

# FLORIDA MARINE RESEARCH PUBLICATIONS

**Life History of Gulf of Mexico Sturgeon, *Acipenser oxyrinchus desotoi*,  
in Suwannee River, Florida.**

JAMES A. HUFF

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**Florida Department of Natural Resources  
Marine Research Laboratory**

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#### ERRATA

#### FLORIDA MARINE RESEARCH PUBLICATIONS Number 16

**ABSTRACT:** Fifth paragraph, first sentence

"Stomach contents of trammel-netted juveniles almost exclusively contained the isopod *Cyathura burbanki* Frankenberg."

Should read:

"Stomach contents of trammel-netted juveniles almost exclusively contained gammaridean amphipods (Family Haustoriidae)."

Page 22: Second paragraph, first sentence

". . . amphipods (Family Haustoriidae)."

Should read:

". . . amphipods (Family Haustoriidae)."

Page 27: SUMMARY AND CONCLUSIONS, Number 4, second sentence

"However, most spring migrants (8%) had no marginal annulus . . ."

Should read:

"However, most spring migrants (92%) had no marginal annulus . . ."

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**Number 16**

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in Suwannee River, Florida<sup>1</sup>**

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**1975**

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<sup>1</sup>This study was funded in part by the U.S. Department of Interior, Fish and Wildlife Service, and the U.S. Department of Commerce, NOAA, National Marine Fisheries Service under PL 89-304, Project Number AFCS-5.

## ABSTRACT

Huff, J. A. 1975. Life History of Gulf of Mexico Sturgeon, *Acipenser oxyrinchus desotoi*, in Suwannee River, Florida. Fla. Mar. Res. Publ. No. 16. 32 p. Most study material was taken from commercial catches of sturgeon landed at Suwannee, Florida, during pre- and post-spawning migrations of 1972-73. Age groups 4 through 17 were continuously represented. Older age groups were sporadically represented through approximately age 42. Ages 1 through 5 were represented in supplementary trammel net collections. Sturgeon began entering the fishery at ages 4 and 5, becoming significantly exploited by age 6. Annual survivorship was 53.7% between ages 8 and 12.

Growth was empirically determined from mean fork length for age groups 1 through 17 ( $FL = 369.2326 \text{ Age}^{0.5284}$ ). Inherent structural features of pectoral fin ray sections prevented measurements for back-calculation of growth. Length-weight curves were significantly different between spring and fall fishing seasons and between sexes.

Microscopic evaluation of gonad material indicated patterns of extended sexual development typical of other *Acipenser* species. Females became sexually active between ages 8-12 (youngest ripe female was age 12). Active males were found between ages 7-21 (youngest ripe male was age 9). Two types of cysts filled with proteinaceous fluid were found on some ovaries.

Sex ratios were significantly different between pre- and post-spawning migrations heavily favoring females during pre-spawning migrations. Data suggest dissimilar in-river migration routes; each are chosen according to season and directions of movement.

Stomachs of trammel-netted juveniles almost exclusively contained the isopod *Cyathura burbanki* Frankenberg. Vegetable material was the major constituent of gill-netted sturgeon stomach contents.

No recommendations for additional fishery regulation are made. Exploitation of Suwannee River sturgeon populations appears to be self-limited by current fishing techniques and geographic river characteristics.

Contribution No. 261, Florida Department of Natural Resources Marine Research Laboratory

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## INTRODUCTION

Previous literature concerning Gulf coast sturgeon, *Acipenser oxyrinchus desotoi* Vladykov, is limited to popular accounts (Ingle and Dawson, 1962; Burgess, 1963), descriptions of subspecies (Vladykov, 1955; Vladykov and Greeley, 1963), and reports of landings (see History of the Fishery). No comprehensive life history work has been done on Gulf sturgeon or its related subspecies, Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus* (Mitchill). Hence, this study was undertaken to describe in-river population dynamics of *A. o. desotoi* as related to the current fishery of Suwannee River, Florida.

Synonymy and relationship of *A. o. desotoi* to the Atlantic subspecies *A. o. oxyrinchus* and western European *A. sturio* Linnaeus is aptly explained by Vladykov and Greeley (1963). Briefly, *A. o. desotoi* in Gulf of Mexico had been known as *A. sturio* until described and diagnosed by Vladykov (1955). He chose as a holotype and paratype two specimens caught at the mouth of Singing River (Mississippi Sound) in 1953. Vladykov also examined two specimens from Cedar Keys and one from Suwannee River, assigning these to *A. o. desotoi*.

Distribution of Gulf coast sturgeon is limited to Gulf of Mexico, northern coast of South America and possibly Bermuda; Atlantic sturgeon occurs along the Atlantic coast of North America (Vladykov and Greeley, 1963). These subspecies are allopatric, having been separated by the emergence of peninsular Florida and maintained by the thermal barrier of the Gulf Stream around south Florida (Rivas, 1954).

Primary differences between subspecies are relative head length (longer in Gulf coast sturgeon), shape of scutes (length shorter than width in Gulf sturgeon; opposite in Atlantic sturgeon), length of pectoral fins (slightly longer in Gulf sturgeon), and most obviously, length of spleen (16-19% of FL in Gulf sturgeon; 3-9% of FL in Atlantic sturgeon) (Vladykov and Greeley, 1963).

Five other *Acipenser* species sturgeons are found in North America. Life history of lake sturgeon, *A. fulvescens* Rafinesque, has been extensively studied (Probst and Cooper, 1954; Harkness and Dymond, 1961; Cuerrier, 1966; Haugen, 1969; Priegel and Wirth, 1971; Priegel, 1973). Migration and life history studies have been done on white sturgeon, *A. transmontanus* Richardson (Pycha, 1956; Semakula, 1963; Miller and Stevens, 1970; Miller, 1972a, 1972b). Larval distribution and migrations of green sturgeon, *A. medirostris* Ayres, were investigated by Miller and Stevens (1970) and

Miller (1972b). Life history of short nose sturgeon, *A. brevirostrum* Lesueur, has been studied by Gorham and McAllister (1974).

## HISTORY OF FISHERIES

Historical aspects of sturgeon fishing in Florida and Suwannee River were taken from Report of the U. S. Commissioner of Fisheries (Bureau of Fisheries). This annual report included statistics of Gulf States Fisheries aperiodically. In 1939, the Commissioner's Report became Statistical Digest of the U. S. Fish and Wildlife Service. The following authors were used to compile this history: Brice, 1898; Townsend, 1900, 1902; Alexander, 1905; Smith, 1917; Radcliff, 1921; Sette, 1927; Fiedler, 1930, 1931, 1932, 1933, 1934; Fiedler, Manning, Johnson, 1936; Anderson and Power, 1945. Recent statistics (Figures 1 and 2) were taken from *Annual Summary of Florida Landings*. (Johnson, 1956-1973).

Florida's first active sturgeon fishery apparently began in Tampa Bay in 1886. This short-lived fishery, conducted only during the winters of 1886-89, was abandoned in 1890 when only seven fish were caught during the previous season. Occasional sightings of sturgeon and captures of individuals in the Tampa Bay area have been reported since the fishery's demise.

Five years later (late 1895), gill netters were sent from Cedar Keys to conduct exploratory sturgeon fishing in the mouth of Suwannee River. The expedition was successful and an active gill-net fishery, employing about 30 fishermen, was begun November 1896. Records indicate that sale of flesh and not caviar was the prime motivation of most in the Suwannee River fishery. Catch recorded for 1897 in Levy County (Suwannee River) was 9,254 lbs (4,206 kg), worth \$331, constituting the entire reported Florida sturgeon landings for that year.

Franklin County, bordered by Apalachicola and Ocklockonee Rivers, became a prominent producer of meat and caviar by 1900. Sturgeon fishing was first begun on Ocklockonee River in 1898 (no report for Apalachicola R.), and statistics for both rivers were first reported for 1900. Commercial fishing for sturgeon in Choctawatchee Bay and River, Escambia Bay and River, and Blackwater River (northwest Florida) began in 1901 with catch statistics first reported for 1902.

Sturgeon landings for west Florida were again reported in 1917, but no specific catch data was given. Annual catch for previous years on Apalachicola River was generally estimated at 20,000-60,000 lbs. There was no mention of the Suwannee River

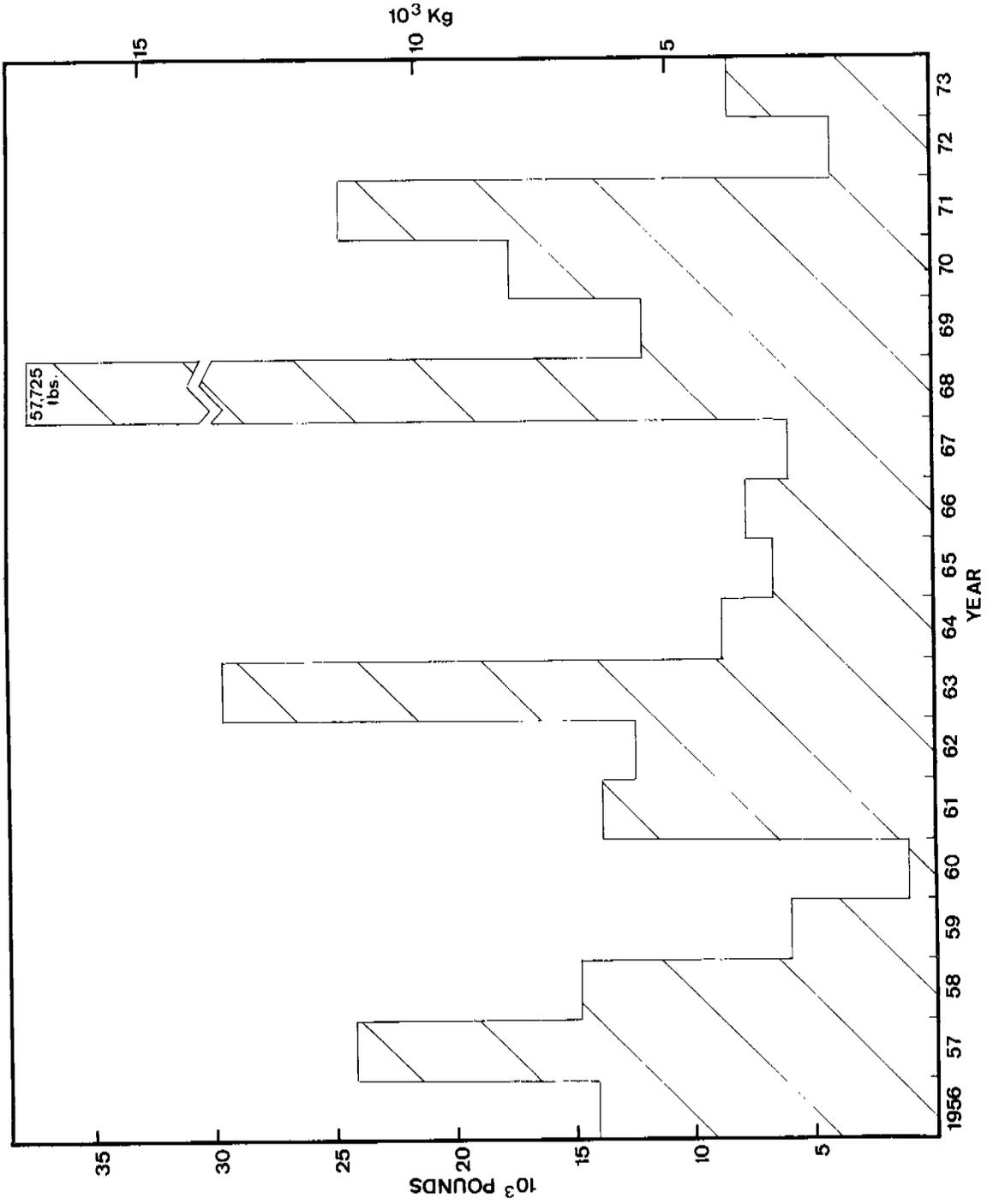


Figure 1. Florida Gulf coast sturgeon landings, 1956-1973.

fishery. Smith (1917) reported that drift nets with six-inch mesh were in use, and average fish size was decreasing. He also expressed concern that the species was nearing extinction and needed "thoughtful attention."

Catch statistics were next given by county for 1918, and on the west coast for 1923 and 1927. Reporting of sturgeon landings by county and gear began in 1931 for 1929 and subsequent years.

Five different techniques have been used to capture sturgeon in the Suwannee and other rivers of northwest Florida. Apparently, drifted gill nets were exclusively used through 1929, but in 1972 accounted for only 13% of the annual whole catch. Pound nets and runaround gill nets were introduced in Suwannee River in 1930-31. In 1932, pound nets were discontinued and replaced by more effective trammel nets. By 1945, only trammel nets were reportedly used in Suwannee River. Presently, anchored gill nets are the principally employed and most effective fishing gear used in this river.

Sturgeon fishing seasons have historically varied among areas. The earliest fishery in Tampa Bay exploited populations during "winter months". Presumably, this included December, January, and February, which presently have low monthly landings (Figure 2). Although sturgeon were taken during only half the time they were available (pre-spawning migrations, if occurring, appeared unexploited), stocks were quickly depleted and the fishery was abandoned after only three years. The early Suwannee River fishery was February 1 to May 1, which obviously excluded exploitation of fall migrations. Sturgeon fishing in Apalachicola Bay and River was from mid-April to the end of June, also excluding exploitation of post-spawning migrations. Sturgeon in this river migrated more than 200 miles (322 km) upstream, but were only netted in the first 30 river miles (48 km). In spring 1957, Jim Woodruff Dam was completed across Apalachicola River at the Georgia-Florida state line. A hook and line sport fishery developed at the dam's base beginning in August 1962 (Burgess, 1963). This fishing was conducted from April through June, and August through September.

Historical catch statistics from Fish Commission Reports and Statistical Digest #18 are presented in Table 1. Recent landings (1956-1973) and 18-year average monthly catch data are shown in Figures 1 and 2, respectively. I found that sturgeon catches from Suwannee River (Dixie County) were incompletely and sporadically reported, perhaps explaining large variations of annual landings. Figure 3 presents complete monthly catch weights from my data taken in 1972-73.

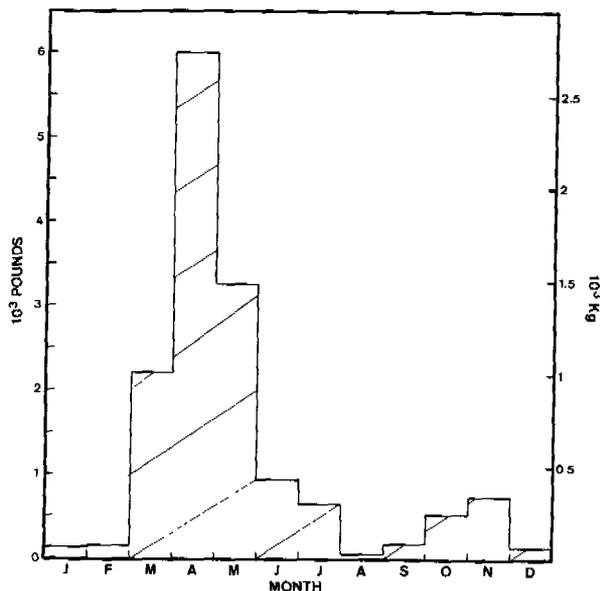


Figure 2. Florida Gulf coast monthly mean sturgeon landings, 1956-1973.

