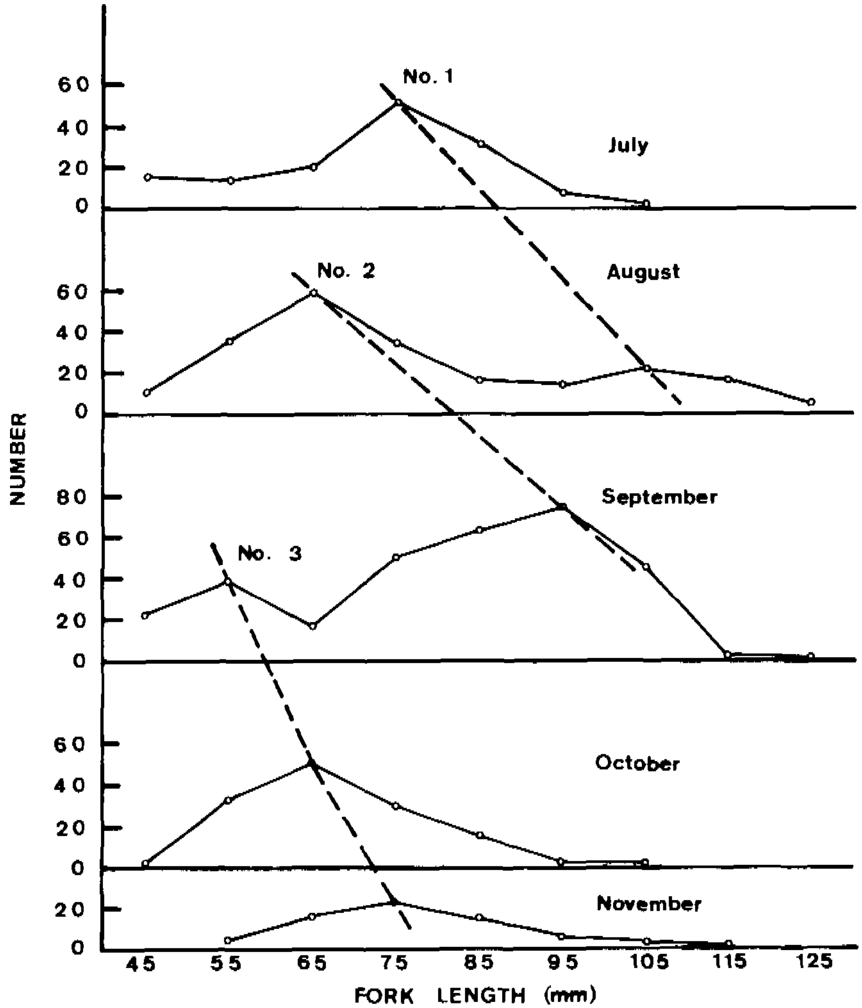

Figure 3. Length frequency progressions of juvenile Alabama shad, Apalachicola River, 1970.

Laurence and Yerger (1967) reported collections of juveniles which, based on size, were separate populations from Jim Woodruff Dam groups and postulated their origin as the Chipola River. Survey records of the Florida Game and Fresh Water Fish Commission reported collections of juvenile shad in the Chipola River in 1957.

The third group of juveniles is represented in September by a less prominent mode at 55 mm (No. 3) which becomes the only remaining mode in October and November at 65 and 75 mm. This group probably spawns above Jim Woodruff Dam. Navigation locks in this dam and the Columbus and Walter F. George Dams north of Jim Woodruff could allow passage of substantial numbers of spawning shad. In April 1970, surface temperatures taken by the U.S. Corps of Engineers at the Walter F. George reservoir 75 miles north of Jim Woodruff averaged 72° F (21° C), while surface temperatures of Lake Seminole averaged 75.6° F (24.5° C). This variation in water temperatures would be greater north of the Walter F. George reservoir, and spawning could be delayed until May. Survey records of the Florida Game and Fresh Water Fish Commission report collection of 25 shad in Lake Seminole during April and May 1957.

Modal increases in Figure 3 were 30 mm from July to August for Jim Woodruff juveniles, 30 mm from August to September for Chipola River juveniles, and 10 mm from September to October and October to November for northern juveniles. The decrease in growth rates from 30 mm to 10 mm per month of northern juveniles may be due to late spawning, lower water temperatures, or decreased food supply.

In 1970 juvenile shad over 125 mm (FL) were not collected in the river, and emigration into salt water by larger juveniles independent of temperatures was indicated. Godwin and Adams (1969) noted similar emigrations into salt water for American shad in the Altamaha River, Georgia.

Attempts to collect juveniles in Apalachicola Bay with a 15 ft try-net or from commercial shrimp boats were negative. Size of the bay and the complexities of the Apalachicola Delta are limiting factors decreasing probability of collection.

