Movements and Home Ranges of Alligator Gar in the Mobile-Tensaw Delta, Alabama

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Abstract: Alligator gar *(Atractosteus spatula)* populations have declined across the species' historical range. Therefore, data on movements and home ranges of alligator gar are needed to evaluate potential management scenarios. The movements of 12 alligator gar were monitored using radio and sonic telemetry in the Mobile-Tensaw Delta, Alabama, from June 1998 to April 2000. Fish were fitted with external radio transmitters ($N = 5$) from June to October 1998 and sonic transmitters ($N = 10$) from March to May 1999. Seven fish were released in Threemile Creek in the western delta, three fish were released in the central delta and five fish were released in the eastern delta. Twelve of 15 alligator gar were located at least once after tagging. Fish were relocated from one to 19 times, and total observed movement was highly variable (1.55–23.10 km). Linear home ranges of fish ranged from 2.73 to 12.25 km. Distance moved per relocation increased with fish size ($r^2 = 0.32$, $P = 0.05$), and the number of relocations decreased with fish size ($r^2 = 0.51$, $P < 0.01$). A relationship ($r^2 = 0.42$, $P = 0.16$) was not found between home range and fish size. Management strategies should incorporate these new data which suggest that juvenile alligator gar exhibit site fidelity and large individuals are highly mobile.

Key words: alligator gar, movement, home range, Mobile-Tensaw delta

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The historic range of alligator gar *(Atractosteus spatula)* included the Mississippi River and its tributaries from the lower reaches of the Ohio and Missouri Rivers southward to the Gulf of Mexico including coastal rivers from the Choctawatchee

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River, Florida, into northern Mexico (Lee et al. 1980). Today, alligator gar are primarily restricted to coastal rivers, with several inland populations persisting in Oklahoma, Arkansas, and Texas reservoirs (Sutton 1998). Along with a reduced range, population densities and number of large individuals in alligator gar populations have declined. Reasons for range contraction and population decline of alligator gar include fishing pressure and habitat loss and degradation (Robison and Buchanan 1988, Simon and Wallus 1989, Etnier and Starnes 1993). Although alligator gar are currently listed as endangered in Kentucky and threatened in Tennessee and Illinois (Simon and Wallus 1989), commercial fisheries still exist in Louisiana and Mississippi (A. Ferrara, unpubl. data, M. Pierson, pers. commun.).

During the late 1980s and early 1990s increased commercial harvest of alligator gar from the Mobile-Tensaw Delta resulted in a population decline of alligator gar that was observed by Alabama Department of Wildlife and Freshwater Fisheries personnel (W. Tucker, pers. commun.). In July 1992, alligator gar were designated as a sportfish in Alabama (Regulation 92-GF-24) and a two-per-day creel limit was implemented in an attempt to sustain an apparently declining population. Until recently, the management potential for alligator gar was limited because basic life history information did not exist for the species. Ferrara (2001) completed research on demographics of several populations of alligator gar, including a population in Alabama. Other studies on alligator gar are largely restricted to food habits (Goodyear 1967, Toole 1970, Seidensticker 1987) because alligator gar were presumed to have negative impacts on sport fisheries through predation. In addition to age, size-structure, and reproductive biology information provided by Ferrara (2001), data on movement patterns and home ranges of alligator gar are needed to address potential effects of management scenarios.

Telemetry studies can delineate areas and habitat types that are used by a fish species and can allow managers to identify, preserve and enhance essential habitat. Snedden et al. (1999) reported on movements of spotted gar *(Lepisosteus oculatus)* in the Atchafalaya River Basin, Louisiana; however, we know of no other research that quantifies movements of other gars. In this study, our objectives were to determine the movements and home ranges of alligator gar in the Mobile-Tensaw Delta, Alabama.

Methods

Multifilament gill nets (22.9 x 1.8 m, and 45.7 x 1.8 m; 76- or 127-mm bar mesh) were used to collect alligator gar for tagging in the lower Mobile-Tensaw Delta (Fig. 1). Nets were set in the late afternoon in the eastern side of the delta (Ducker Bay, Sardine Pass, and the Blakeley River—Fig. 1) and in the central delta (Tensaw River—Fig. 1), checked hourly, and removed after several hours. On the western side of the delta (Threemile Creek—Fig. 1), nets were set during daylight hours, checked hourly, and removed before dusk.