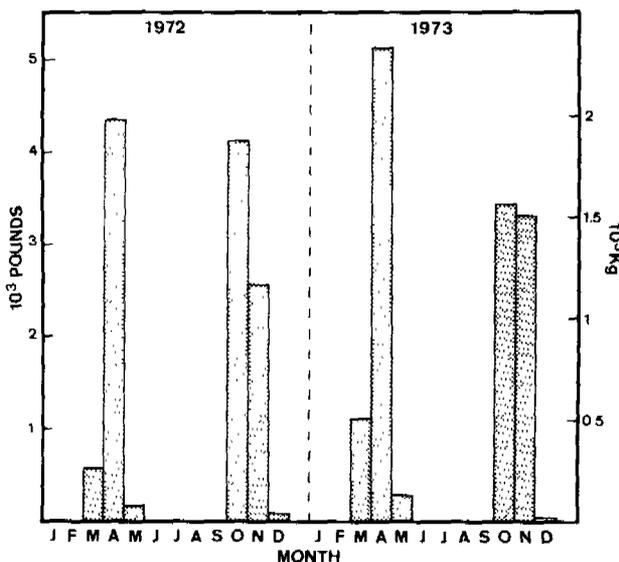


Figure 3. Monthly Suwannee River sturgeon landings, 1972-1973 (whole weight).

### SUWANNEE RIVER DESCRIPTION

The dark, tannin-stained Suwannee River, originating in the Okefenokee Swamp in southeast Georgia, flows 394 km (245 mi) to its mouth at Suwannee, Florida (Figure 4). From the Georgia-Florida state line to Ellaville, Florida, the river is characterized by steep banks, swift currents, and numerous shoals. River height in this area can rise

6-9 m (20-30 ft) during annual spring floods.

Below Ellaville, the river widens and deepens but currents remain swift (Appendix I). Fathometer recordings show that regularly exposed limestone bottom ends at Ellaville; no steep limestone banks occur below this point.

Numerous large and small springs enter the river from Dowling Park downstream to Manatee Springs. River width gradually increases in this stretch as does the flood plain. Prominent areas of wooded marsh border the river a few miles north of Old Town and extend downstream to the mouth, which is surrounded by tidal and wooded marsh.

## METHODS AND MATERIALS

### SOURCE OF MATERIALS

Adult and juvenile sturgeon were collected on Suwannee River during pre-spawning (March through early May) and post-spawning (October through December) migrations of 1972 and 1973. A commercial fisherman, Mr. Wilmer Corbin, and his wife, Anita, were contracted to provide sturgeon caught with anchored or drifted gill nets. Anchored nets were placed in East Pass (Figure 22) and drifted nets were used between Fannin Springs (Figure 23) and the river mouth. Additional juvenile sturgeon were trammel netted in Alligator Pass (Figure 22).

### PROCEDURES, MEASUREMENTS, AND GEAR

Most specimens were caught using three to six anchored gill nets (100 yd [90 m] long, 10 in [24.5 cm] stretched mesh) placed in large eddies of East Pass. Nets were placed in eddies so that lead lines would remain on river bottom. Cork lines were submerged 1-2 m (3-6 ft) and marked by several one-gallon plastic jugs. One end of each net was tied to shore vegetation or to a pole driven into the bottom near the bank, with the opposite end anchored by some heavy object (lawnmower engines, crankshafts, boat anchors, etc.). Two or three large eddies in East Pass are fished, these having been traditionally exploited by Mr. Corbin and his father for 50 years. One to three nets were placed perpendicular to the river bank, approximately 100 m (330 ft) apart within each eddy.

The same type net (with anchor removed) was drifted at various locations between Fannin Springs and Suwannee, catching 26 sturgeon in spring 1972.

Small juveniles were caught in a trammel net (300 yd [273 m] long, 11 in [27.9 cm] stretched outside mesh, 2- $\frac{1}{4}$  in [5.7 cm] trammel) drifted with the current and falling tide in Alligator Pass during April and May 1973. The net was drifted for approximately  $\frac{1}{2}$  hour over a sand bar submerged 1-2 m (3-6 ft) where small sturgeon were observed feeding during previous pre-spawning migrations.

Catches from anchored gill nets were usually harvested daily; measurements and tissues were taken during butchering. Fork lengths (FL) were measured to nearest  $\frac{1}{4}$  in (0.64 cm) on a standard fish measuring board. Weights to nearest  $\frac{1}{2}$  lb (0.2 kg) were taken on an old but accurate counter-weighted cotton scale. Sturgeon were placed on a work table and the left operculum and/or pectoral fin ray removed. Gonads were removed and weighed to the nearest 5 grams (0.18 oz) as each fish was gutted. A small cross section from one gonad lobe was placed in Bouin's or Davidson's fixative. (Bouin's was replaced by Davidson's in late October 1972, because yellow picric acid of Bouin's was difficult to wash from gonad tissue.) Stomach contents were examined but not preserved.

Trammel-netted juveniles were iced or frozen and returned to St. Petersburg for measurement (mm), weighing (g) and dissection. Stomach contents were examined in these specimens and preserved from 5 randomly selected fish.

### AGE AND GROWTH

Opercular plates were initially collected from each fish during 1972. First (anterior) pectoral fin rays and operculi were both collected during the pre-spawning migration, 1973, and only pectoral rays were collected thereafter. Operculi and pectoral fin rays were frozen and returned to the Laboratory where they were boiled for 1-5 min, cleaned, and dried for several days. I removed one to three cross sections (0.5 mm thick) from an area approximately 0.5 cm to 1.0 cm from the proximal end of each pectoral ray using a fine-toothed jeweler's saw. These sections were placed in a small black dish containing glycerin and examined with a dissecting microscope and reflected or transmitted light. Opercular annuli were visible to the unaided eye when placed in a watch glass containing 40% isopropanol and placed over an incandescent light.

TABLE 1. HISTORICAL CATCH STATISTICS

YEAR	LOCATION	GEAR	MEAT lb	VALUE \$	CAVIAR lb	VALUE \$	TOTAL MEAT lb
1886-87	Tampa Bay	—	1,500 f.	—	5,000	—	—
1887-88	Tampa Bay	—	2,000 f.	—	6,300	—	—
1888-89	Tampa Bay	—	7 f.	—	—	—	—
1897	Levy Co.	DGN	9,254	331	—	—	9,254
1900	Suwannee R.	DGN	44,000	2,664	1,260	1,008	165,000
	Ochlocknee R.	DGN	37,000	2,322	850	595	
	Apalachicola R.	DGN	84,000	4,800	2,160	1,152	
1902	Escambia Co.	DGN	259,171	3,491	4,326	1,753	343,291
	Franklin Co.	DGN	74,120	1,950	3,706	1,073	
	Levy Co.	DGN	10,000	250	500	200	
1917*	Apalachicola River & Bay	DGN	20,000- 60,000	2,000- 6,000	—	—	—
	Escambia Co.	DGN	2,250	270	—	—	4,915
Franklin Co.	DGN	1,215	60	—	—		
Levy Co.	DGN	1,450	290	—	—		
1923	West Coast	DGN	7,400	1,088	—	—	7,400
1927	West Coast	DGN	7,669	932	—	—	7,669
1929	Escambia Co.	DGN	3,604	432	—	—	16,247
	Franklin Co.	DGN	9,599	1,056	—	—	
	Levy Co.	DGN	3,044	609	—	—	
1930	Franklin Co.	DGN	6,119	857	—	—	13,126
	Levy Co.	RGN	5,230	951	—	—	
	Levy Co.	PN	1,777	323	—	—	
1931	Franklin Co.	DGN	3,041	276	—	—	8,260
	Levy Co.	RGN	4,207	765	—	—	
	Levy Co.	PN	1,012	184	—	—	
1932	Franklin Co.	DGN	5,941	447	—	—	14,734
	Levy Co.	RGN	3,645	265	—	—	
	Levy Co.	TN	5,148	374	—	—	
1933	West Coast	DGN	4,379	199	—	—	4,379
1945	Franklin Co.	RGN	3,700	925	—	—	7,200
	Dixie Co.	TN	3,500	675	—	—	

DGN, drifted gill net; RGN, runaround gill net; PN, pound net; TN, trammel net.

Suwannee R. catches landed in Levy and Dixie Co., Apalachicola and Ochlocknee R. catches landed in Franklin Co. Tampa Bay landings reported as number of fish (f).

\*Estimated annual landings for unspecified previous years.

## REPRODUCTION

Gonadal tissue was stained with hematoxylin/eosin and a modified Alcian blue periodic acid Schiff (PAS) stain, utilizing Alcian Blue, PAS, hematoxylin and Orange G. Slides were examined with a compound microscope equipped with an ocular micrometer. Developmental oocyte stages were assessed following criteria of Moe (1969). Stages I, II, and early stage III oocytes were measured at 125X (one ocular micrometer unit [omu] = 9.3  $\mu$ ). Late stages III and IV were measured at 35X (one omu = 31  $\mu$ ). Twenty-five oocytes from each stage (Stages I and II were considered as one stage) were measured if present and measur-

able. Measurements were taken across the greatest diameter of each oocyte in which the nucleus was sectioned through its approximate center. Females were judged immature, resting, active, regressing, ripe, or spent. Measurements were not taken on male gonadal tissue, but they were judged immature, inactive, active, ripe, or spent.

## EGG AND LARVAL SAMPLING/POTENTIAL SPAWNING LOCATIONS

One-meter plankton nets (0.5 m in earliest sampling) were used in an attempt to capture eggs and larvae. These nets (similar in design to those

used by Williams and Bruger, 1972:6) were anchored to river bottom from late afternoon to the following morning when they were moved to new stations. Exploratory stations were most extensively sampled between 5 May 1972 and 20 July 1972. Stations were generally located 3-8 km apart along approximately 129 km, mostly upriver from Branford, Florida. Most stations were selected in the upper river above Ellaville, Florida, where suspected spawning grounds were located. Egg and larval sampling in 1973 was delayed one month

and subsequently severely limited by record flooding.

Bottom  $O_2$ ,  $CO_2$ , pH, and total hardness ( $CaCO_3$ ) were measured at each station at time of net recovery. Current velocity, depth, surface and bottom water temperature, and air temperature were also recorded.

Selected portions of the upper river were surveyed using a flashing recording fathometer (Apelco 201-B) to locate potential spawning sites. Tapes were interpreted to distinguish rock, gravel, sand, and mud. Interpretations were noted on topo-

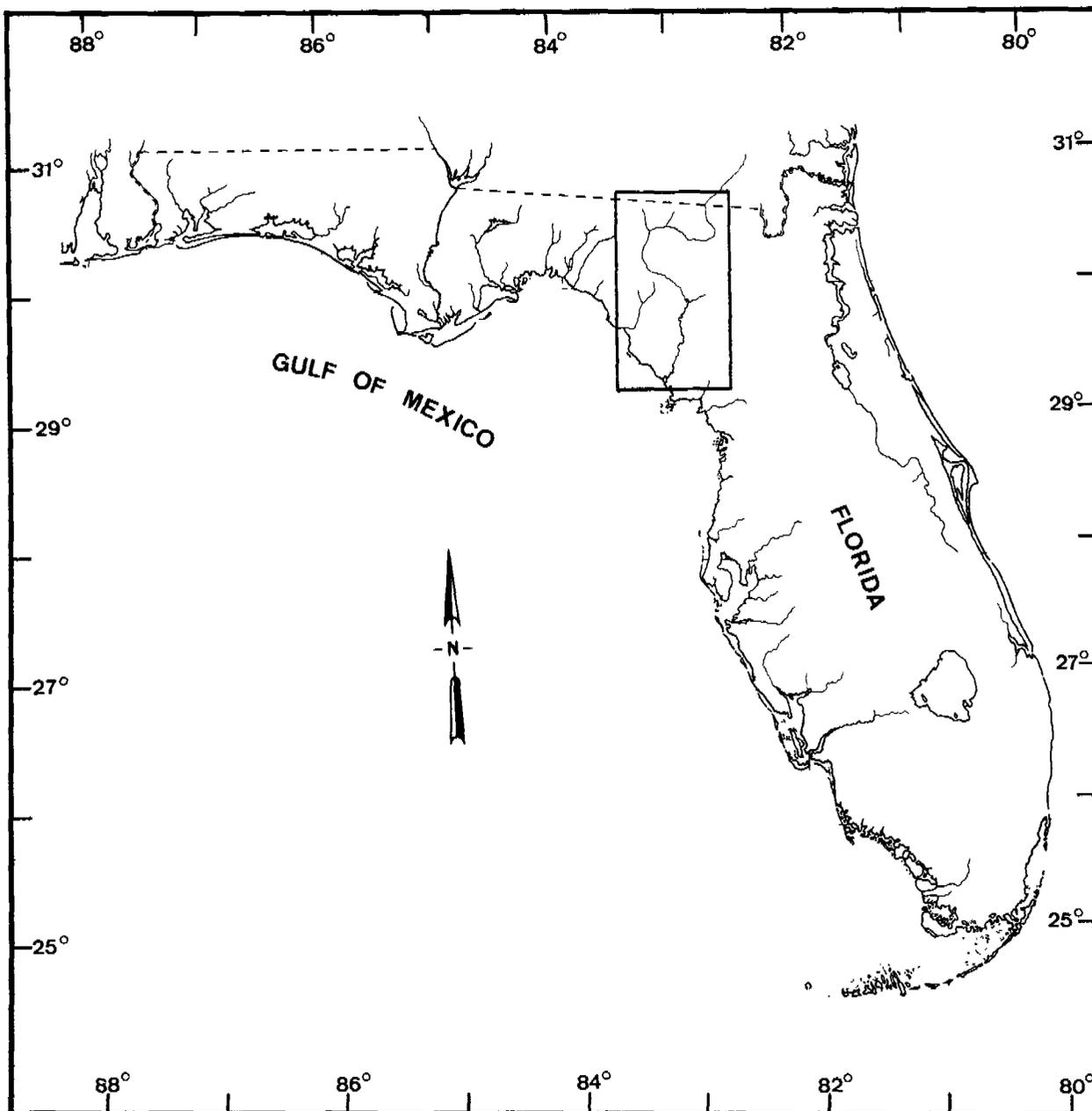


Figure 4. Suwannee River in Florida.

graphic maps of the river basin and reference points were marked on both tapes and maps. The survey was conducted during spring flooding, 1973, which allowed access to many areas that were inaccessible to bottom plankton net sampling of May and June 1972.

## RESULTS AND DISCUSSION

### LENGTH FREQUENCY

Study material consisted of 301 males and 331 females ranging in fork length from 38-188 cm (Figures 5 and 6).

### AGE AND GROWTH

#### SUITABILITY OF AGING STRUCTURES

My eventual utilization of fin ray sections was based on literature (Cuerrier, 1951; Probst and Cooper, 1954; Pycha, 1956; Roussow, 1957; Chugunova, 1963; Semakula, 1963; Zwieacker, 1967; Haugen, 1969; Priegel and Wirth, 1971) and the generally distinct appearance of annuli in this structure.

Examinations of operculi revealed that resulting age determinations were unreliable because circuli became obscured as sturgeon aged. Experimental techniques to improve circulus visibility (hot glycerin baths, formic acid baths, sanding and smoothing rough exterior opercular surfaces) had little or no effect. In October and November (1972), first pectoral fin rays and operculi were collected from 26 specimens, allowing 17 age comparisons between the two structures (Table 2). Ages from fin ray sections were 2 to 7 years older than those determined from operculi ( $\bar{X}=3.11$  years).

Ages were positively determined from 72% of gill-netted specimens and 86% of trammel-netted specimens from which fin rays were collected. Double annuli, false or incomplete annuli, and difficulty in locating the first annulus were the primary causes of questionable age determinations.

#### ANNULUS FORMATION

Fishery seasonality and procedural complications of preparing fin ray sections prevented measurements of marginal increment for determining time of annulus formation. Since sturgeon were unavailable 6-7 months a year, no periodic mean marginal increment could be plotted. Also, the varying angles at which sections were cut and distances from the proximal end where sections were removed were considered procedural difficulties that would have introduced significant experi-

mental error. Oblique cuts increased distances between the last annulus and the margin as cutting proceeded proximally. Distally removed sections had smaller marginal increments on the same or different fin ray.