Sport Fishing Potential

An estimate of sport fishing potential was obtained by collecting adult Alabama shad with rod and reel. A unit of work was two rods fished for one minute. A total of 133 Alabama shad were collected in 1920 min for an average of 14.66 work units per fish. The most productive day was on 2 March 1969, when 34 shad were collected in four hours, or one for every 7.06 work units.

Two similar techniques were found best for collecting Alabama shad with rod and reel. At the Dead Lakes Dam, Wewahitchka, Florida, the bait was drifted in the tailrace, one to two feet below the surface. At Jim Woodruff Dam, Chattahoochee, Florida, the bait was cast straight out into the tailrace and allowed to drift downstream until the arc was complete.

During the study, sport fishing for Alabama shad was limited to two forms: 1) entertainment while fishing for other game fish, and 2) obtaining live bait for striped bass, *Morone saxatilis*. No one interviewed or observed fishing for Alabama shad saved either the fish or the roe.

A commercial fishery for Alabama shad does not exist in Florida, even though the population appears large enough to support one.

Table 8 lists representative fishes collected during the 30-month survey.

TABLE 8. FISHES COLLECTED IN THE APALACHICOLA RIVER 1968-1969-1970

Lepisosteidae — Gars

Lepisosteus osseus (Linnaeus): Longnose gar
Lepisosteus oculatus (Winchell): Spotted gar

Amiidae — Bowfin

Amia calva Linnaeus: Bowfin

Clupeidae — Herrings

Alosa alabamae Jordan and Evermann. Alabama shad
Alosa chrysochloris (Rafinesque). Skipjack herring
Dorosoma cepedianum (Lesueur): Gizzard shad
Dorosoma petenense (Günther): Threadfin shad

Esocidae — Pikes

Esox niger Lesueur: Chain pickerel

Catostomidae — Suckers

Carpiodes cyprinus (Lesueur): Quillback
Minytrema melanops (Rafinesque): Spotted sucker

Cyprinidae — Minnows

Cyprinus carpio Linnaeus: Carp
Notemigonus crysoleucas (Mitchill): Golden shiner
Notropis venustus (Girard): Blacktail shiner

Table 8 (Continued)

Ictaluridae — Freshwater Catfishes

Ictalurus catus (Linnaeus): White catfish
Ictalurus natalis (Lesueur): Yellow bullhead
Ictalurus punctatus (Rafinesque): Channel catfish

Anguillidae — Eels

Anguilla rostrata (Lesueur): American eel

Belonidae — Needlefishes

Strongylura marina (Walbaum): Atlantic needlefish

Mugilidae — Mullets

Mugil cephalus Linnaeus: Striped mullet

Atherinidae — Silversides

Labidesthes sicculus (Cope): Brook silverside

Percichthyidae — Temperate basses

Morone chrysops (Rafinesque): White bass

Centrarchidae — Sunfishes

Lepomis auritus (Linnaeus): Redbreast sunfish
Lepomis macrochirus Rafinesque: Bluegill
Lepomis microlophus (Günther): Redear sunfish
Micropterus coosae (Hubbs and Bailey): Redeye bass
Micropterus salmoides (Lacépède): Largemouth bass
Pomoxis nigromaculatus (Lesueur): Black crappie

Bothidae — Lefteye Flounders

Paralichthys albigutta Jordan and Gilbert: Gulf flounder

Soleidae — Soles

Trinectes maculatus (Bloch and Schneider): Hogchoker

SUMMARY

1. Biology of the Alabama shad was explored between April 1968 and April 1971. A total of 1,376 adult and juvenile shad were collected.

2. Adult shad entered the Apalachicola River in February and males outnumbered females at temperatures below 17° C.

3. Shad do not feed during the spawning run; only 0.8% have stomach contents.

4. The spawning population is composed mainly of two and three year old fish, although some of the two year olds have previous spawning marks on their scales.

5. Females are larger than males in every age class.

6. Repeat spawners represented 38.3% of the population in 1969 and 6.3% in 1970. Three specimens had spawned twice.

7. Below Jim Woodruff Dam, spawning occurs at water temperatures of 19-22°C over bottom of coarse sand and gravel with a current of 0.5-1.0 m/sec.

8. Fecundity estimates ranged from 61,238 to 257,655. Fecundity increased with a decrease in repeat spawners. There is little variation in stage IV oocyte diameters between virgins and previous spawners, between age 2 and age 3 fish, or among specimens collected in February, March, or April. Diameters averaged 1159.0 μ. Shad enter the river with ripe gonads dominated by stage IV oocytes. Fecundity varied considerably among specimens of a given size.

9. Length frequency analysis of juveniles indicated three spawning populations in the Apalachicola River and it was hypothesized that their origins were: 1) below Jim Woodruff Dam, 2) the Chipola River, 3) the Chattahoochee-Flint rivers.

10. Juvenile shad migrate down river and enter salt water at 120 mm FL or at smaller sizes in cold weather. Modal growth of most juveniles was 30 mm per month.

11. Sport fishing potential of Alabama shad was excellent with an average of one fish caught every 14.66 minutes when two reels were used.

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