Distribution and Population Attributes of Gulf Sturgeon in the Lower Pearl River System, Louisiana

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Abstract: Seven reaches of the lower Pearl River system were sampled with bottom set gill nets from 1992 through 1995. One hundred fifty-eight Gulf sturgeon (*Acipenser oxyrinchus desotoi*) were captured in 3 reaches. Mean fork length (FL) was 734 mm, and weight (W, g) to length (FL, mm) relation was: $W = 1.786 \times 10^{-6}(FL)^{3.204}$. Mean weight loss during summer was 1.9 g/day. Ninety-two percent of Gulf sturgeon were captured in the West Middle River reach which is comprised of deep holes and little current. Radio telemetry indicated that the West Middle River was an important summer habitat for juveniles and subadults. Estimated mean summer population size in the West Middle River, determined from mark and recapture, ranged from 67 to 124 individuals, but low intra-year tag return indicated this may be part of a larger population. Annuli on pectoral fin rays were formed during May–July and 94% of fish aged were <6 years old. Adults (those >1.2 m FL) were scarce, suggesting excessive mortality.

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The Atlantic sturgeon (*A. oxyrinchus*) is a diadromous fish that historically inhabited rivers from Labrador to northeastern Florida on the Atlantic coast and from Tampa Bay to the Mississippi River, and possibly further west, on the Gulf of Mexico coast (Lee et al. 1980). The Gulf of Mexico population, Gulf sturgeon, is recognized as a separate subspecies (Vladykov 1955), presently ranging from the Suwannee River to the Mississippi River (Lee et al. 1980). Gulf sturgeon populations have declined due to over-exploitation (Barkuloo 1988), reduction of spawning habitat by

dam construction, and deterioration of water quality (Wooley and Crateau 1985, U.S. Fish and Wildl. Serv. and Gulf States Mar. Fish. Comm. 1995). In the Suwannee River, Gulf sturgeon require 9–12 years to become sexually mature (Huff 1975), suggesting slow recovery of depleted populations. Consequently, Gulf sturgeon were listed as a federally threatened species in 1991 (U.S. Fish and Wildl. Serv. 1991).

Gulf sturgeon spend cool months (October or November through March or April) in estuarine areas or in the Gulf of Mexico and the balance of the year in freshwater rivers (Odenkirk 1989, Foster 1993, Clugston et al. 1995). They spawn in early spring in freshwater rivers; however, juveniles and subadults also participate in yearly migration (Carr 1983, Foster 1993). Eggs have been collected in the Suwannee River (Marchant and Shutters 1996) and larvae in the Apalachicola River (Wooley et al. 1982), but reproductive behavior and habitat requirements remain poorly understood.

The Pearl River is near the western limits of the Gulf sturgeon range. It drains 22,688 km^2 in central Mississippi and southeastern Louisiana (U.S. Army Corps Eng., Mobile Dist. 1970), flows into Lake Borgne and the Rigolets, and is part of the Lake Pontchartrain estuary. The West Pearl River Navigation Project, completed in 1956, provides a minimum depth of 2.1 m from the mouth of the West Pearl River to Bogalusa, Louisiana (U.S. Army Corps Eng., Vicksburg Dist. 1994). The navigation project includes 2 sills that provide minimum pool elevations in the navigation channel: the Pools Bluff sill on the Pearl River and the Bogue Chitto sill on the Bogue Chitto River (Fig. 1). Ross Barnett Dam was constructed at river km 444 in 1964 (U.S. Army Corps Eng., Mobile District 1970). Historically, Gulf sturgeon inhabited many of the larger tributaries, including some upstream of the present location of Ross Barnett Dam (Cook 1959, Lee et al. 1980). At least 5 Gulf sturgeon have been collected between Pools Bluff sill and Ross Barnett Dam since 1970 (Miss. Mus. Nat. Sci., specimen catalogue numbers 15589, 20206; Miranda and Jackson 1987), indicating some upstream migration over Pools Bluff sill. Juveniles and subadults have been collected in the lower Pearl River system downstream from the Pools Bluff and Bogue Chitto sills (Davis et al. 1970, Douglas 1974, Barkuloo 1988, Esher and Bradshaw 1988, Rogillio 1992, F. Pezold, unpubl. data). Presence of juveniles suggests spawning in the Pearl River system; however, few adults have been captured in recent years and their rarity is cause for concern (Rogillio 1992).