Percentages of fin ray sections having marginal annuli were greater in fall (1973) than in spring. Eight percent of pre-spawning sturgeon (positively aged specimens only) had annuli on the margin. Sixty-six percent of post-spawning sturgeon had marginal annuli, indicating in-river annulus formation.

#### TOTAL INSTANTANEOUS RATE OF MORTALITY

Total rate of instantaneous mortality was calculated according to D. W. Chapman (1968: 187):

$$Z = -(\log_e N_2 - \log_e N_1) / \Delta T.$$

All aged fish caught in 10-in. gill nets from age 8 to 12 were used to calculate various "Z" values. Thus,

$$Z = -(\log_e N_{12}) - \log_e N_8) / 4.$$

Z, calculated for aged sturgeon in spring and fall 1973, was -0.4479 and -0.9284, respectively. The mean of these two values ( $Z = -0.6882$ ) compares favorably to that calculated from all aged sturgeon caught in gill nets ( $Z = -0.6212$ ).

Slope of the descending limb of the age-frequency curve (Figure 7) can be represented by "the geometric mean estimate of the functional regression" (Ricker, 1973) and described by the formula:

$$\nu = \pm \frac{\sqrt{\sum y^2}}{\sum x^2}$$

This slope ( $\nu = -0.7447$ ), which was calculated from all aged sturgeon, ages 8 to 12, is similar to total instantaneous rate of mortality calculated for the same group of fish ( $X = -0.6212$ ).

Percent survivorship between successive years from ages 8 to 12 is represented by the natural anti-log of  $Z \times 100$ .

$$Z = -0.6212 \text{ then;}$$

$$\% \text{ survivorship} = e^{-0.6212 \times 100} = 53.73\%.$$

#### AGE-LENGTH RELATIONSHIP

Growth of sturgeon was empirically determined from mean FL for age groups 1 through 17, sexes combined (Figure 8). Age groups after age 17 were poorly represented and are not displayed. The regression line is based on mean FL for each age group. Variates were transformed into common logarithms for regression computation (see Appendix II). Because most fin ray sections contained one to four secondary growth centers, back-calculation of growth was not attempted. Secondary growth centers caused by fusing of imme-

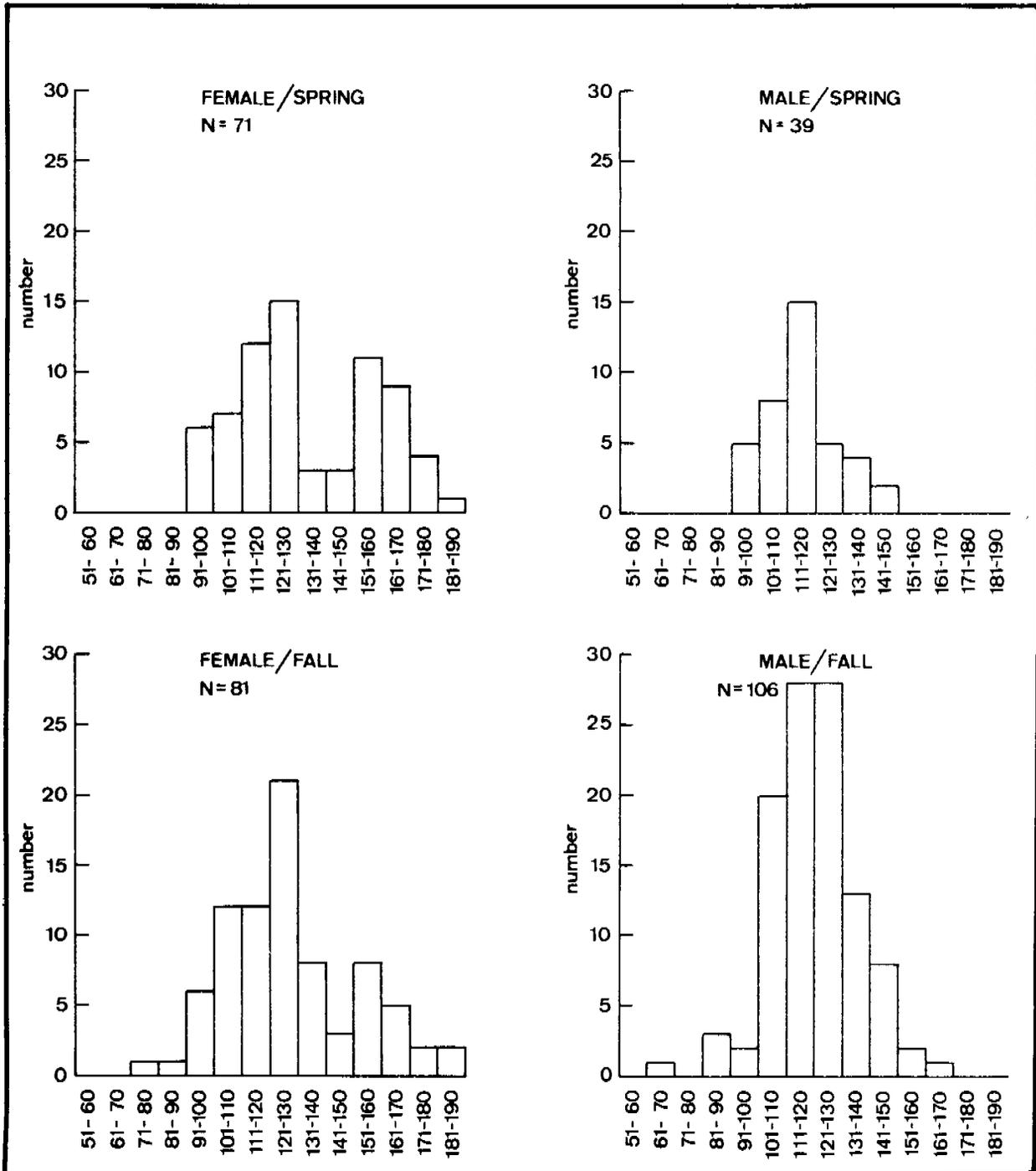


Figure 5. Length frequencies (10 cm size classes) of sturgeon gill netted in 1972.

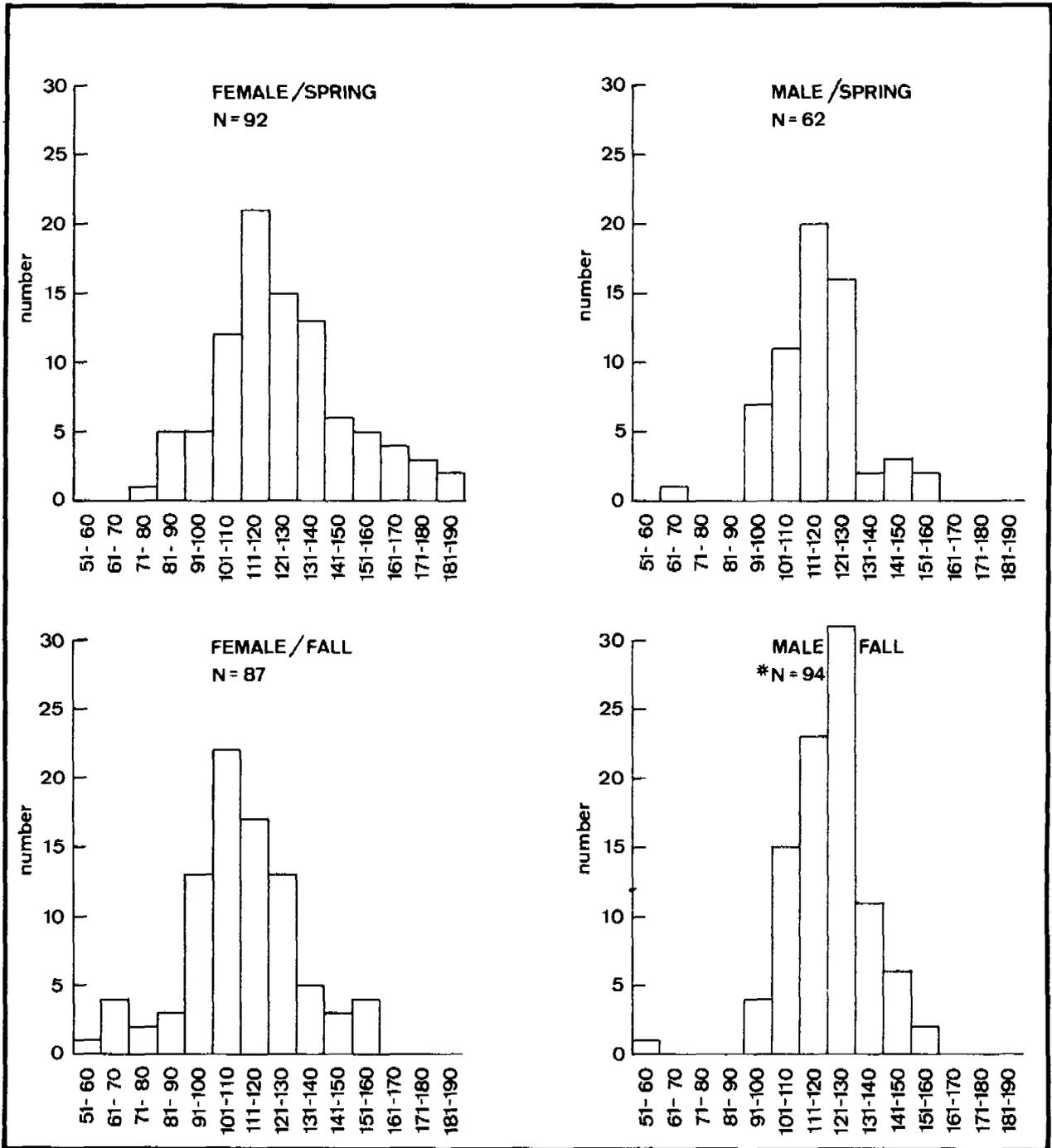


Figure 6. Length frequencies (10 cm size classes) of sturgeon gill netted in 1973. Includes one fish in 31-40 cm size class which is not displayed.

TABLE 2. RESULTS OF COMPARATIVE AGING BETWEEN SECTIONED PECTORAL FIN RAY SECTIONS AND OPERCULI

SPECIMEN NUMBER	AGE (SPINE)	AGE (OPERCULI)
X-48-72	8	6
X-49-72	8	5
X-56-72	9*	6
X-82-72	8	6
X-84-72	9*	6
X-85-72	9*	5
X-86-72	8*	5
X-93-72	9*	6
X-95-72	8	5
X-96-72	12	5
X-99-72	7*	4
X-100-72	8	4
X-103-72	7*	5
X-104-72	9*	6
X-105-72	7*	5
XI-64-72	8*	3
XI-66-72	7	5

\* annulus on margin. Mean age difference = 3.11 years.

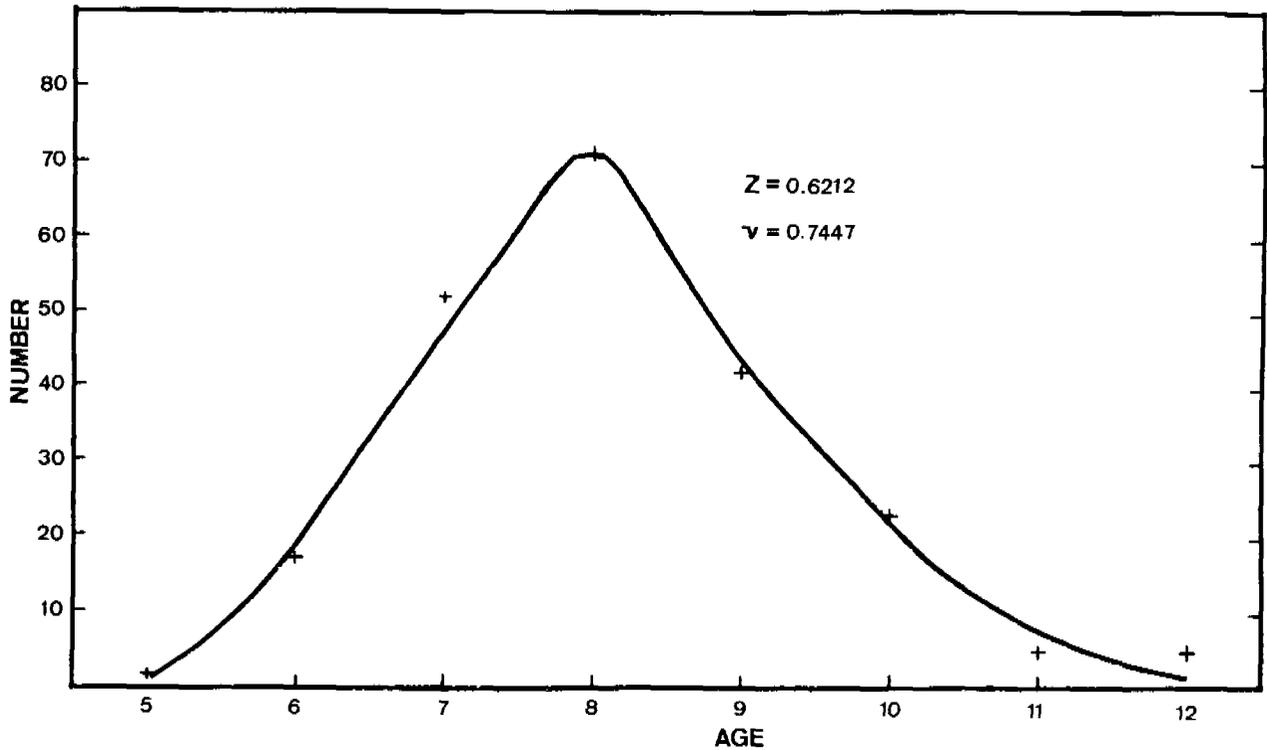


Figure 7. Age-frequency curve for 1973 gill-netted sturgeon.

diately posterior fin rays and subsequent enclosing of these within annuli of the first fin ray occurred along the axis of back-calculation measurements. Fusing typically happened during the first few years of life and greatly increased the distance between annuli where fusing occurred. Probst and Cooper (1954) considered a similar problem with lake sturgeon, *Acipenser fulves-*

*cens*, partially prohibitive to back-calculation. Semakula (1963) performed back-calculation measurements from fin ray sections of white sturgeon, *A. transmontanus*, but avoided sections containing secondary growth centers. Similarly, Chugunova (1963) recommends using only fin ray sections without secondary growth centers for back-calculation measurements.

Irregular shapes of fin ray sections, causing extremely variable diameter measurements, was another factor in not attempting back-calculation. A similar problem cited by Probst and Cooper (1954) and Haugen (1969) prevented back-calculation of growth for lake sturgeon. Also, occurrence of disproportionately narrowly spaced annuli in spawning belts, associated with extended gonadal maturation prior to spawning activity (Roussow, 1957), would have prevented measurements in several fin ray sections. This was a prohibitive factor for back-calculated growth determinations of shovelnose sturgeon, *Scaphirhynchus platorynchus* (Zwieacker, 1967).

Finally, the origin of the primary growth center was often obliterated by vascular tissue and hard to locate, thus making radial measurements difficult. Also, the distance from the articulatory end of each fin ray where sections were removed and the angle of cuts were variable procedural difficulties that would have possibly introduced significant experimental error.

**LENGTH-WEIGHT RELATIONSHIP**

Nine length-weight regression lines were developed according to sex, season, and method of capture (8 from gill-netted specimens, 1 from trammel-netted specimens). I noted considerable variation in y-intercepts and slopes of these lines and compared them by analysis of covariance (Snedecor and Cochran, 1964: 432-436). ANCOVA tests were performed between all possible pairs of regression lines. With two exceptions (fall '72 males/ fall '72 females and spring '73 males/fall '73 males), all regressions were significantly different at P=.05 (Table 3).