Initially, five alligator gar (1170–1830 mm TL) were fitted with custom-made radio transmitters (AVM Instrument Company, Ltd., Colfax, California) from June to October 1998 and were tracked until April 2000. The radio transmitters (10 x 8 cm, ~

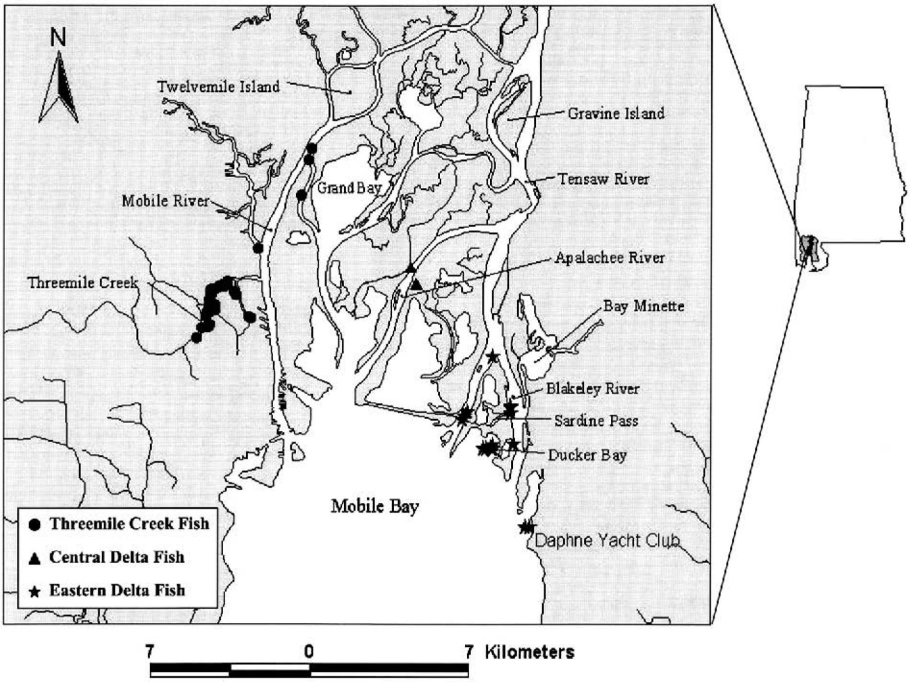

Figure 1. Telemetry sampling area and fish locations in the Mobile-Tensaw Delta, Alabama (June 1998–April 2000). Alligator gar were fitted with either an external radio ($N = 5$) or an external sonic ($N = 10$) transmitter. Seven fish were released in the western delta (Threemile Creek), three fish were released in the central delta and five fish were released in the eastern delta. The maps were produced in ArcView GIS (Environmental Systems Research Institute, Inc., Redlands, California).

247 g) operated at a unique frequency between 40.037 and 40.098 MHz and had a life expectancy of 36 months. Unfortunately, signal attenuation was problematic due to saline waters and background interference. We subsequently used sonic transmitters, which improved our tracking capabilities. Ten fish (970–1935 mm TL) were fitted with sonic transmitters during March to May 1999 and were tracked until April 2000. The sonic transmitters (Sonotronics, Inc., Tucson, Arizona) emitted unique pulse codes. The transmitters (6.5 x 1.8 cm, ~ 27 g) operated at frequencies ranging from 72–74 kHz and had a life expectancy of 48 months.

Hart and Summerfelt (1975) reported that ganoid scales of gar made it impossible to implant transmitters, so we used external attachment procedures. The methods of Snedden (1997) were modified for the large body size of alligator gar. Prior to surgery, fish were removed from the gill net, placed on wetted egg crate foam, and covered with moist towels. All surgical tools were sterilized with betadine. A cordless nine-volt drill was used to drill two holes through the dorsal region of the fish, anterior to the dorsal fin for radio tags and directly below the dorsal fin for ultrasonic tags. Oxytetracycline (OTC; 55 mg/kg body weight, Hart and Summerfelt 1975, Markham et al. 1991) was injected into each fish to prevent infection. A plastic pipette threaded with 200-lb. test stainless steel leader was passed through each surgical hole. The leader was then threaded through the corresponding hole in the transmitter, secured with stainless steel crimps, and excess wire was removed. After tagging, fish were placed in a holding net in the water until they regained equilibrium, at which time they were released. Of the 15 fish tagged with transmitters, seven were released in Threemile Creek, three in the central area of the delta and five in the eastern delta (Fig. 1).