We assessed distribution and abundance of Gulf sturgeon in the lower Pearl River system from 1992 to 1995. Our objectives were to a) identify and describe habitat utilized by Gulf sturgeon in the lower Pearl River system, b) determine age structure and population size in this system, and c) make recommendations for future research and management.

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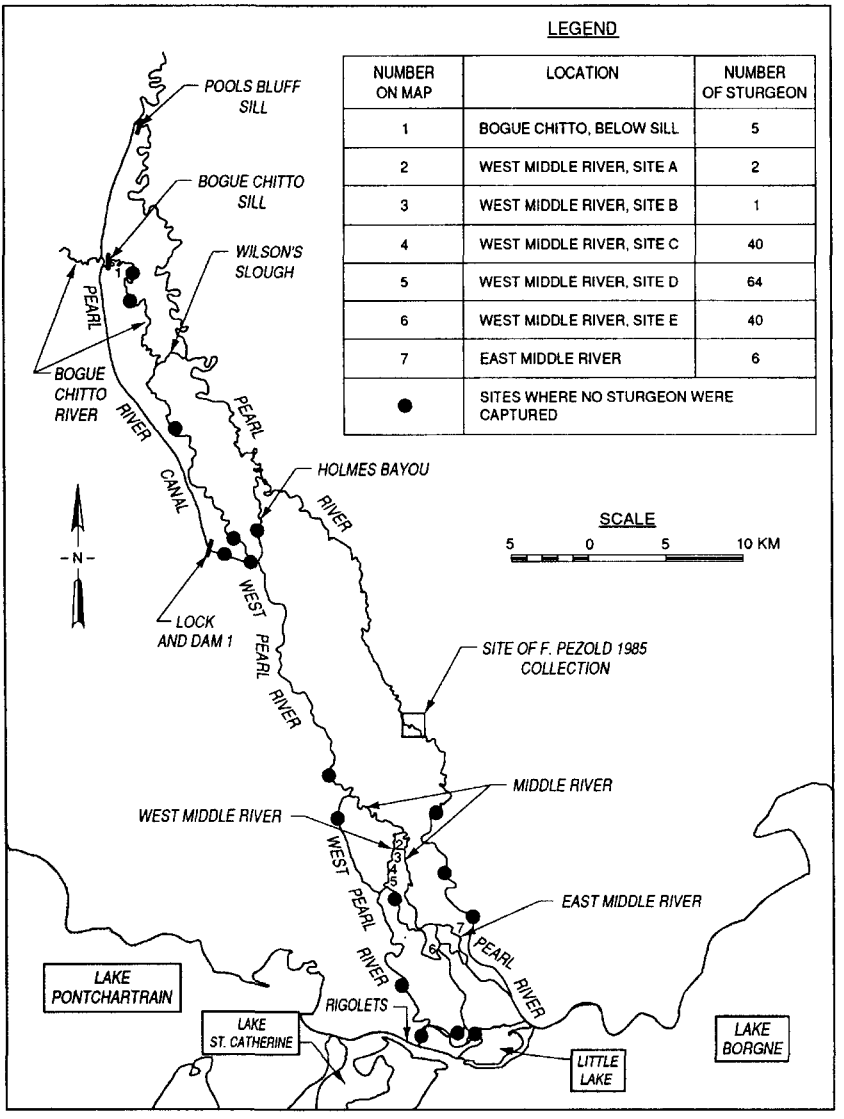

Figure 1. Locations of gill netting sites in the lower Pearl River system, 1992–1995.

of Engineers, Vicksburg District. Museum specimen data were provided by Northeast Louisiana University, Mississippi Natural History Museum, and Tulane Museum of Natural History. F. Parauka of the USFWS provided technical assistance. This project was funded by LDWF, the U.S. Army Corps of Engineers Environmental Management and Restoration Research Program, and the U.S. Army Corps of Engineers, Vicksburg District. Permission was granted by the Chief of Engineers to publish this information.