I believe sexual dimorphism, large differences between percent gonad weight to body weight between males and females, and in-river environ-

mental and migratory stresses are major contributors to significantly different regression lines of exploitable populations. Such change in length-weight relationships are further discussed by Tesch (1968: 116). Sexual dimorphism (females mature later, live longer, and attain greater lengths than males) and large differences between relative gonad weights (Tables 5 and 6) were probably responsible for significant differences between sexes. In-river stresses (i.e., low protein diet and long distance migrations) would probably cause significant differences between contrasting seasons of the same year. Similarities between like sexes of like fishing seasons of 1972-73 did not occur and remain unexplained. The regression line developed for trammel netted juveniles is different because it is based on a limited smaller size range in which growth rates are presumably greatest.

Table 4 lists various length-weight regression formulae and related values according to sex, season, and method of capture. Slope is represented by the geometric mean ( $GM = \sqrt{\frac{\sum y^2}{\sum x^2}}$ ) as suggested by

Ricker (1973: 430) and is used in estimating weight from length. Also listed are two additional regression formulae whose combination was suggested by ANCOVA tests. Figure 9 graphically displays these regression lines. Appendix III contains necessary information for ANCOVA analyses if future studies of Suwannee River populations are accomplished.

**REPRODUCTION**

**SEXUAL MATURATION**

Age of sexual maturation was estimated from microscopic examination of gonad tissue and by methods suggested by Roussow (1957). I considered active gonads as the criterion of sexual maturity. Mature, active females ranged in age from 8 to 17

TABLE 3. ANALYSIS OF COVARIANCE OF REGRESSION LINES COMPUTED BY SEASON, SEX, AND METHOD OF CAPTURE

	SPRING 1972		FALL 1972		SPRING 1973		JUV. <sup>1</sup>	FALL 1973		
	MALE	FEM.	MALE	FEM.	MALE	FEM.		MALE	FEM.	
Male	—	—	—	—	—	—	—	—	—	Spring 1972
Female	*	—	—	—	—	—	—	—	—	Spring 1972
Male	*	*	—	—	—	—	—	—	—	Fall 1972
Female	*	*	ns	—	—	—	—	—	—	Fall 1972
Male	*	*	*	*	—	—	—	—	—	Spring 1973
Female	*	*	*	*	*	—	—	—	—	Spring 1973
Juv. <sup>1</sup>	*	*	*	*	*	*	—	—	—	Spring 1973
Male	*	*	*	*	ns	*	*	—	—	Fall 1973
Female	*	*	*	*	*	*	*	*	—	Fall 1973

<sup>1</sup> These specimens were small juveniles caught in a trammel net, all other specimens were sub-adults and adults caught in gill nets.

\* significant at P=.05

ns- not significant

TABLE 4. REGRESSION FORMULAE AND RELATED VALUES 1972 - 1973

SEASON	SEX	LOG	EXPONENTIAL	N	% VAR.	r	YEAR
1. Spring	male	LogW = 3.2330 LogFL - 5.5473	W = 2.8359 x 10 <sup>-6</sup> FL <sup>3.2330</sup>	39	82.13	.906	1972
2. Spring	female	LogW = 3.2617 LogFL - 5.6067	W = 2.4732 x 10 <sup>-6</sup> FL <sup>3.2617</sup>	71	97.70	.988	1972
3. Fall	male	LogW = 2.8262 LogFL - 4.7465	W = 1.7928 x 10 <sup>-5</sup> FL <sup>2.8262</sup>	106	65.85	.811	1972
4. Fall	female	LogW = 2.9190 LogFL - 4.9176	W = 1.2089 x 10 <sup>-5</sup> FL <sup>2.9190</sup>	81	83.73	.915	1972
5. Spring	male	LogW = 2.5820 LogFL - 4.1676	W = 6.7978 x 10 <sup>-5</sup> FL <sup>2.5820</sup>	62	73.75	.859	1973
6. Spring	female	LogW = 2.9140 LogFL - 4.8210	W = 1.5100 x 10 <sup>-5</sup> FL <sup>2.9140</sup>	92	86.97	.932	1973
7. Spring	juv.*	LogW = 3.5576 LogFL - 6.1068	W = 7.8190 x 10 <sup>-7</sup> FL <sup>3.5576</sup>	106	97.33	.986	1973
8. Fall	male	LogW = 2.1308 LogFL - 3.2335	W = 5.8406 x 10 <sup>-4</sup> FL <sup>2.1308</sup>	94	75.01	.866	1973
9. Fall	female	LogW = 2.0525 LogFL - 3.0581	W = 8.7476 x 10 <sup>-4</sup> FL <sup>2.0525</sup>	87	52.46	.724	1973
Fall	male & female	LogW = 2.9240 LogFL - 4.9404	W = 1.1471 x 10 <sup>-5</sup> FL <sup>2.9240</sup>	187	77.35	.880	1972
Spring Fall	male	LogW = 2.2793 LogFL - 3.5426	W = 2.8667 x 10 <sup>-4</sup> FL <sup>2.2973</sup>	156	74.24	.862	1973

\*Trammel-netted small juveniles, all other formulae from gill-netted sub-adults and adults.

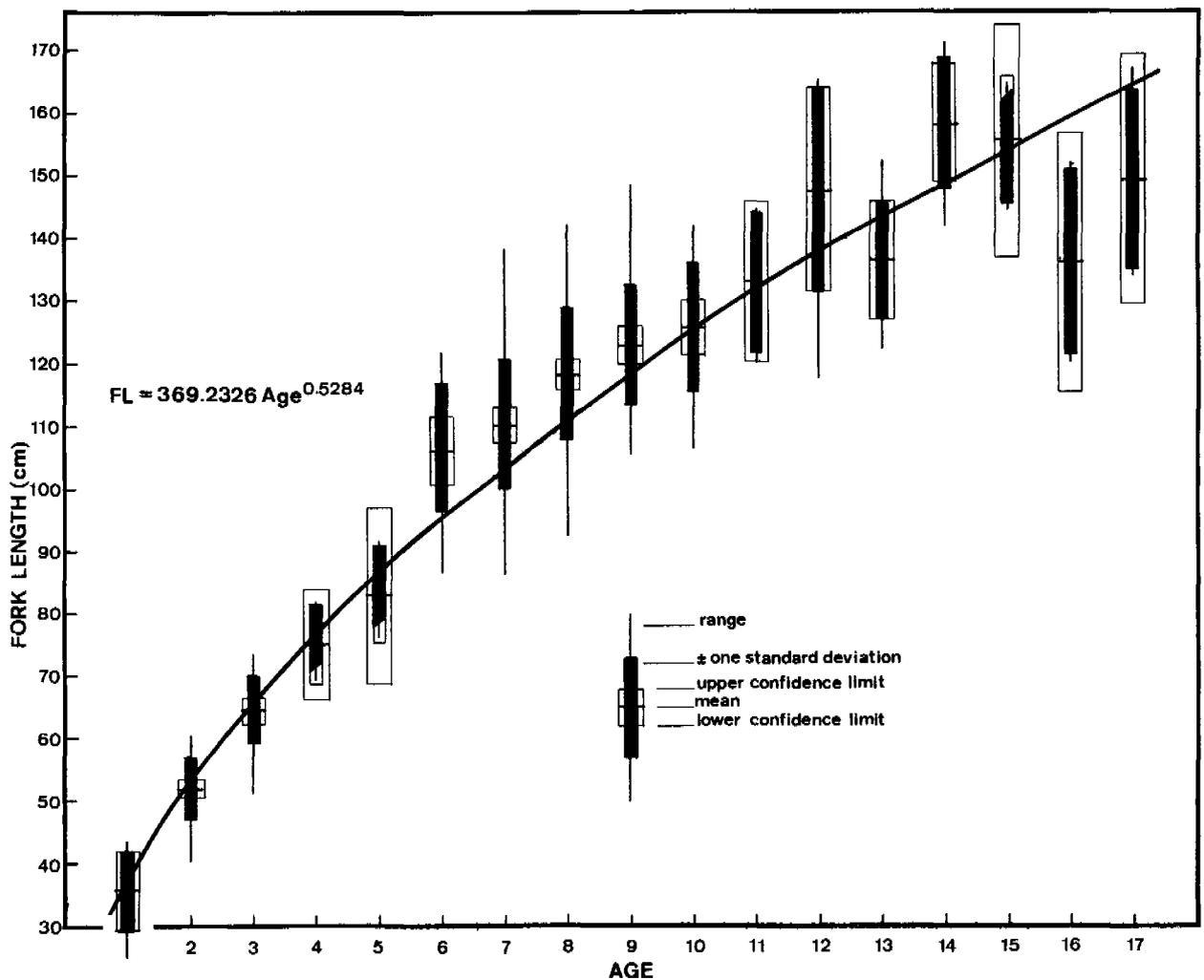


Figure 8. Length-range diagram and regression line for age groups 1-17.

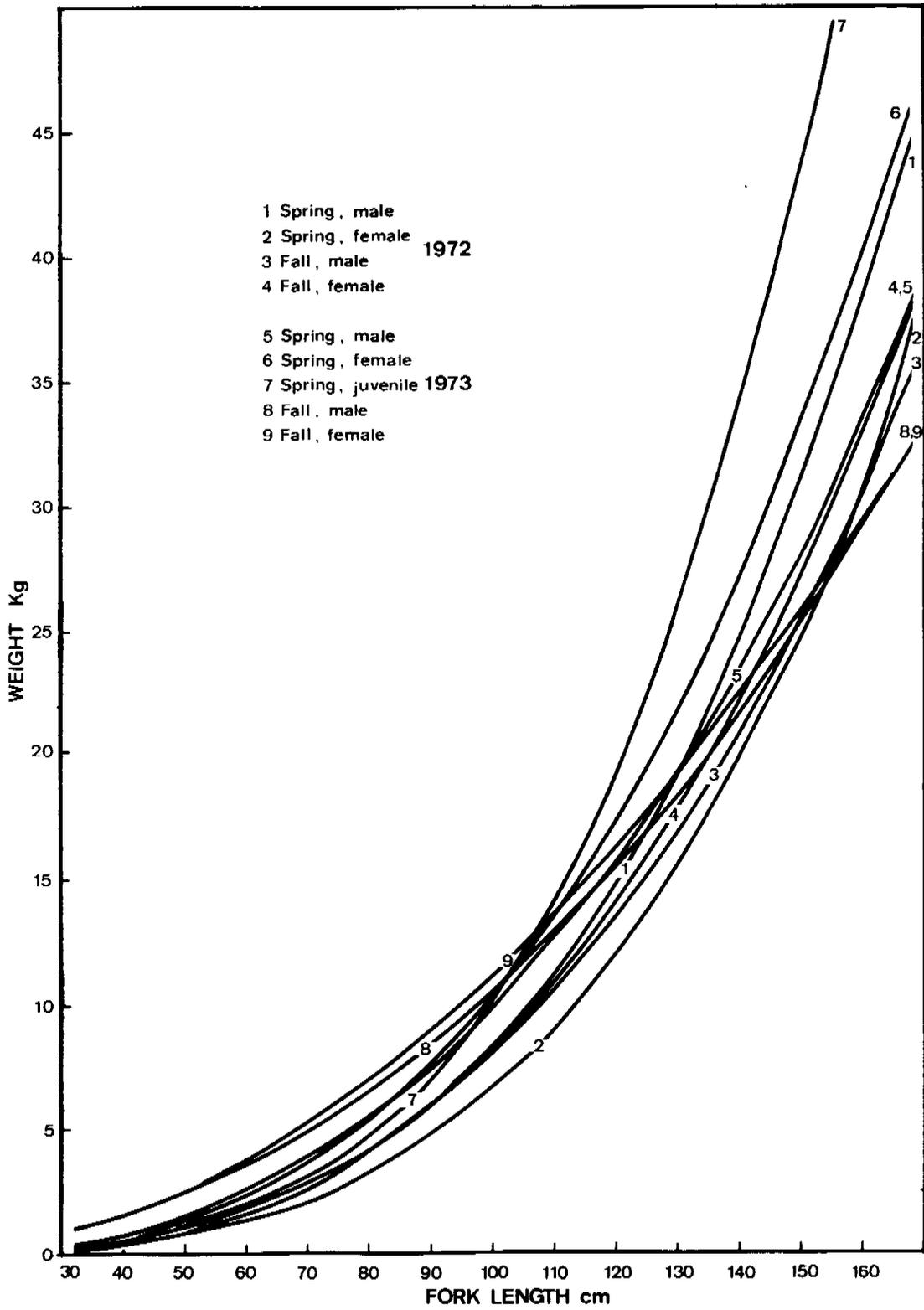


Figure 9. Length-weight regression lines.

years and active males from 7 to 21 (Figures 7 and 8). The youngest ripe specimens were 12 and 9, respectively. Additionally, the oldest immature female was age 12 and oldest immature male was age 10. Spawning may be delayed by several years because behavioral and hormonal development may not be sufficient to elicit spawning.

Roussow (1957), working on *Acipenser fulvescens*, suggested another method for determining maturation age. He determined that belts of closely spaced annuli found in fin ray sections (more strongly expressed in females) were caused by metabolic energy being shunted to extended gonad development. Overall growth was slowed and expressed as narrowly spaced annuli comprising a spawning belt. He concludes that the beginning of the first spawning belt corresponds to sexual maturation and termination of the belt indicated spawning and subsequent recovery. Thus, I found 12 females and 11 males with clearly expressed first spawning belts. Mean maturation age (beginning of belts) for these specimens was 16.8 and 12.2 years, respectively.

#### FEMALE GONAD DEVELOPMENT CLASSES AND SEXUALITY

**Immature:** This class contained Stage I and II oocytes (Figures 10 and 11). Many oogonia (Figure 11) were usually scattered in packages throughout the gonad. There was no evidence of prior spawning, although oocytes appeared to expand and regress aperiodically.

**Active:** This development class contained Stage I, II, III (Figure 12) and occasional Stage IV oocytes. Oogonia could still be found in scattered packages, but were less apparent than in immature gonads. Females in this class may or may not have spawned previously.

**Ripe:** This class gonad contained few Stage I oocytes, numerous Stage II oocytes, few or no Stage III oocytes, and well-advanced Stage IV oocytes (Figure 13). Oogonia were difficult to find, being displaced and obscured by Stage IV oocytes. (Females in this class would soon spawn or reabsorb advanced eggs.)

**Spent:** This class contained primarily Stage II oocytes (Stage I oocytes were not apparent). Stage IV oocytes were degenerated and reabsorbing. Occasionally observed Stage III oocytes were regressing. Gonadal connective tissue and lamellae had lost integrity due to spawning activity. Atretic bodies were relatively large or just beginning to form from degenerating eggs.

**Regressing:** This class contained very few Stage I oocytes, regressing Stage II and Stage III oocytes,

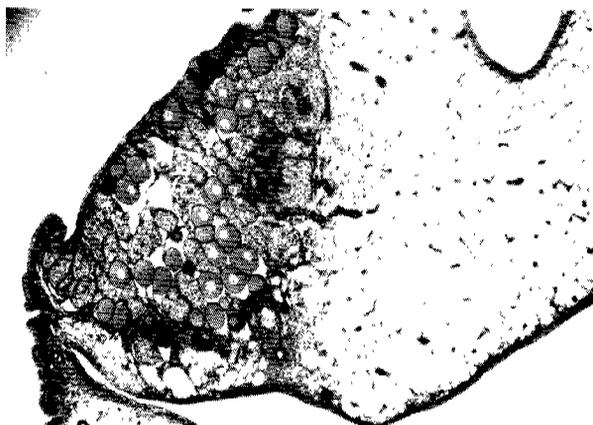


Figure 10. Photomicrograph (48x) of Stage II oocytes (left) and typical fat deposits (right) of an immature 3-year-old female. Taken from a 699 mm FL specimen captured in Alligator Pass, April, 1973.