Alligator gar were tracked by boat from June 1998 to April 2000 during which 27 sampling trips were made. Fish were tracked one to three times monthly with the exception of September 1998 and December 1999 through February 2000 when fish were not monitored. Radio-tagged fish were tracked with an omnidirectional loop antenna connected to a 4 MHz band programmable radiotelemetry receiver (Advanced Telemetry Systems, Isanti, Minnesota). Fish tagged with ultrasonic transmitters were tracked with an underwater hydrophone connected to a portable receiver (model USR - 96, Sonotronics, Inc., Tucson, Arizona). General methods of tracking by boat were followed as described by Winter (1996). The tracking territory was rectangular in shape with corners at Twelvemile Island, the mouth of the Mobile River, the Daphne Yacht Club, and the north side of Gravine Island (Fig. 1). Both radio and ultrasonic tracking devices were monitored at 400-m intervals. Tracking interval distance was frequently reduced to 100 m due to interference from background noise and in areas with meandering waterways. The location of detected fish was recorded using a GPS unit. Two days were required to cover the entire study area.

All fish locations and relocations were plotted on a map of the Mobile-Tensaw Delta in ArcView GIS (Environmental Systems Research Institute, Inc., Redlands, California). Distances moved per relocation (km) were measured and total observed movement (km) was calculated for each fish. A distance moved per relocation was defined as the minimum linear distance a fish could travel between relocations. Total observed movement was computed as the sum of all successive movements for a fish. Linear home range (km) was measured as the minimum linear distance between the outermost relocations of ultrasonically tagged fish with five or more relocations. Because radio-tagged fish were difficult to locate in saline waters, they were not included in the home range analysis. Regression analysis was used to examine relations between fish size (TL) and fish home range, fish size and number of relocations, and fish size and mean distance moved per relocation. Mean distances moved per relocation were log-transformed for the regression analysis. Regression analysis was also used to determine the relationship between number of days tracked and fish size for fish tagged with ultrasonic transmitters. Linear relationships were considered statistically significant at $P < 0.10$ due to small sample sizes. Because fish activity between relocations was unknown, we did not estimate movement rates (e.g., km/day). We reported successive distances moved to further illustrate the potential range of alligator gar movement, however, we advise that these are not movement rates.

Table 1. Movement and home range statistics for alligator gar in the Mobile-Tensaw Delta.[a]

Fish ID	Total Length (mm)	Tracking period	N days tracked	N relocations	Linear home range (km)	Total observed movement(km)	Mean distances moved per relocation (±S.D.)—(km)
285-U	1640	—	0	0	—	—	
384-U	1645	—	0	0	—	—	
456-U	1685	—	0	0	—	—	
294-U	1580	13 Apr 1999–15 Apr 1999	4	1	—	11.57	11.57
98-R	1830	15 Apr 1998–20 Nov 1998	148	2	—	5.49	2.75 (±3.66)
5-R	1520	26 Oct 1998–6 Nov 1998	12	2	—	5.00	2.50 (±0.52)
73-R	1170	26 Jun 1998–18 May 1999	327	3	—	1.55	0.52 (±0.82)
37-R	1730	26 Oct 1998–14 Apr 1999	171	3	—	1.78	0.59 (±0.48)
71-R	1580	25 Oct 1998–25 May 1999	213	5	—	8.12	1.62 (±2.09)
555-U	1160	26 Apr 1999–27 Apr 2000	368	5	12.14	12.99	2.60 (±3.34)
258-U	1935	25 Mar 1999–15 Apr 1999	22	6	12.25	23.10	3.85 (±2.95)
366-U	970	23 Mar 1999–18 May 1999	56	11	2.73	3.02	0.27 (±0.58)
267-U	1215	24 Mar 1999–14 Mar 2000	358	13	3.32	11.54	0.89 (±0.90)
339-U	1030	25 Mar 1999–08 Nov 1999	229	17	5.20	16.38	0.96 (±0.94)
249-U	1060	25 Mar 1999–28 Apr 2000	401	19	6.74	18.63	0.98 (±1.13)
		Grand mean	161	5.9	6.57	10.30	
		S.D.	156	6.4	3.34	8.44	

a. Linear home ranges were estimated for fish (ultrasonic) with five or more locations. The number of days between relocations was included for maximum and minimum successive distances moved. The U or R reported after the Fish ID indicates if the fish was fitted with an ultrasonic or radio transmitter. We assumed that Fish 366 shed its transmitter or died after 56 days; therefore, only data up to and including day 56 were included in our analyses.