Methods

This article is the result of a combined effort of LDWF and WES, and methods vary somewhat. All Gulf sturgeon were captured in bottom set gill nets, weighed to the nearest 30 g, and measured for total length (TL) and fork length (FL) to the nearest cm. A weight-length relation for all Gulf sturgeon captured was estimated using a power function (Ricker 1975): Weight = a $(FL)^b$. A Peterson disk (WES) or Floy tag (LDWF) was attached to the base of the dorsal fin and a passive integrated transponder (PIT) tag was implanted on the right side at the posterior base of the dorsal fin and fish were released at the capture site.

Mesh size of gill nets used by LDWF ranged from 14.0 to 22.9 cm stretch and length from 30.5 to 91.5 m. LDWF sampled from April through November 1992 and 1993, May through September 1994, and March through August 1995. WES sampled with 27.5-m experimental (3.81-cm, 7.62-cm, 12.7-cm, 15.2-cm, and 17.8-cm stretch mesh) monofilament gill nets and 45.7-m (30.5-cm stretch mesh) monofilament and multifilament gill nets from January 1994 through August 1995. Water velocity, dissolved oxygen, temperature, and salinity were measured on the surface and bottom at each sampling site and substrate was classified qualitatively.

We sampled 24 sites distributed among 7 reaches in the lower Pearl River system: Bogue Chitto River, West Pearl River, Pearl River Canal, Holmes Bayou, West Middle River, East Middle River, and the Pearl River (Fig. 1). Three sites were sampled on the Bogue Chitto River between the Bogue Chitto sill and the confluence with Wilson's Slough for a total of 348 net hours. The confluence of Wilson's Slough and Bogue Chitto River marks the beginning of the West Pearl River, which runs from there to the Rigolets where it splits into east and west mouths. Sampling effort was 2,186 net hours at 9 sites on the West Pearl River, 574 net hours at 2 sites on the Pearl River Canal below Lock and Dam 1, 90 net hours at 1 site near the mouth of Holmes Bayou, 8,992 net hours at 6 sites on the West Middle River, 79 net hours at 1 site on the East Middle River, and 121 net hours at 3 sites on the lower Pearl River. Most water in the Pearl River flows to the West Pearl River via Wilson's Slough, leaving the Pearl River below Wilson's Slough, the West Middle River, the East Middle River, and Holmes Bayou without appreciable flow except during times of high water. The West Pearl and Bogue Chitto rivers were the only reaches sampled that had appreciable flow during periods of low water.

Fish were radio-tagged by LDWF during 1993 and 1994 and LDWF and WES in 1995. Radio transmitters were cylindrical with external antennae and had stainless steel cables attached to both ends for external attachment. Transmitters were attached by drilling 2 2.4-mm holes in the dorsal scutes through which the attachment cables at either end of the transmitter were run. The attachment cables were then run through a plastic backing plate and clamped together with aluminum cable clamps. In 1993 and 1994, a total of 4 Gulf sturgeon were tagged with radio transmitters in the 150-MHz range with a battery life of 1 year (Table 1). Twenty attempts, 17 by boat and 3 by airplane, were made to relocate these fish between 12 May 1993 and 2 August 1994.

Table 1. Size, tagging location, and tagging date for radio-tagged Gulf sturgeon in the Pearl River-Lake Pontchartrain system.