Figure 11. Photomicrograph (222x) of a Stage I oocyte (center arrow, 51  $\mu$ ) in an immature 7-year-old female. Taken from a 1143 mm FL specimen captured in East Pass, April, 1973. Also appearing are surrounding Stage II oocytes and oogonia (upper right).

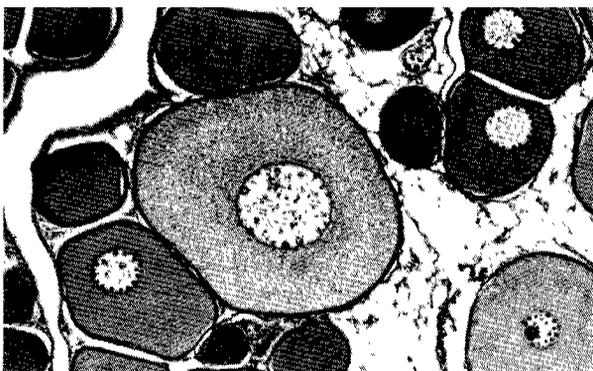


Figure 12. Photomicrograph (136x) of a Stage III oocyte (center, 484  $\mu$ ) in a newly active 10-year-old female. Taken from 1346 mm FL specimen capture in East Pass, October, 1973.

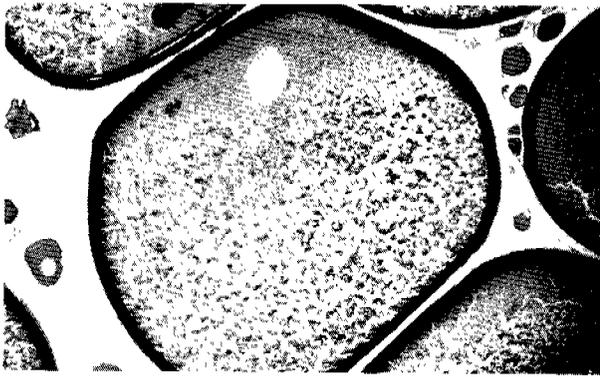


Figure 13. Photomicrograph (49x) of a Stage IV oocyte (center, 2015  $\mu$ ) in a ripe 14-year-old female. Small oocytes are Stage II. Taken from 1676 mm FL specimen captured in East Pass, April, 1973.

and numerous reabsorbing Stage IV (Figure 14) oocytes. Oogonia were not readily apparent. Atretic bodies, if present, were far more numerous than in spent gonads. This category was devised to include those females that were in an advanced active state or ripe and did not spawn. In many cases, this class was difficult to distinguish from spent classes because gross gonad structural integrity was lost as if from spawning. Major distinguishing characters of regressing gonads were large numbers of reabsorbing Stage IV oocytes and atretic bodies with more numerous Stage III oocytes than in spent gonads.

**Resting:** This developmental class contained mostly Stage II oocytes that had obviously regressed from a prior expansion. Packages of oogonia and Stage I oocytes were rarely observed; regressed Stage III oocytes were occasionally observed. Atretic bodies were few if the female had spawned or many if the female had recovered from a ripe or near ripe condition in which no spawning occurred. Oocytes were never well-packed and much fat was

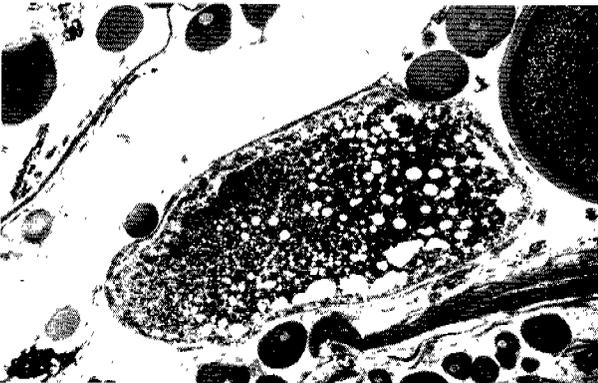


Figure 14. Photomicrograph (55x) of a typical reabsorbing Stage IV oocyte (center, 1612  $\mu$ ) in a regressing 14-year-old female. Taken from a 1727 mm FL specimen captured in East Pass, April, 1973.

present and lamellar integrity had returned.

Figure 15 displays length data for each gonadal class of gill netted females. Note the lower range of length for regressing and resting females, possibly reflecting those females with ripening gonads who aborted and did not spawn because they were not old enough.

Table 5 summarizes other gonad development data. Age ranges were taken from only positively aged 1973 specimens. Additionally, a ripe female was aged at approximately 31 years and a regressing female at approximately 42 years.

There was a very low percentage of spent females (Table 5). They were not captured in fall 1972 and 1973 post-spawning migrations when they would be most expected. Paucity of spent females suggests an unsuccessful spawning season. However, fishery techniques in relation to migration routes for females leaving the river provides a more plausible explanation.

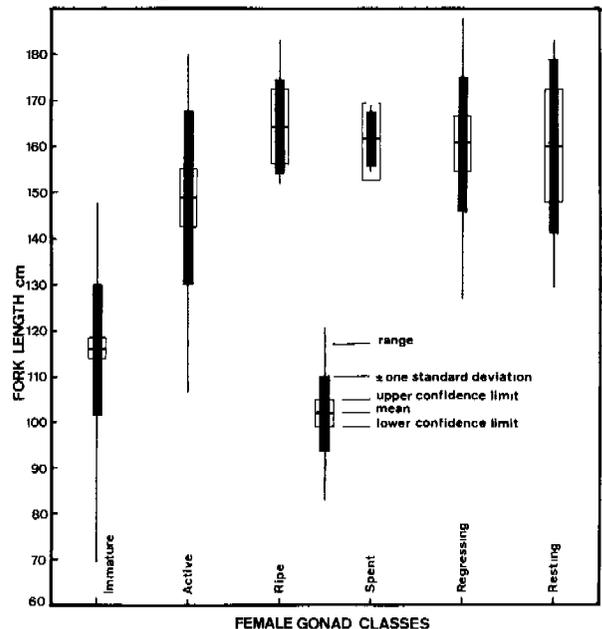


Figure 15. Length-range diagram for female gonad classes of gill-netted sturgeon.

Shubina (1970:91) reported on the differential migration routes of pre- and post-spawning sevryuga, *Acipenser stellatus* (Pallas), in Volga River. Volga River flow rates are similar to those of Suwannee River. Shubina traced routes taken by different size ranges of migrating males and females, showing that large post-spawning females (>160 cm, TL) "irrespective of their point of release . . . proceeded . . . where depths and flow rates were greatest". If sturgeon in Suwannee River behave similarly, then they would pass by anchored gill nets placed in relatively shallow water near the

TABLE 5. VALUES FOR GILL-NETTED FEMALE STURGEON

	IMMATURE	ACTIVE	RIPE	SPENT	REGRESSING	RESTING	TUMORS	MEAN FL (cm)
Mean % Gonad Weight to Body Weight	0.67	3.61	12.67	2.15	3.28	1.93		
Age Range(1973)	6-12	8-17	12-26	12*	12-17	8-15		
Length Range (cm)	69.8-148.0	106.7-180.3	152.4-182.9	154.9-168.9	127.0-188.0	129.5-182.9		
Mean Fork Length	115.8	148.9	164.3	161.6	160.6	160.1		
PERCENTAGE OF OCCURRENCE								
Spring 1972**	60.0	12.8	—	5.1	12.8	10.2		132.4
Fall 1972	71.2	20.0	1.2	—	6.2	1.2	7.5	127.7
Spring 1973	73.2	4.6	2.3	1.2	16.3	2.3	3.5	127.3
Fall 1973	82.6	11.6	4.6	—	—	1.2	4.6	120.3
Overall	73.5	12.0	2.4	1.0	8.2	2.4		

\*Only one specimen was positively aged in this developmental class.

\*\*Eighteen specimens were caught by drifted gill nets (method described in text). Mean fork length computed separately for this group was 140.6 cm. Other values were not used in this table.

river banks. In pre-spawning migrations, this trend is reportedly reversed and larger females would become available to the fishery, allowing the capture of spent females (spawning occurring in the previous year). Accordingly, one will observe lower mean fork lengths and lower percentages of larger females (spent, regressing, and resting) in fall than in spring.

I found a smaller percentage of resting females than expected. Roussow (1957) showed that after reaching sexual maturity, *A. fulvescens* require 3-6 years of extended gonadal development before spawning and 1-2 years to recover to a resting state (termed regressing in this study). This pattern is repeated with an average of 4-7 years between spawnings. If this concept can be applied to other sturgeons (as Roussow implies), then obviously few resting females would be encountered and would explain the overall low percentage of these found in Suwannee River populations.

Temporal distribution of fish size and oocyte development within pre- and post-spawning migrations was assessed. Figures 16 and 17 display mean FL, mean Stage I-II and III oocyte diameter during each week of migrations. The pre-spawning migration of 1973 began 9 March. No exact beginning for the 1972 pre-spawning migration is available, because two weeks of that run were unsampled. However, the migration began during the first full week of March as it did in 1973. Last upstream moving fish were caught 3 May 1972 and 10 May 1973.

Post-spawning migrations began 17 October 1972 and 19 October 1973, and ended 24 and 27 November, respectively. In the figures, weeks are

comparable between like migrations.

Expected increases of mean oocyte diameters during spring migrations and decreases of mean oocyte diameters during fall migrations did not occur. Instead, mean Stage I-II oocyte diameters were related to fish length and age, rather than season. Overall, 73.5% of migrating females were immature (Table 5) and did not display short-term oocyte development associated with spawning migrations documented for many teleostean fishes.

#### OVARIAN CYSTS

During removal of gonads for histological preparation, Mr. Corbin observed previously unreported tumor-like growths on several sturgeon ovaries. Ovarian tissue with macroscopic tumors was found and preserved from 7.5% of gill netted females in fall 1972; 3.5% of females in spring 1973; and 4.6% of females in fall 1973 (Table 5). Microscopic examination of this material revealed two types of growths. One was a perifollicular pseudocyst (surrounding follicles) filled with proteinaceous fluid often containing viable oocytes. The other type was a parafollicular serous cyst (a true separate fluid-filled cyst) containing denser proteinaceous fluid. Both types are considered sub-clinical, having little or no effect on adjacent organs, general ovarian development, fecundity, or spawning behavior. Microscopic slides containing this material were accessioned by the Registry of Tumors in Lower Animals, Smithsonian Institution (RTLA nos. 979 and 980).

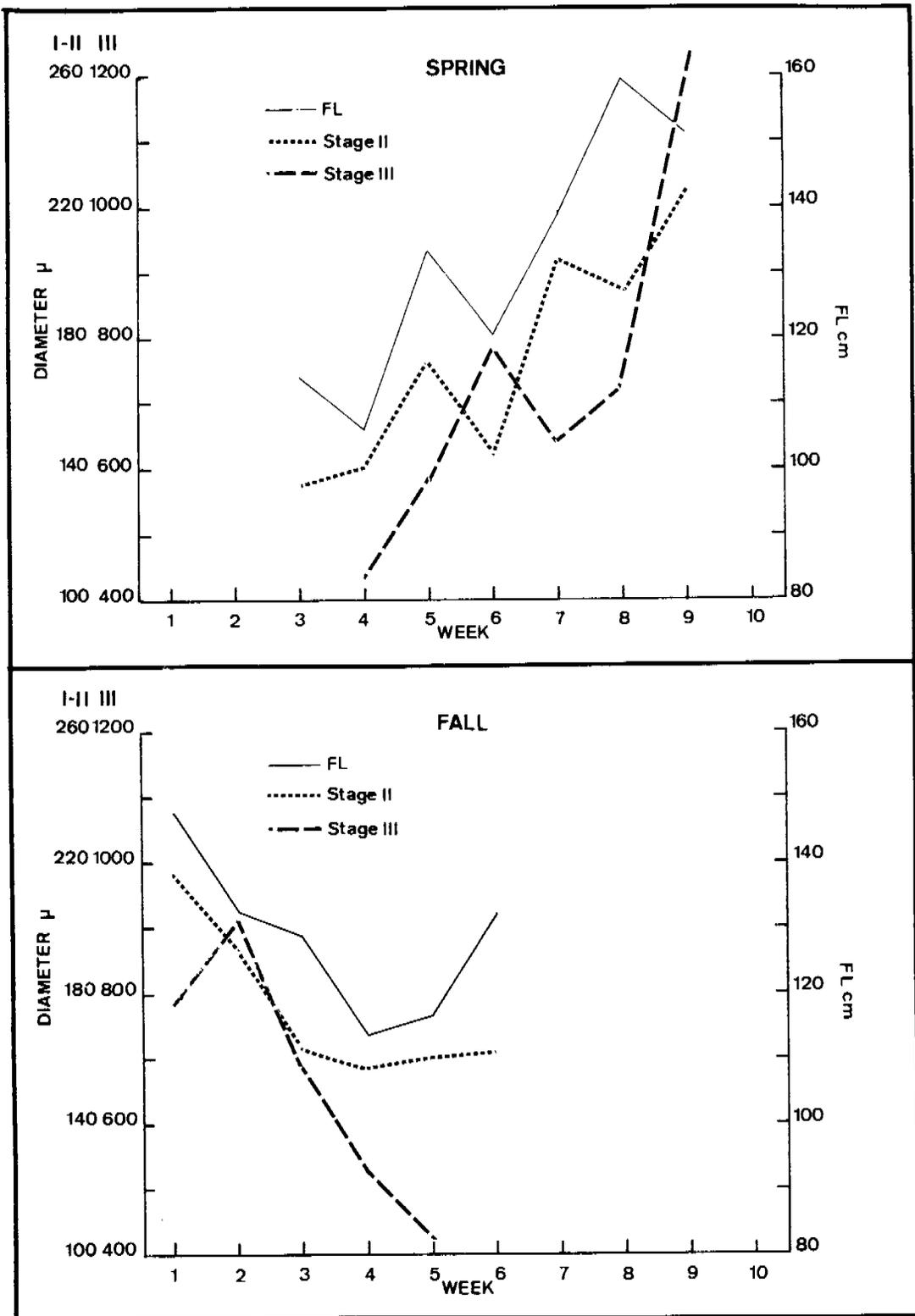


Figure 16. Weekly mean oocyte diameter (Stages II and III) and fork length (1972). (First two weeks of spring migration were un-sampled.)