Results

Twelve of 15 alligator gar were relocated at least once after tagging (Fig. 1). Fish were relocated from one to 19 times, and total observed movement was highly variable (1.55–23.10 km). Linear home ranges of fish ranged from 2.73–12.25 km. The greatest distance moved was 11.57 km exhibited by fish 294 (Table 1). Five of seven fish released in Threemile Creek remained in the creek whereas two fish (fish 249 and 258) exhibited upstream movements in the Mobile River (Fig. 2). Fish 258, the largest alligator gar tagged in Threemile Creek, traveled approximately 6 km up-

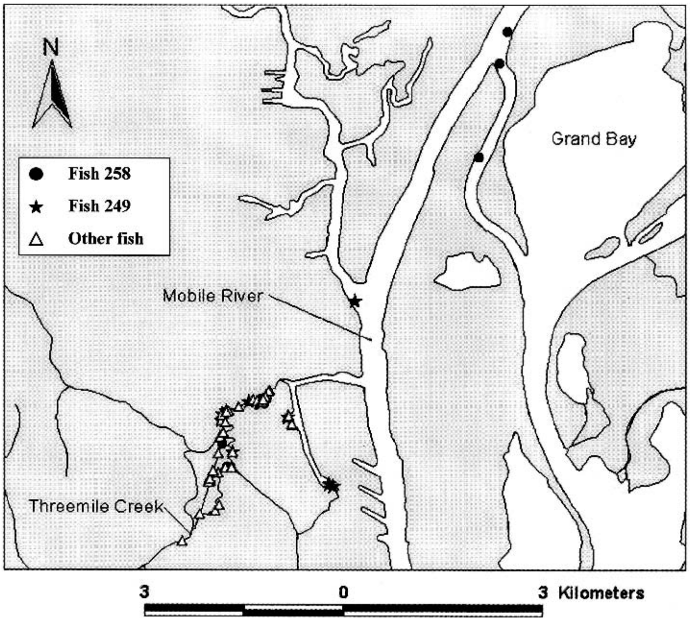

Figure 2. Locations of alligator gar released in Threemile Creek. Five of seven remained in the creek, whereas two fish (Fish 249 and 258) exhibited upstream movements in the Mobile River.

stream in the Mobile River during early spring 1999. Fish 258 also traveled approximately 2.1 km in 1.25 hours (14.3 km/day potential) on 6 April 1999. Fish 366 was assumed to have shed its transmitter or to have died in Threemile Creek after 56 days, where it was consistently found at the same location. Home range and fish size appeared to have a positive relationship, but the relation was not significant ($N = 6$, $r^2 = 0.42$, $P = 0.16$). The number of relocations decreased with fish size ($N = 15$, $r^2 = 0.51$, $P < 0.01$; Fig. 3), and distance moved per relocation increased with fish size ($N = 12$, $r^2 = 0.32$, $P = 0.05$; Fig. 3). A negative linear relation was found between number of days tracked and size of fish tagged with ultrasonic transmitters ($N = 10$, $r^2 = 0.49$, $P = 0.02$).

Discussion

Our data are the first to quantify movements and home ranges of alligator gar. We determined that fish movement was positively related to fish size. Because of the tenuous status of alligator gar throughout much of its range, we contend that these data provide insight into the potential effectiveness of management strategies. Our data indicate that large, mature alligator gar have an expanded range allowing these larger individuals to exploit a wider range of resources. Similar movement patterns have been found in gulf sturgeon. Sulak and Clugston (1999) reported that juvenile gulf sturgeon (*Acipenser oxyrinchus desotoi*, <1000 mm TL) overwinter in the river mouth and adjacent estuary of the Suwannee River, Florida, and that larger, older

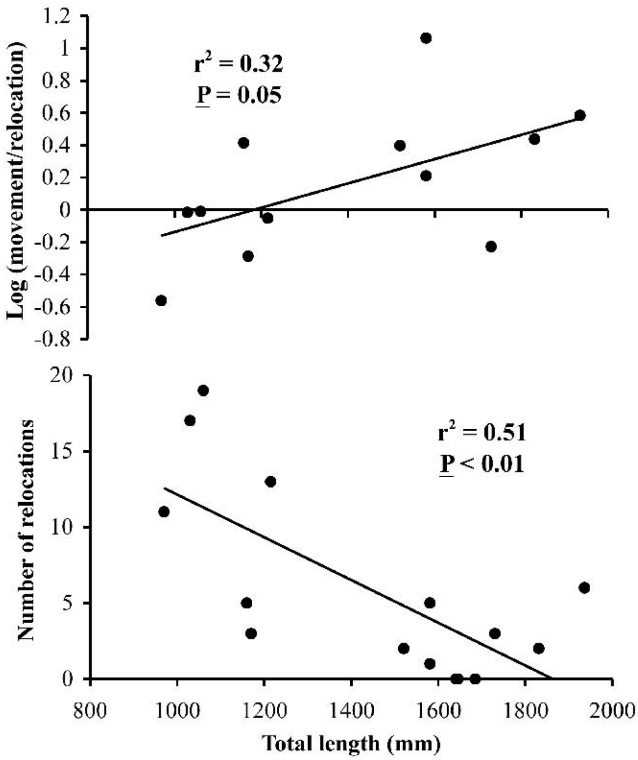

Figure 3. A positive relation was found between distance moved per relocation and size of alligator gar (mm TL), and the number of relocations decreased with fish size. Both relations were significant ($P < 0.10$). Data were collected in the Mobile-Tensaw Delta, Alabama.