Date	Location[a]	Fork Length (mm)	Weight (kg)	Tag frequency (MHz)
29 Apr 93	West Middle River, Site E	965	7.0	150.303
6 May 93	West Middle River, Site F	991	7.5	150.273
19 Aug 93	West Middle River, Site D	1,168	13.6	150.633
26 Jan 94	Lake Pontchartrain[b]	1,295	19.1	150.184
25 Jul 95	West Middle River, Site D	635	1.6	49.947
25 Jul 95	West Middle River, Site D	1,003	7.3	49.917
25 Jul 95	West Middle River, Site D	889	4.5	49.878
25 Jul 95	West Middle River, Site D	851	4.2	49.898
25 Jul 95	West Middle River, Site D	521	0.8	49.964
25 Jul 95	West Middle River, Site D	483	0.7	49.934
17 Aug 95	West Middle River, Site D	864	4.6	49.984
25 Aug 95	West Middle River, Site D	914	5.4	49.834

[a]See Figure 2 for locations.

[b]The sturgeon tagged in Lake Pontchartrain was captured by a commercial fisher.

In 1995, 8 fish were tagged with transmitters in the 49-MHz range (Table 1). Two tag sizes were used. Small tags, attached to sturgeon weighing 1.5–3.0 kg, were 46 mm long, 13 mm in diameter, weighed 12.5 g, and had a battery life of 120 days. Large tags, attached to sturgeon weighing >5 kg, were 92 mm long, 21 mm in diameter, weighed 52.3 g, and had a battery life of 360 days.

The West Pearl River (mouth to beginning of lateral canal), Middle River, and West Middle River (Fig. 2) were searched by boat for radio-tagged fish on 2 August, 17 August, 19 September, 10 October, and 11 December 1995. If a sturgeon was located in an area where it had not been on the previous search, it was counted as a relocation. Capture of a radio-tagged sturgeon in a gill net was also counted as a relocation. Global positioning system coordinates were recorded and physicochemical parameters previously described were measured at each relocation site.

Thirty-five Gulf sturgeon captured in the West Middle River during 1995 were aged as described by Rien and Beamesderfer (1994). A portion of the anterior pectoral fin ray was removed by making 2 cuts, the first approximately 1 cm distal to the body and the second approximately 1.5 cm distal from the first cut. Cuts were made with either fingernail clippers or wire cutters. The fin ray was removed and stored in a coin envelope. Fin rays were air dried for 2 months and then cut into 0.3- to 0.6-mm sections using a Buehler Isomet slow speed saw with diamond wafering blade. Sections were polished with 1,500-grit wet sandpaper, mounted on microscope slides using clear fingernail polish, and annuli counted using a binocular microscope at 40× magnification. Each section was read once.

We used the Schnabel method (Everhart et al. 1975) to estimate population size in a 15-km section of the West Middle River for the summers of 1993, 1994, and 1995. This method, estimates population size using the formula:

$$\hat{N} = (C_1 \times M_1) + (C_2 \times M_2) + \ldots (C_i \times M_i)/R_1 + R_2 + \ldots R_i$$