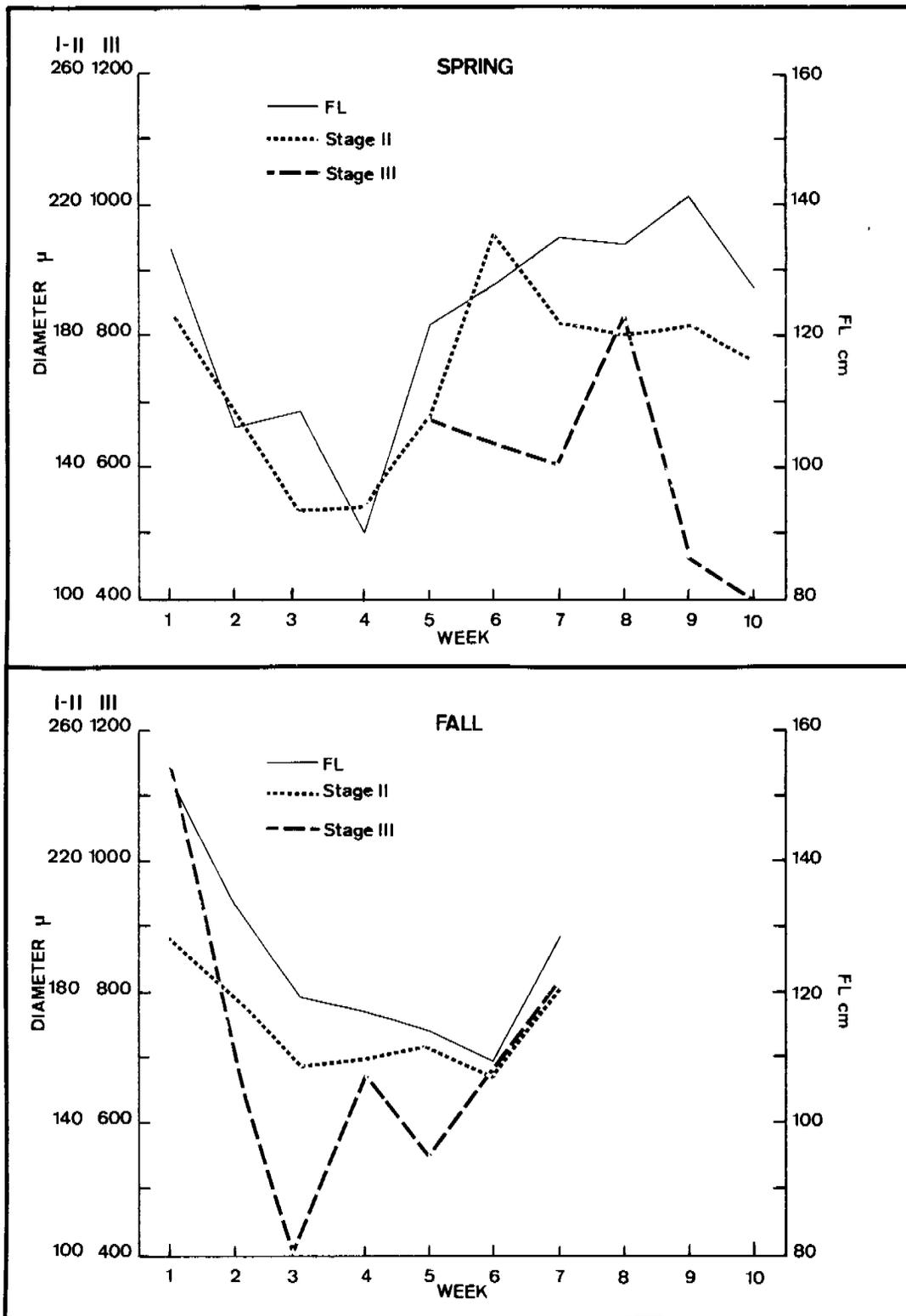


Figure 17. Weekly mean oocyte diameter (Stages II and III) and fork length (1973). (No Stage II oocytes were encountered during week 6 of fall migration.)

### MALE GONAD DEVELOPMENT CLASSES AND SEXUALITY

**Immature:** This class contained mostly spermatogonia and primary spermatocytes in elongate crypts. Packets of secondary spermatocytes or spermatids were rarely observed. There was no evidence of prior spermiogenesis.

**Active:** This developmental class contained occasional spermatogonia, some primary spermatocytes, many secondary spermatocytes, and spermatids. Tailed and untailed spermatozoa were in crypts scattered throughout the gonad. Prior spermiogenesis may or may not have occurred.

**Ripe:** This class gonad contained only readily apparent tailed spermatozoa in swollen, occasionally ruptured crypts. Some partially emptied crypts were found dorsally associated with partially emptied lumen.

**Spent:** This class contained unejected tailed spermatozoa, spermatogonia, and primary spermatocytes in mostly empty crypts. Crypts were shrunken and lined with spermatogonia and primary spermatocytes. Crypts containing unejected spermatozoa were concentrated dorsally.

**Inactive:** This developmental class, often difficult to distinguish from active classes, contained few spermatogonia, some primary spermatocytes, numerous secondary spermatocytes and spermatids. Tailed and untailed spermatozoa from previous advanced development were found in crypts with secondary spermatocytes and spermatids. Crypts containing spermatozoa were concentrated dorsally in the testes and not scattered throughout as in active gonads. Inactive testes contained more numerous secondary spermatocytes and spermatids than immature gonads and crypts were less elongate (some crypts were ruptured in ripe gonads, causing a more rotund shape when testes recovered). Active development of males begins between approximately 95 and 130 cm (Figure 18) and mean fork length for each mature class were approximately 30 cm less than comparable female classes.

Table 6 summarizes other sex related data. Age ranges were taken from only positively aged 1973 specimens. No aged spent males were encountered in 1973. However, a spent 13-year old male was captured in fall 1972.

No overall pattern of male migration was indicated in weekly mean fork lengths (Figure 19). However, males, like females, did display a higher mean fork length in spring pre-spawning migrations than in fall post-spawning migrations (Table 6). Mean fork lengths were almost identical between like seasons of 1972-73, indicating possible homogeneous seasonal size composition. Females

did not display this characteristic, which possibly reflected a heterogeneous seasonal size composition caused by apparent greater longevity and length attained by females.

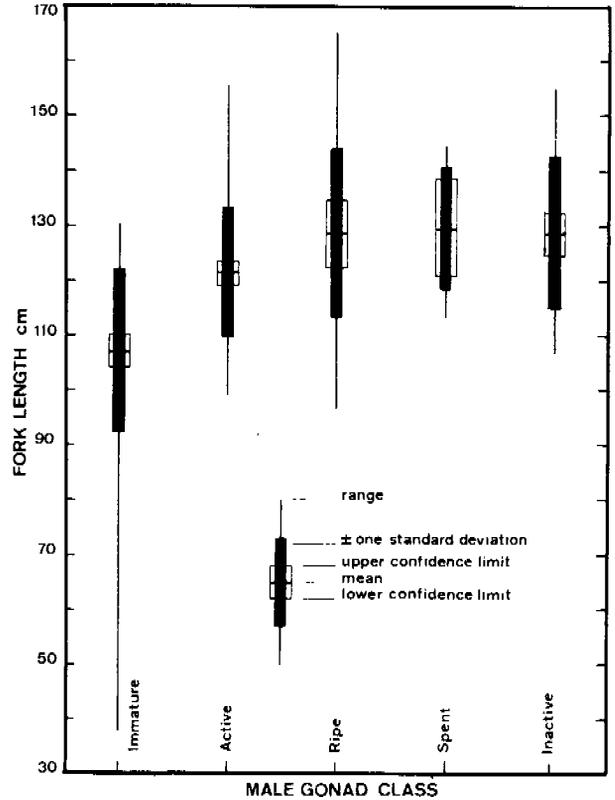


Figure 18. Length-range diagram for male gonad classes of gill-netted sturgeon.

### JUVENILE SEXUALITY

During spring 1973, 106 juvenile sturgeon were captured in a drifted trammel net, ranging in age from less than one to five years. Gonads were too small and unremoved in 55 of these specimens. Five gonads of 51 (9.8%) removed for histological examination were undifferentiated, 20 (39.2%) were male, and 26 (51.0%) were female.

Nine (34.6% of 26) female gonads contained 216 measurable Stage I-II oocytes with mean diameter of 91 microns. All of these fish were 3-year-olds, except for one 5-year-old. Other female gonads contained primary and secondary oogonia from fish aged 2 and 3 years (76.5% were 2-year-olds).

Male gonads from 2-, 3-, and 4-year-old fish contained only spermatogonia and primary spermatocytes.

Sexes began to differentiate at approximately 500 to 700 mm FL (Figure 20). Oocyte development (Stage I-II) in females appeared to begin around 670 mm. Differentiation occurred at ages 2, 3, and 4

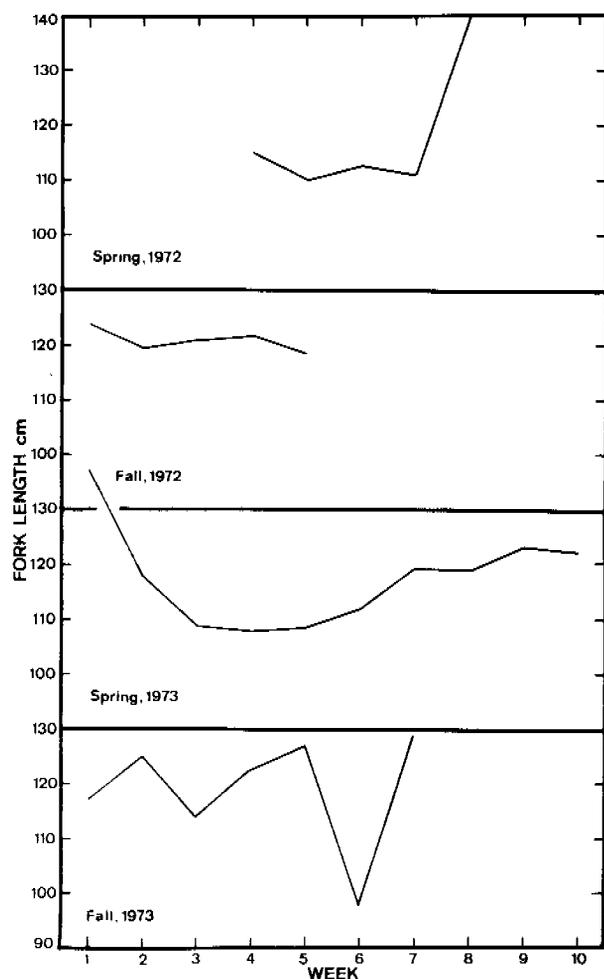


Figure 19. Weekly mean fork length for gill-netted males.

(Figure 21). No undifferentiated age 5 sturgeon were found in either trammel- or gill-netted collections. However, six gill-netted females (age 6-8, 800-1118 mm FL) contained all oogonia with no Stage I and II oocytes.

### SEX RATIOS

Sex ratios displayed apparent seasonal heterogeneity (Table 7) and suggested a sex ratio other than 1:1 in spring 1972-73 (pre-spawning migrations) and possibly fall 1972 (post-spawning migration). Hence, G-statistics (Sokal and Rohlf, 1969; 575) were developed for sex data to test the significance of various ratios (Table 8).

Pooled sex data ( $\delta$ 301;  $\text{q}$ 331) did not differ significantly from a 1:1 ratio. However, the G-statistic was highly significant for seasonal sex ratios, demonstrating considerable heterogeneity among seasons.

Sex data partitioned and tested seasonally displayed significant deviation from 1:1 sex ratio in spring 1972-73. Fall 1972 was marginally insignificant ( $\chi^2 = 3.841$ ;  $P = .05$ ; 1 df), suggesting it may be comparable to the sex ratio of fall 1973.

Tables 7 and 8 indicated homogeneity between comparable seasons. This was tested using a *posteriori* test by STP (Sokal and Rohlf, 1969: 582). G-statistics thus developed demonstrated comparable sex ratios between like seasons favoring females during spring and slightly favoring males during fall.

Sex data for spring of each year and fall of each year were combined and tested for homogeneity between contrasting migrations. The G-statistic thus

TABLE 6. VALUES FOR GILL-NETTED MALE STURGEON

	IMMATURE	ACTIVE	RIPE	SPENT	INACTIVE	MEAN FL (cm)
Mean % Gonad Weight to Body Weight	0.41	1.76	1.94	0.86	1.09	
Age Range (1973)	4-10	7-21	9-16	*	8-22	
Length Range (cm)	38.1-130.8	99.1-155.6	96.5-165.1	113.0-144.8	106.7-154.9	
Mean Fork Length	107.1	121.5	128.6	129.6	128.6	
PERCENTAGE OF OCCURRENCE						
Spring 1972**	30.4	13.0	21.7	8.7	26.1	114.8
Fall 1972	27.6	36.2	9.5	4.8	21.9	120.6
Spring 1973	59.0	26.2	1.6	1.6	11.5	115.8
Fall 1973	17.6	49.4	12.1	—	20.9	120.7
Overall	33.6	31.2	11.2	3.8	20.1	

\* No positively aged 1973 specimen in this developmental class.

\*\*Eleven specimens were caught by drifted gill nets (method described in text). Mean fork length computed separately for this group was 118.5 cm. Other values were not used in this table.

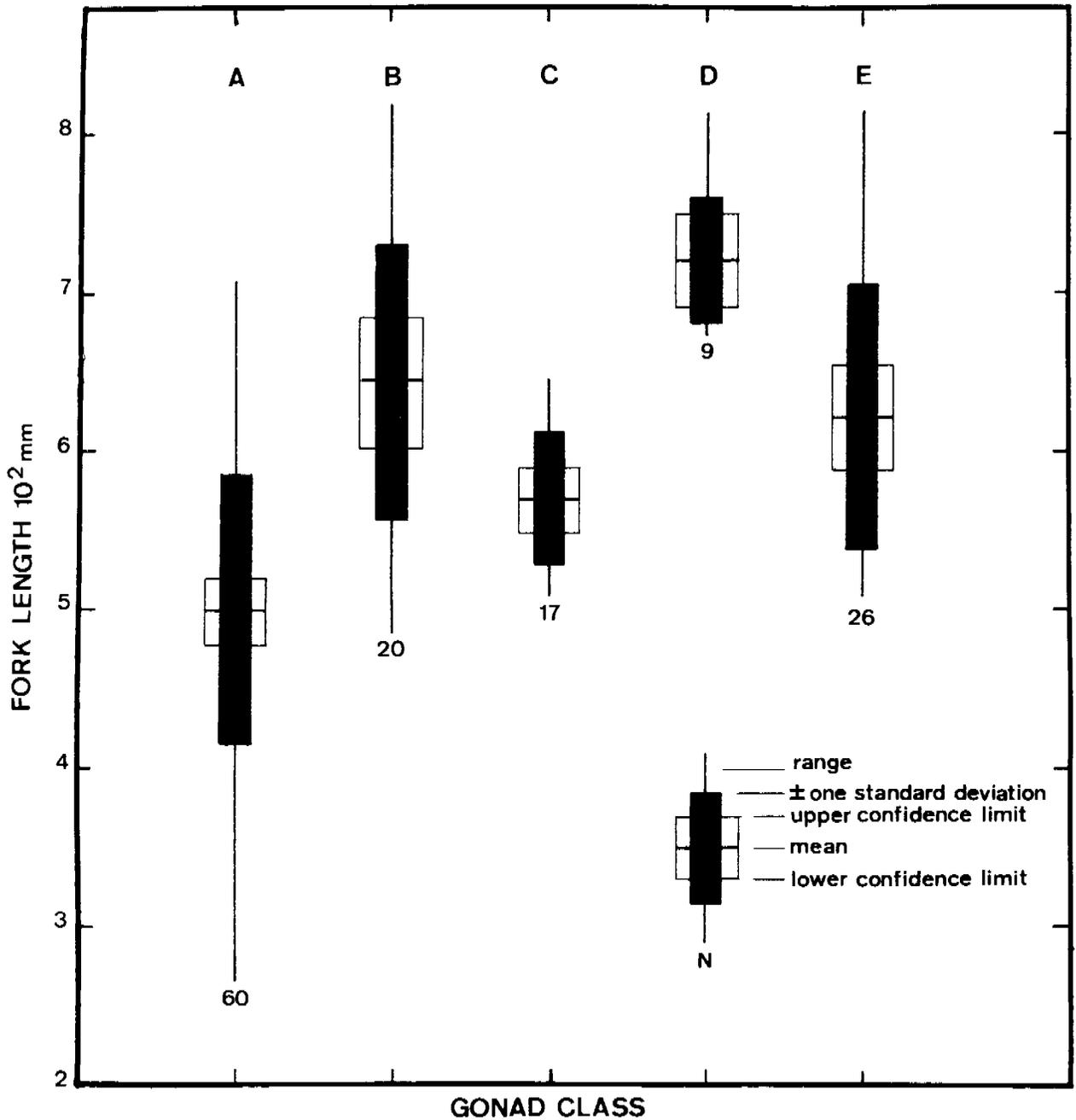


Figure 20. Sex-related length-range diagram for 106 trammel-netted sturgeon: A) specimens with undifferentiated or too small and unremoved gonads, B) males, C) females without oocytes, D) females with oocytes, E) all females.

developed was highly significant, demonstrating (as expected) heterogeneity of sex ratios between pre- and post-spawning migrations.