adults migrate further offshore. An expansion of range may also be related to spawning activity, which has been observed in a variety of fishes (Buckley and Kynard 1985, McKinley et al. 1998, Pellett 1998). Snedden et al. (1999) reported that spotted gar established their largest home ranges during spring, which was concurrent with an increase in temperature and river stage. Spring home ranges included large areas of inundated floodplain, which were identified as areas with suitable spawning and nursery habitat (Snedden et al. 1999).

Threemile Creek is hypothesized to be a nursery and potential spawning area for alligator gar in the Mobile-Tensaw Delta and was a site where catch rates for small alligator gar were high (Ferrara 2001, Irwin et al. 2001). Our data corroborate that hypothesis; smaller fish were located multiple times in the creek, suggesting site fidelity. Site fidelity has been exhibited by various fish species such as brown trout, largemouth bass, smallmouth bass and yellow perch (Mesing and Wicker 1986, Bridcut and Giller 1993, Ridgeway and Shuter 1996, Hodgson et al. 1998). In these studies, a fish was considered to exhibit "site fidelity" when it returned to its original home range after being displaced or if the fish had a high probability of being recaptured within the original capture site. The two alligator gar that moved from Threemile Creek into the Mobile River (Fish 258 and Fish 249) later returned to the creek, further supporting the idea that these fish exhibited site fidelity. Because alligator gar reach maturity at approximately 1000–1400 mm TL, with males maturing earlier than females (Ferrara 2001), the smaller gar released in Threemile Creek were probably juvenile fish. The restricted movements and greater site fidelity of juvenile alligator gar likely enabled us to locate smaller fish more effectively than larger fish (Fig. 3) and to track smaller fish for longer time periods than larger fish (Table 1). Although we did not document spawning behavior or movements associated with spawning in Threemile Creek, the presence of juvenile fish exhibiting site fidelity indicated that Threemile Creek might be an important nursery area. Using elasticity analysis, Ferrara (2001) showed that decreased survival of juvenile alligator gar may lead to population decline. She suggested that identification and protection of nursery areas is a management strategy critical to recovery of alligator gar populations in areas where nursery habitats have been altered by human activities. Similarly, because stock enhancement efforts are underway (R. Campbell, pers. commun.) and because juvenile alligator gar may exhibit nursery site fidelity, identification of suitable nursery areas could help managers to select appropriate stocking sites thus increasing the survival of stocked individuals (Jackson et al. 2002).

The largest fish we monitored (Fish 258), traveled approximately 2.1 km in 1.25 hours indicating that alligator gar are capable of high movement rates. Therefore, to obtain more accurate estimates of movement rates (km/day or km/hr) of alligator gar (particularly large individuals), fish should be tracked frequently within a sampling period. Ideally, multiple positions should be recorded for a particular fish within a sampling day. The potential for underestimating movement rates of an animal generally increases as the time between relocations increases (Sakaris et al. 2002) and when highly mobile species are considered.

Because our data suggest that large alligator gar are mobile and have large home ranges, management strategies must consider the potential for large individuals to cross boundaries between areas where alligator gar are protected and areas where harvest may occur. For example, areas that may function as seasonal refuges from harvest (such as peripheral management units at Bayou Sauvage National Wildlife Refuge and Sabine National Wildlife Refuge, Louisiana) would likely not be effective in protecting large individuals due to the ability of large alligator gar to expand their home ranges into unprotected areas outside of the refuges.

In addition to fish size, sexual and seasonal variation in movement of alligator gar may influence the home range. Snedden (1997) reported that spotted gar movement was coincident with increased river stage and was associated with floodplain spawning activity. Unfortunately, we were unable to determine the sex of our tagged fish, and the amount of data collected was insufficient for estimating seasonal home ranges and movement patterns. In the future, we recommend that movement studies on alligator gar consider sexual and seasonal effects on home range. Furthermore, more intensive movement studies on alligator gar may help managers identify spawning habitat, the preservation of which may be critical for the persistence of this species.

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