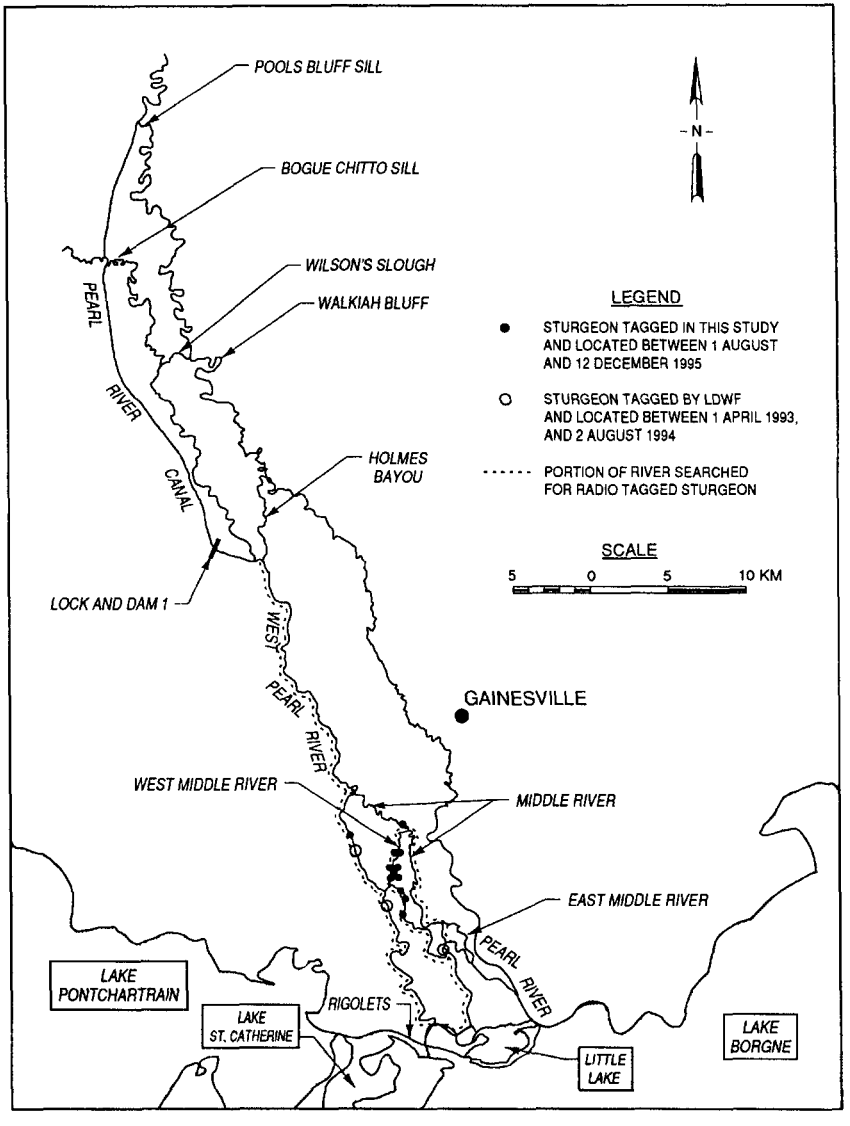

Figure 2. Locations of radio-tagged Gulf sturgeon in the lower Pearl River system.

where $\hat{N}$ is the estimated population size, C is the total number of animals captured per sample, M is the number of tagged animals at large when the sample was taken, and R is the number of tagged animals captured per sample. Each sampling day in which Gulf sturgeon were captured was counted as 1 sample and therefore all within-day recaptures were disregarded. We assumed complete mixing within the West Mid-

dle River, equal catchability of tagged and untagged sturgeon, and no mortality, recruitment, emigration, or immigration during each summer (Seber 1973).

Results

A total of 158 Gulf sturgeon were captured with gill nets at 7 sites in the lower Pearl River system. One hundred forty-seven (93%) were captured at 5 sites on the West Middle River, 6 (4%) were captured at 1 site in the East Middle River, and 5 (3%) were captured at the base of the sill on the Bogue Chitto River (Fig. 1). All sites where Gulf sturgeon were captured in the West Middle River and East Middle River were characterized by 9- to 19-m deep water with sluggish (<10 cm/sec) flows and sand and silt substrates. The site on the Bogue Chitto River, which was immediately below the sill, was shallow (2–3 m deep) with moderate flows (0.5–1.0 m/sec) and sand and gravel substrate. No sturgeon were captured in the West Pearl River, Pearl River Canal, Holmes Bayou, or Pearl River. The West Pearl River had numerous shallow moderate- to fast-flowing riffles, and bendways that were moderately deep (4–9 m) with instream cover of logs and debris. Pearl River Canal and Holmes Bayou were usually nonflowing with depths of 2–5 m. Sites on the Pearl River had little flow and 9- to 15-m depths.