I believe these differing sex ratios are the strongest indirect evidence of previously discussed differential migration routes chosen by pre- and post-spawning sturgeon (Shubina, 1970). Assuming

an indicated 1:1 overall sex ratio, then it is apparent that females actively seeking shallow water during spring and deep water during fall would significantly alter seasonal sex ratios. Shubina also reports that distribution of males across the river bed was more uniform (avoiding either extreme of depth) and hence, would be less influential to sex ratios.

## DIET

Stomachs of sturgeon gill netted in East Pass (Figure 22) contained partially digested, fibrous, dark green vegetable material interspersed with occasional crab hard parts (probably blue crab, *Callinectes sapidus* Rathbun). Relative abundance of crab parts was generally greater in stomachs of pre-spawning migrants than in those of post-spawning migrants (most post-spawning migrants had no crab parts). Opportunistic feeding is indicated; blue crabs are unavailable beyond tidally influenced portions of the river, and hence, an unavailable dietary item in the upper river. Data indicate that post-spawning migrants spend little time feeding in the tidally influenced lower river (blue crabs are readily available there during fall), quickly moving into the Gulf of Mexico.

Stomach contents were similar among trammel-netted juveniles (Alligator Pass, Figure 22), primarily containing gammaridean amphipods (Family Haustoridae). These organisms are generally associated with bottom similar to the submerged tidal sand bank where these sturgeon were netted. Other food (less than approximately 5% by weight) found in five randomly preserved stomachs included isopods (*Cyathura burbancki*), midge larvae, mud shrimp (*Callinassidae*, probably *Callinassa* sp.), an eel (*Moringua* sp.), and some unidentifiable tubular animal or vegetable matter. Apparently, these small sturgeon occupy a different benthic habitat, consuming primarily animal material until entering the gill net fishery of East Pass.

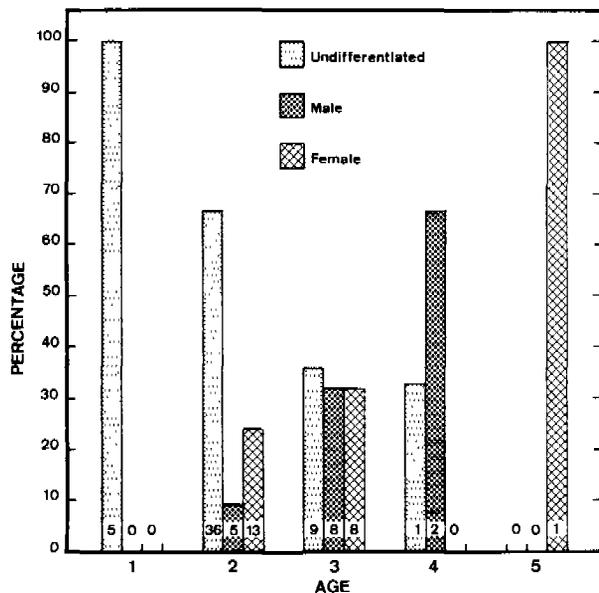


Figure 21. Relative abundance of undifferentiated, male and female, sturgeon in age classes 1-5 of trammel-netted specimens.

TABLE 7. MALE, FEMALE, AND TOTAL CATCH BY YEAR AND SEASON WITH MALE/SEASONAL TOTAL RATIO

	MALE	FEMALE	TOTAL	MALE RATIO
1972				
Spring	39	71	110	0.354
Fall	106	81	187	0.567
1973				
Spring	62	92	154	0.402
Fall	94	87	181	0.519
Total*	301	331	632	

\*Table does not include 2 fish caught in Spring, 1973, with confused sex data.

TABLE 8. SUMMARY OF G-STATISTIC ANALYSIS OF SEX RATIOS

TEST	df	G	SEASON	df	G
Pooled	1	1.364 ns	1972		
Heterogeneity	3	17.522 *	Spring	1	9.435 *
Total	4	18.886 *	Fall	1	3.334 ns
			1973		
			Spring	1	5.868 *
			Fall	1	0.254 ns
			Total	4	18.891

Difference between G-totals due to rounding error.

\* significant at 5% level

ns-not significant

## EGG AND LARVAL SAMPLING/ SPAWNING GROUNDS LOCATION

One-meter bottom plankton nets were used in unsuccessful attempts to capture sturgeon eggs and larvae. Sturgeon eggs are large (2.6-3.0 mm diam), demersal, and adhesive. An external membrane of post-spawned eggs absorbs water, becoming sticky within one hour (Vladykov, 1963; Vladykov, personal communication). I had hoped that plankton nets placed close enough to spawning sites would capture short-term, free floating eggs before they become attached to substrates. Apparently, these eggs have sufficient specific gravity for them to remain relatively unaffected by swift river currents and hence, unavailable to fixed plankton nets.

Assuming that sturgeon successfully spawned, my inability to catch larvae and small juveniles is less easily explained. The nets captured catfish (*Ictalurus* sp.) and gar (*Lepisosteus osseus*) larvae, which are benthic in earliest stages of development. However, both species soon become free swimming, associating with shallower habitats (Mansueti and Hardy, 1967). Perhaps larval and juvenile sturgeon remain closely associated with deep bottom habitats, never rising sufficiently in the water column to become susceptible to capture.

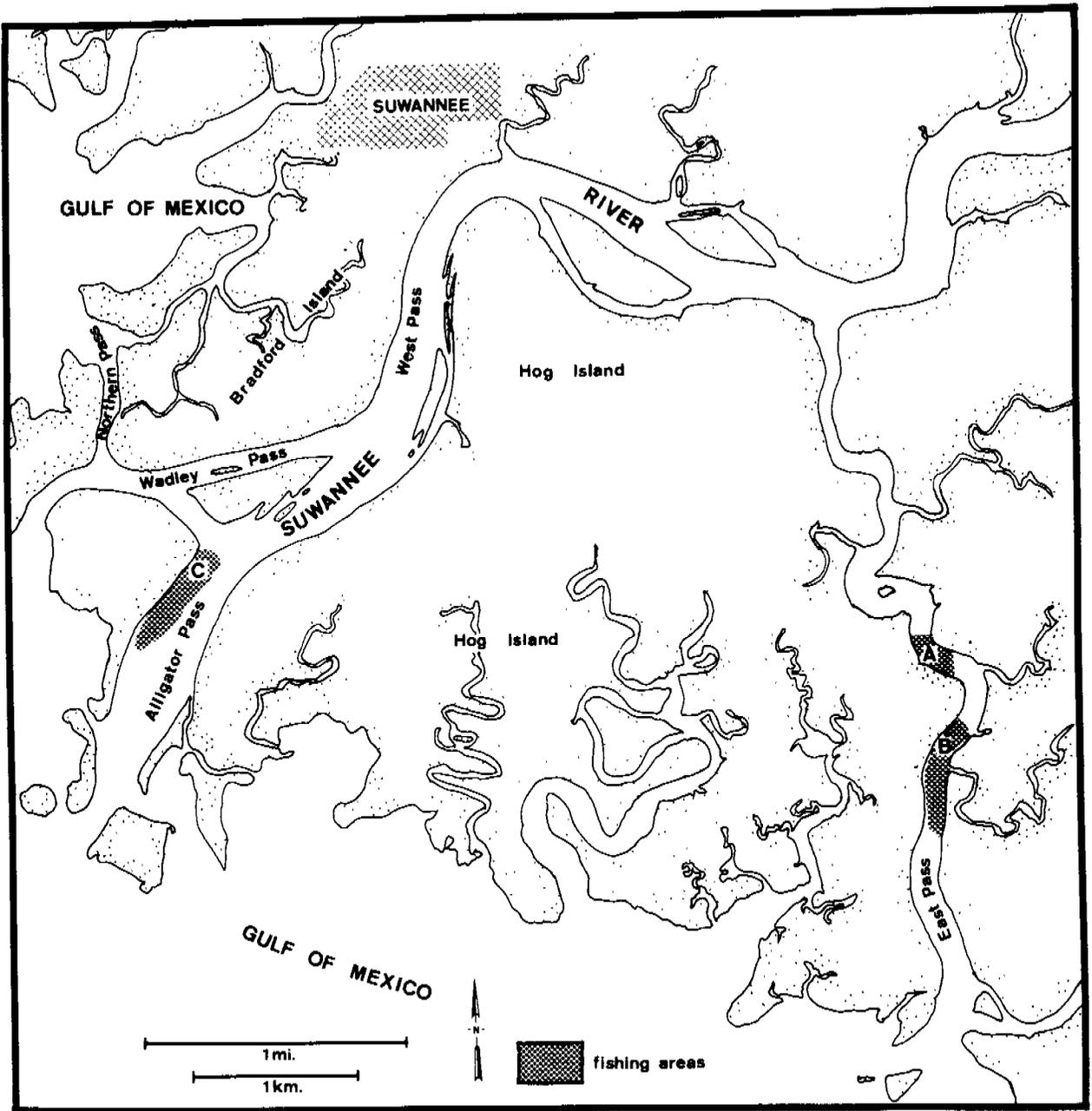


Figure 22. Map of Suwannee River mouth.

Predominant fish fauna found in plankton samples was larval catfish. Seventy-three clupeid eggs (probably *Alosa alabamae*) found in several samples from various stations at different times (Figures 23 and 24 and Appendix I) were the only eggs captured.

River conditions prevented use of most conventional methods of collecting eggs, larvae, and small juveniles. Tannin-stained water and swift currents deter observations and subsequent hand collection of eggs. Large, floating logs and strong currents hamper placement of trap nets to capture larvae and juveniles. Limestone outcroppings, rock, rubble, and submerged logs prevent bottom trawling for larvae and juveniles.

Spawning areas are probably located above Ellaville (Figure 24) and possibly extend above Big Shoals near White Springs. Big Shoals is probably impassable to sturgeon during low water periods. Mr. Corbin has followed and netted sturgeon upstream to shoals below Ellaville (station o) where hard bottom snags prevented further fishing. Fathometer recordings confirm that discontinuously exposed limestone bottom begins at these shoals and extends as far upstream as Stephen Foster Memorial near White Springs (upper limit of our survey).

Sturgeon spawn over hard bottom in running water (shoals) and in pools below waterfalls (Dees, 1961; Vladykov, 1963). Fathometer tracings recorded during spring flooding (1973) revealed suitable bottom and conditions existing in numerous areas between Ellaville and White Springs. These areas were typically located in and below bends, often having rugged bathymetry varying as much as 6 m (20 ft). Unsuitable bottom existed in straight reaches where sediments generally accumulated. No suitable spawning bottom or conditions were found below Ellaville.

Of chemical and physical parameters measured at each station (Appendix I), hardness and water temperatures were notable. Surface and bottom temperatures, with one exception, never varied more than 0.5°C. Hardness was similarly low for stations a through h (average 72.1 mg/l) and similarly high for stations i through ff (average, 151.6 mg/l). The Alapaha River enter between stations i and h, evidently contributing significant amounts of CaCO<sub>3</sub>.

#### EARLY LIFE IN-RIVER MOVEMENT AND ANADROMOUS MIGRATION

Miscellaneous observations, collections, and communications indicate that young sturgeon may begin participating in spawning runs as early as age one. Vladykov (personal communication) spec-

ulated that sturgeon fry "gradually move to the estuaries and eventually to the sea." Florida Game and Freshwater Fish Commission personnel gave me a young sturgeon captured in Santa Fe River (near Branford, Figure 24) in January 1974. This specimen was 1+ year old, spawned in summer 1972. It may have remained in the river since then or may have migrated to the estuary during fall or winter after its birth, returning upstream the following spring (1973). Annual spring appearance of yearlings and older sturgeon in the river mouth would tend to support the latter.

Mr. Corbin reported annual observations of small sturgeon over a submerged sand bank in Alligator Pass (Figure 22). He subsequently aided our attempts to capture these individuals in spring 1973. One of these was apparently less than a year old and the others ranged from 1-5 years. This would indicate at least an annual return to the river mouth. Additionally, Mr. Corbin observed small sturgeon (2.3 kg [5 lb] or less) schooled on the surface and rapidly leaving the river in December 1973. These sturgeon would be similar in size and age as those captured in spring. Sightings and capture of juveniles in Alligator Pass in spring and the sighting of juveniles leaving the river in December would indicate that they may have participated in pre- and post-spawning migrations.

#### FISHING PRESSURE

Present fishing pressure is limited by geographical river characteristics and fishing techniques. Figure 22 displays the Suwannee River mouth with labelled fishing areas. Sub-adults and adults were gill-netted in areas A and B (East Pass) and juveniles were trammel-netted in area C (Alligator Pass). Of several river entrances, only East Pass is commercially exploited, leaving other potential migration routes unfished. Nets were placed in eddies of East Pass which do not exist in other passes. Sturgeon entering these passes can never be exploited using anchored gill nets, because swift currents and tides render this gear ineffective.

When sturgeon pass fishing areas of the river mouth, they become vulnerable to drift gill netting, which may be pursued upstream to Ellaville. Requiring more effort and operating costs, this method is currently not extensively employed. If drift gill-netting again became popular, resulting in significantly increased effort, then some regulation may be necessary. This could be easily accomplished by limited numbers of drift nets used and limiting operations to fall, post-spawning migrations.

Anchored gill nets were relatively unselective, capturing sturgeon between 38 and 188 cm FL (1.2-6.2 ft), weighing approximately 3.6 to 58.2 kg

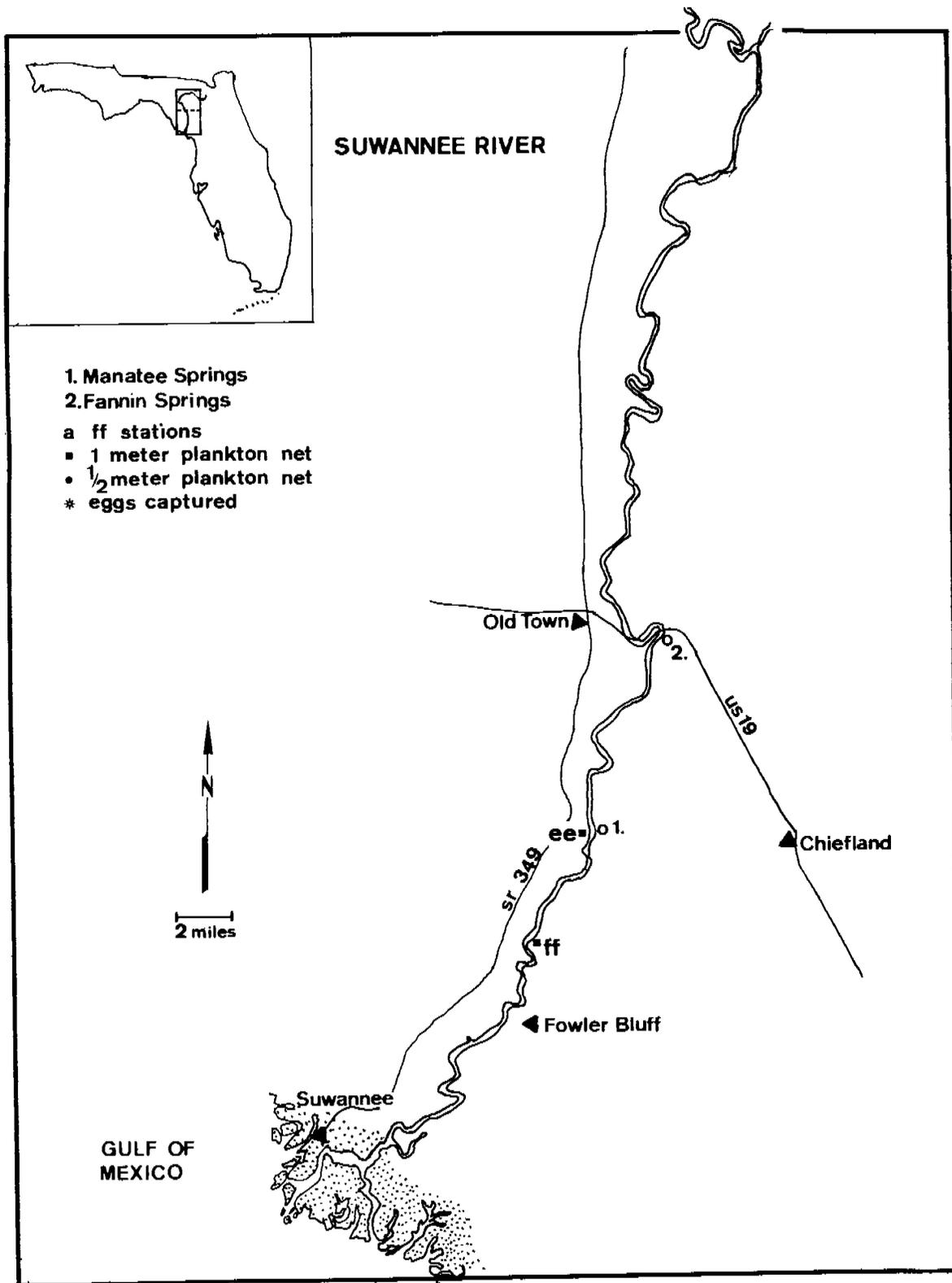


Figure 23. Map of southern Suwannee River.