Gulf sturgeon were captured in water temperatures ranging from 15.3 to 33.7 C at the surface and from 15.3 to 30.8 C at the bottom. Dissolved oxygen levels ranged from 5.6 to 9.1 ppm at the surface and 0.3–9.1 ppm at the bottom. Seventy-four percent were captured when sites were thermally stratified with surface temperatures ranging from 25.5 to 33.7 C, bottom temperatures ranging from 24.0 to 27.7 C, and bottom dissolved oxygen levels ≤2.0 ppm. Low salinity (about 3 ppt) was detected on the bottom of the most downstream site (site E) in the West Middle River.

Fork length ranged from 320 to 1,520 mm ($\bar{x}$ = 734 mm, SD = 208 mm). Relation between FL (mm) and TL (mm) was: TL = FL(1.10) + 17.1 and relation between FL and weight (W,g) was: $W = 1.786 \times 10^{-6}(FL)^{3.204}$. Overall, catch per unit of effort was 0.017 Gulf sturgeon/net hour, which ranged from a low of 0.008/net hour in 1993 to 0.279/net hour in 1995. The 35 Gulf sturgeon aged in 1995 ranged from 2 to 11 years old but only 2 individuals were >5 years old (Table 2). Annuli were apparently formed

Table 2. Mean length at age for 35 Gulf sturgeon captured in the West Middle River, May–July 1995.

Age	*N*	Mean fork length (mm)	Range	SD
2	9	459	378–530	52.4
3	9	511	423–635	67.2
4	9	835	572–970	114.5
5	6	859	736–1,103	130.4
9	1	965		
11	1	1,143		

Table 3. Number of Gulf sturgeon tagged, recaptured, and estimated population size (with 95% confidence limits) in the West Middle River.

Year	*N* tagged	*N* recaptured	Estimated population		
			Lower	Mean	Upper
1992	4	0			
1993	17	2	28	67	∞
1994	48	16	59	88	171
1995	59	16	85	124	236

between 20 May and 25 July and consisted of a dark band followed by a thin translucent band.

Total numbers of sturgeon tagged yearly were 6 in 1992, 23 in 1993, 50 in 1994, and 59 in 1995. There were 36 recaptures, 1 in 1992, 2 in 1993, 16 in 1994, and 17 in 1995. All recaptures were intra-year except for 1 fish that was tagged in a separate study in Lake Pontchartrain in March 1994 and recaptured in the West Middle River in summer 1995. All recaptures were in the West Middle River except for 1 fish that was tagged in the Bogue Chitto River in summer 1992 and recaptured by a commercial fisher in Lake Pontchartrain in fall 1992. Estimated summer population size of Gulf sturgeon in the 15-km section of the West Middle River for 1993, 1994, and 1995 was 67, 88, and 124, respectively (Table 3). Weight change of Gulf sturgeon recaptured during summer ranged from a gain of 26.0 g/day to a loss of 14.4 g/day ($\bar{x}$ = −1.9 g/day, SD = 6.8, N = 34).

Of the 12 Gulf sturgeon equipped with radio transmitters, 9 were relocated at least 1 time after they moved from the tagging site. Of these, 1 was relocated 4 times, 1 was relocated 3 times, 1 was relocated 2 times, and 6 were relocated 1 time after tagging. These 15 relocations were distributed among 9 separate sites in the Pearl River system (Fig. 2). Eleven relocations occurred in the West Middle River, 1 occurred in the Middle River, and 3 occurred in the West Pearl River (Fig. 2). Nine of the 11 relocations in the West Middle River were at 3 sites where sturgeon were captured regularly, and these were the only sites with multiple relocations. The other 2 relocations in the West Middle River and the 1 relocation on the Middle River were in sites with similar habitats, i.e., deep bendways with little flow. The 3 relocations on the West Pearl River were in sites with relatively shallow water (2–4 m deep) and moderate to high flows (0.5–1.0 m/sec). Five of the transmitters remained at the same sites for several months suggesting tag loss or death of the fish.