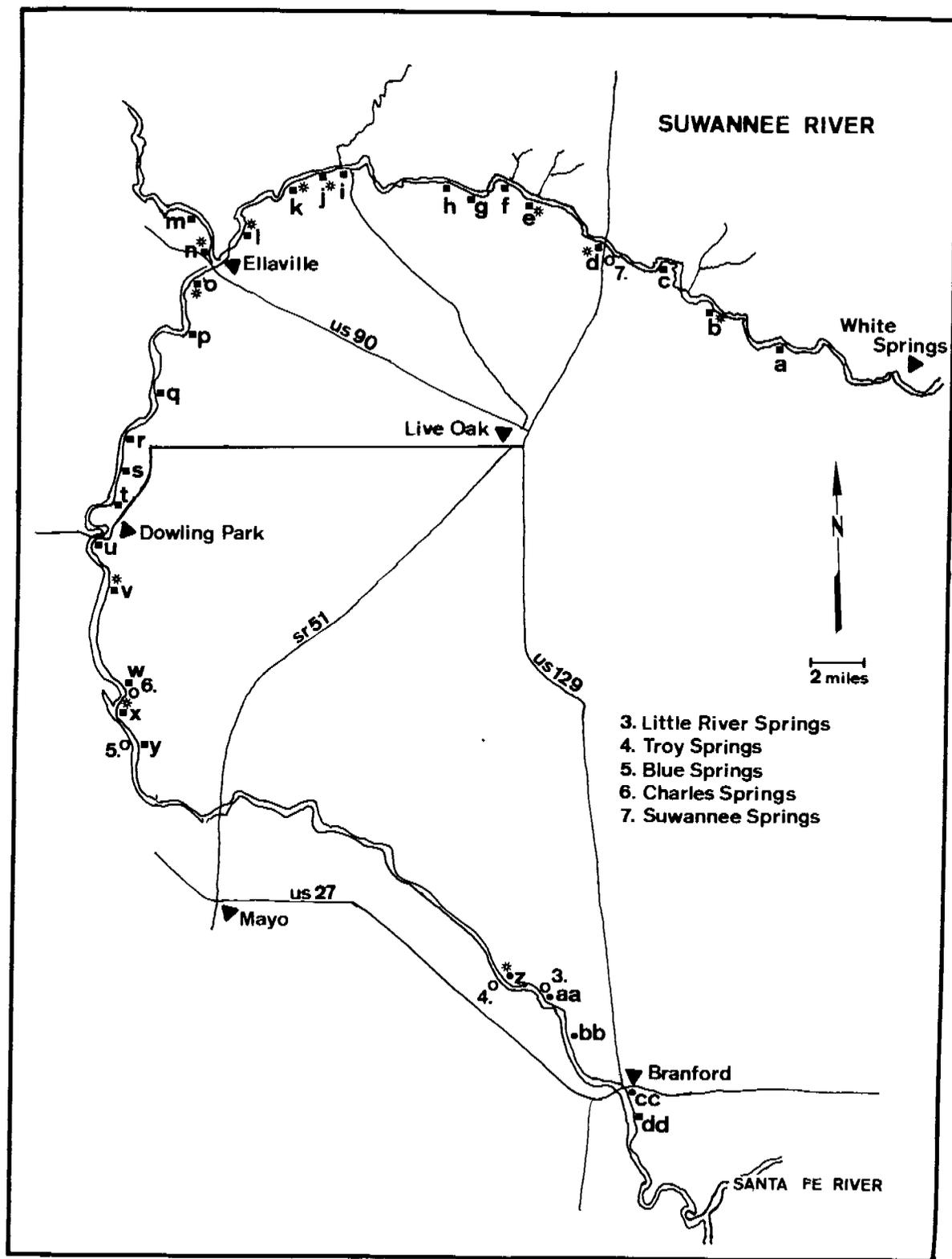


Figure 24. Map of northern Suwannee River.

(8-128 lbs). Gear selectivity is reduced by dermal scutes, which are strongly expressed in small sturgeon. These scutes are angular with a recurved apex, encouraging entanglement and subsequent capture. With increasing age, as sturgeon become vulnerable to gilling, scutes flatten, becoming smoother and less angular. Very large, less easily enmeshed fish will repeatedly hit gill nets, increasing their chances of capture. Lack of gear selectivity allows development of relatively unbiased statements and conclusions regarding common sturgeon populations in Suwannee River.

Illegal trammel-netting of juveniles (only 10 in gill nets may be used) was observed in Alligator Pass during spring 1973. An individual was seen on several occasions fishing the same submerged sand bank where we caught juvenile study specimens. These young sturgeon are unusually vulnerable to this gear (dermal scutes encourage entanglement), allowing near complete removal of schooled, feeding fish. This could be done on a daily basis until stocks were depleted. This activity, if repeated annually, represents an intolerable threat to the fishery and should be actively discouraged.

### SUMMARY AND CONCLUSIONS

1. Life history of common sturgeon, *Acipenser oxyrhynchus desotoi*, was studied during spring and fall spawning runs of 1972-73 in Suwannee River, Florida.
2. Although the history of most United States and Florida sturgeon fisheries has been one of overfishing and decline, the Suwannee River fishery has remained viable.
3. Opercular plates were initially collected in 1972 as possible aging structures. When they were found unsuitable, pectoral fin rays were collected (1973), sectioned, and examined for age determination (72% readable).
4. Fishery seasonality and procedural variabilities of sectioning fin rays prohibited measurement of marginal increment to establish time of annulus formation. However, most spring migrants (8%) had no marginal annulus and most fall migrants (66%) had marginal annuli, indicating in-river annulus formation.
5. Sectioned pectoral fin rays were structurally insufficient for back-calculation measurements. Growth was empirically determined using mean fork length for each age class ( $FL = 369.2326 \text{ Age}^{0.5284}$ ).
6. Nine length-weight formulae were generated according to sex, season, and capture method. All 36 possible paired combinations of regression lines were tested (ANCOVA) and, with two exceptions, were significantly different and noncombinable, probably caused by sexual dimorphism differences in relative gonad weight and in-river migratory and environmental stresses.
7. Female sexual maturity occurs at age 8-12, male sexual maturity at age 7-9. Sturgeon begin entering the fishery at age 4-5, and become significantly exploited by age 6.
8. Most females (72.5%) were immature. No short-term sympathetic increase or decrease of oocyte diameter occurred in upstream or downstream migrating non-spawning females. However Stage II oocyte diameter appeared directly related to fork length.
9. Heterogeneity of sex ratios between contrasting spawning runs (spring vs. fall) and homogeneity of sex ratios between like seasons of 1972-73, were considered strong evidence that sturgeon choose different migration routes according to sex and direction of in-river movement. Larger females seeking shallow water when migrating upstream and deep water when migrating downstream most likely affected sex ratios of gill net landings.
10. Trawling for eggs and larvae to locate spawning grounds was not possible in the upper river. Anchored 1-m bottom plankton nets failed to collect these forms. However, field observations, interviews, and suitable bottom characteristics suggest spawning areas from Ellaville upstream to White Springs and possibly farther, depending on river height.
11. Miscellaneous observations, interviews, and collections indicate that common sturgeon may begin anadromous migrations as yearlings.
12. Current fishing pressure is limited by geographical river characteristics and fishing techniques. Continued harvesting of commercial stocks is not endangered as long as current levels of exploitation by 10-in gill net are not greatly exceeded.

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## APPENDIX I

## PHYSICAL AND CHEMICAL STATION PARAMETERS WITH SAMPLING DATES

DATE	AIR TEMP	SURF TEMP	BOT TEMP	pH	O 2	CO 2	HARD- NESS	DEPTH	CURRENT VELOCITY
a 6-12,13-72	26.0	25.5	25.8	6.8	5.6	15	85.8	1.5	0.42
b 5-24,25-72*	27.0	25.0	25.0	6.5	6.0	45	68.6	1.2	0.50
6-12,13-72	26.5	25.5	25.8	6.8	6.0	15	85.8	1.0	0.50
c 5-24,25-72	26.0	25.6	25.8	6.8	6.2	40	68.6	2.1	0.44
6-12,13-72	25.0	25.5	25.5	6.8	6.4	25	85.8	1.8	0.31
d 5-24,25-72*	25.0	26.0	26.0	6.5	5.6	45	68.6	1.5	0.50
6-12,13-72	25.0	25.5	25.5	7.2	6.4	15	102.9	1.5	0.44
6-05,06-73	—	25.0	25.5	5.0	6.8	30	51.5	3.0	0.34
7-10,11-73	—	28.2	28.5	6.0	6.0	35	51.5	2.4	—
e 5-24,25-72*	27.0	26.0	25.8	7.0	5.6	45	85.8	1.2	0.67
6-12,13-72	26.0	25.5	25.5	6.8	6.4	15	102.9	3.0	0.22
f 5-24,25-72	29.0	26.2	25.8	7.0	5.6	45	85.8	1.8	0.67
g 7-10,11-73	—	27.0	27.5	6.0	5.4	20	51.5	3.6	0.40
h 6-05,06-73	—	26.0	26.0	5.2	6.8	25	34.3	6.7	0.75
7-10,11-73	—	27.0	27.5	6.0	5.4	20	51.5	4.6	—
i 6-13,14-72	23.0	24.2	24.0	7.2	5.4	15	154.4	1.2	—
j 5-23,24-72*	23.2	23.2	23.4	7.3	4.4	60	137.3	1.8	0.80
6-13,14-72	22.0	23.2	23.5	7.5	3.6	15	137.3	1.2	0.57
k 5-11,12-72* <sup>0</sup>	—	—	—	8.5	3.4	40	137.3	1.5	0.80
5-23,24-72	22.5	23.2	23.1	7.3	3.4	35	120.1	1.5	0.57
6-13,14-72*	21.0	23.0	23.0	7.2	4.2	10	154.4	4.6	0.44
l 5-11,12-72* <sup>0</sup>	—	—	—	6.8	3.6	30	120.1	2.1	0.67
7-11,12-72	—	25.0	25.0	6.8	5.0	20	85.8	4.6	0.38
m 5-23,24-72	21.9	23.0	23.0	8.5	4.0	40	137.3	1.8	0.44
7-11,12-72	—	25.0	25.0	7.5	5.0	10	137.3	4.6	0.35
n 5-11,12-72* <sup>0</sup>	—	—	—	7.5	3.8	50	137.3	1.5	0.57
5-23,24-72*	22.5	23.0	23.0	8.5	4.0	40	120.1	1.5	0.57
6-13,14-72	20.0	23.2	23.0	7.2	4.6	15	154.4	1.2	0.44
o 5-11,12-72* <sup>0</sup>	—	—	—	7.8	3.8	40	137.3	3.0	0.67
5-23,24-72*	22.0	23.0	23.0	7.8	4.0	45	154.4	3.0	—
6-13,14-72	20.7	23.2	23.0	7.8	4.5	10	171.6	1.8	0.53
6-05,06-73	—	25.0	25.5	6.5	6.2	15	34.3	4.9	0.60
7-11,12-73	—	25.0	25.3	7.0	5.0	15	102.9	2.7	0.53
p 6-14,15-72	28.2	24.5	24.5	7.3	5.6	10	171.6	3.6	0.36
q 6-14,15-72	25.0	24.5	24.5	7.5	5.4	5	188.8	2.4	0.44
r 6-14,15-72	24.5	24.7	24.7	7.7	6.0	15	205.9	3.0	0.50
s 6-14,15-72	25.2	25.0	25.0	7.2	6.0	15	188.8	1.5	0.50
t 6-14,15-72	25.5	25.0	25.0	7.5	6.0	10	188.8	1.8	0.67
u 6-15,16-72	25.0	25.5	25.5	7.5	6.2	10	188.8	1.8	0.50
v 6-15,16-72*	27.0	25.5	25.5	7.5	6.8	15	188.8	2.4	0.50

w 6-15,16-72	29.0	25.5	25.5	7.5	6.6	5	188.8	2.4	0.50
x 6-15,16-72*	27.5	25.2	25.2	7.5	6.6	15	188.8	3.0	0.50
y 6-15,16-72	28.5	25.0	25.5	7.4	6.6	15	171.6	2.1	0.40
z 5-10,11-72* <sup>o</sup>	24.0	23.5	—	7.8	5.2	35	171.6	6.4	0.67
aa 5-10,11-72 <sup>o</sup>	24.5	23.0	—	8.3	5.0	55	171.6	3.0	0.57
bb 5-10,11-72 <sup>o</sup>	—	23.0	—	7.5	5.0	35	205.9	3.6	0.67
cc 5-10,11-72 <sup>o</sup>	—	23.0	23.0	7.5	5.0	35	154.4	6.7	0.50
dd 7-20,21-72	31.0	27.0	26.8	7.3	6.0	15	137.3	3.0	0.67
ee 7-18,19-72	28.0	27.5	26.5	6.8	6.2	10	137.3	2.1	0.67
ff 7-18,19-72	29.0	27.0	26.8	6.8	—	15	137.3	3.0	0.50

\* eggs found in sample

<sup>o</sup> 1/2 meter plankton nets  
temperatures (C°); O<sub>2</sub>, CO<sub>2</sub>, hardness (mg/l); depth (m); current (m/sec.)

## APPENDIX II

### SUMS OF SQUARES, SUM OF PRODUCTS FOR AGE-LENGTH REGRESSION

$\Sigma x^2$	$\Sigma y^2$	$\Sigma xy^2$
1.9110	0.5478	1.0098

## APPENDIX III

### SUMS OF SQUARES, SUM OF PRODUCTS FOR LENGTH-WEIGHT REGRESSION

	$\Sigma x^2$	$\Sigma y^2$	$\Sigma xy^2$
1.	0.1011	1.0563	0.2961
2.	0.4681	4.9801	1.5091
3.	0.3813	3.0454	0.8744
4.	0.5241	4.4654	1.3998
5.	0.2228	1.4856	0.4941
6.	0.5725	4.8614	1.5559
7.	0.7851	9.9362	2.7554
8.	0.5081	2.3068	0.9376
9.	0.7128	3.0026	1.0595