Discussion

Two hundred seventy-one Gulf sturgeon captures have been documented from the Pearl River-Lake Pontchartrain system since 1956 (Morrow et al. 1996) (Fig. 3). Ninety-eight percent of these were collected downstream from Pools Bluff and Bogue Chitto sills. We expended approximately 459,445 net-m hours and captured 193 Gulf sturgeon (including recaptures). Mississippi State University researchers expended

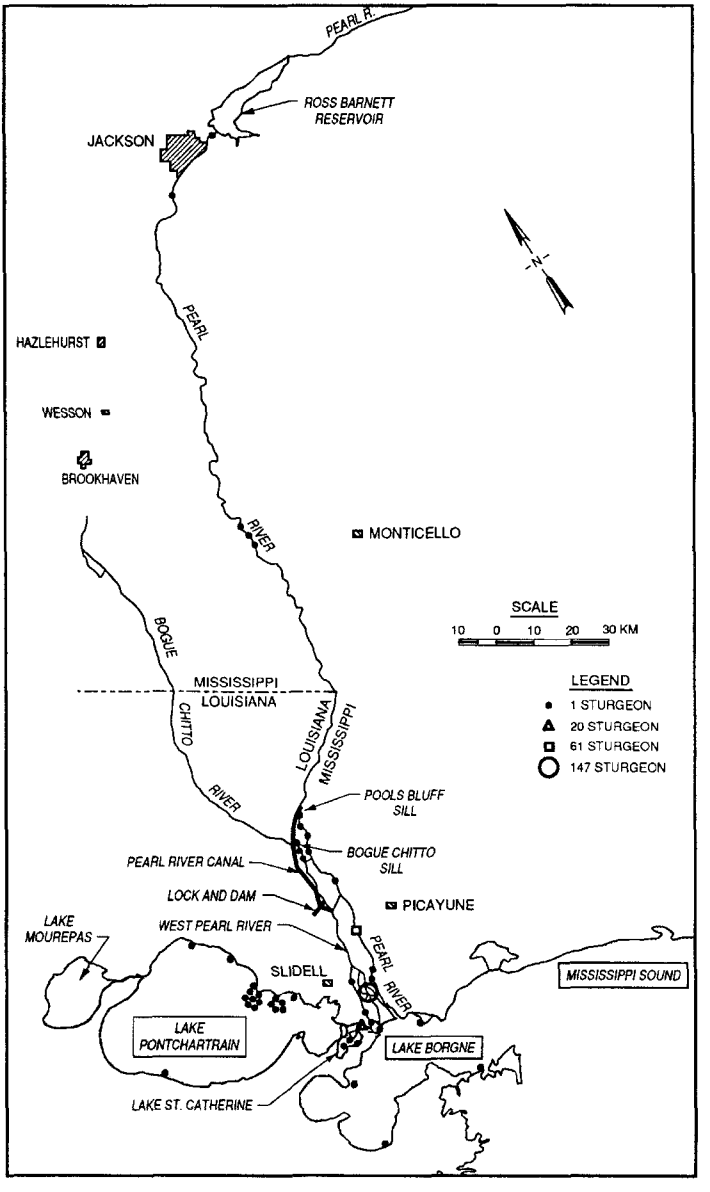

Figure 3. Locations of Gulf sturgeon collections in the Pearl River-Lake Pontchartrain systems, based on specimens captured in this study and records provided by Louisiana Department of Wildlife and Fisheries, Mississippi Museum of Natural Science, Tulane Museum of Natural History, and Northeast Louisiana Natural History Museum.

3,066 net-m hours on the Pearl River below Wilson's Slough (Fig. 1) and captured 68 Gulf sturgeon (F. Pezold, unpubl. data). In contrast, researchers with the Mississippi Museum of Natural Science expended 131,530 net-m hours in the Pearl River system upstream from the Pools Bluff and Bogue Chitto sills and failed to catch any Gulf sturgeon (Knight 1996, 1997).

Gulf sturgeon may be more abundant in the lower Pearl River system because they prefer the sluggish, deep holes that are prevalent in the Pearl River delta, and the sills may partially impede upstream migration. Although Pearl River Gulf sturgeon appear to prefer deep holes during the summer, they have been found in high water velocity and moderately shallow reaches (this study; Tulane Univ. Mus. Nat. History specimen catalogue numbers 29880, 34188, 39561, 86578; Northeast La. Univ. Mus. specimen catalogue number 11693). Gulf sturgeon may be more abundant in high flow velocity habitats than our sampling indicates because gill nets are more effective in sluggish flow habitats.

In Florida, mean population sizes ranged from 282 individuals (>45 cm FL) in the Apalachicola River (Wooley and Crateau 1985) to 3,300 individuals in the Suwannee River (USFWS and Gulf States Mar. Fish. Comm. 1995). Our estimated summer (May–Sep) populations for the 15-km reach of the West Middle River ranged from 67 to 124 individuals. These estimates assume complete mixing within this river reach and no emigration or immigration. These assumptions may not be completely valid since 3 radio-tagged fish moved from the West Middle River to the West Pearl River during summer. However, radio-telemetry and mark-recapture data suggests most Gulf sturgeon remain in the West Middle River during summer, and limited summer movement is consistent with other studies (Wooley and Crateau 1985, Foster 1993, Clugston et al. 1995). Consistent catches of Gulf sturgeon in the West Middle River suggests this is a summer population center for Gulf sturgeon in the lower Pearl River system. However, since only 1 fish was recaptured in successive years, other summer populations may exist within the Lake Pontchartrain system and our estimates should not be considered absolutes, but rather an indicator of population trends.

Forty-eight percent of Suwannee River Gulf sturgeon collected by Huff (1975) were >1.2 m FL, which he found to be the minimum size of sexually mature adults. We captured only 1 (0.6 %) Gulf sturgeon of 153 that was >1.2 m FL. The apparent rarity of adult Gulf sturgeon in the lower Pearl River system may be partly attributable to inadequate spatial and temporal sampling, but other factors have been implicated (USFWS and Gulf States Mar. Fish. Comm. 1995). Winter habitat in Lake Pontchartrain has been altered due to urbanization, causing a substantial reduction in diversity of the benthos (Stone et al. 1982) which could adversely affect this bottom feeding fish. Atlantic and Gulf sturgeons are susceptible to incidental mortality from gill netting and shrimp trawling (Wooley and Createau 1985, Collins et al. 1996), both of which are legal in the Pearl River-Lake Pontchartrain system. Numbers of adults may have been reduced by legal harvest prior to 1990 and mortality associated with incidental capture and habitat changes may be hindering recovery.

Our data suggests that steps should be taken to reduce mortality of Gulf sturgeon in the Pearl River-Lake Pontchartrain system to increase recruitment of adults into

the population. However, better estimates of habitat requirements, population attributes, and sources of mortality are needed to help managers implement appropriate remediation. Presence of juveniles in the Pearl River system indicates that Gulf sturgeon are successfully reproducing, although spawning and rearing locations are still unknown. Cooperative studies between LDWF, WES, and Mississippi Department of Wildlife, Fisheries, and Parks have been established. These ongoing studies are evaluating the possibility that sills impede upstream spawning migrations, concentrate juveniles and adults during low flows, and reduce availability of suitable summer habitat. We are also developing population models to evaluate effects of incidental mortality and habitat loss on adult recruitment, and we are attempting to locate population centers in other reaches of the Pearl River-Lake Pontchartrain system.

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