CONTRIBUTIONS TO THE LIFE HISTORY OF ALLIGATOR GAR, *ATRACTOSTEUS SPATULA* (LACÉPÈDE), IN OKLAHOMA

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ERIC L. BRINKMAN

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Arkansas Tech University

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ALLIGATOR GAR, *ATRACTOSTEUS SPATULA*

(LACÉPÈDE), IN OKLAHOMA

Thesis Approved:

Dr. William L. Fisher

Thesis Adviser

Dr. Anthony A. Echelle

Dr. Daniel E. Shoup

Dr. A. Gordon Emslie

Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Alligator gar (*Atractosteus spatula*) are large-bodied fishes that inhabit medium to large rivers and flood plain pools of the Mississippi River Valley and coastal rivers and estuaries along the Gulf of Mexico (Page & Burr 1991). The alligator gar is the third largest freshwater fish in North America behind white sturgeon (*Acipenser transmontanus*) and Atlantic sturgeon (*A. oxyrhynchus*), and of the three species it has the largest freshwater range (Page & Burr 1991).

In the 1980s biologists began documenting a decline in the abundance and individual size of alligator gar populations throughout their range in the United States (Robison & Buchanan 1988; Ferrara 2001). Alligator gar are considered vulnerable to extirpation (NatureServe 2008); they have been extirpated from Ohio and Illinois and are considered imperiled or critically imperiled in Alabama, Arkansas, Indiana, Oklahoma, Kentucky, Mississippi, and Tennessee, and vulnerable in Florida. In the United States, alligator gar are considered secure only in Texas and Louisiana. The reasons for these declines are not completely understood. However, as with many large-river fish populations, the decline of alligator gar is generally attributed to hydrologic alterations of rivers including dams that block seasonal migrations and levees that disconnect rivers from floodplain habitats, which affects reproductive success (Simmon & Wallus 1989; Etnier & Starnes 1993; Irwin et al. 2001; Boschung & Mayden 2004). A relatively old age at maturity (Ferrara 2001) and susceptibility to harvest by commercial and recreational fishermen are other factors contributing to the decline of alligator gar. Ferrara (2001) found that female alligator gar in the gulf coast of the United States were sexually mature at about 11 years and lived at least 52 years, whereas males were sexually mature at approximately 6 years and lived at least 26 years. Alligator gar populations in Louisiana, the United States and Tamaulipas, Mexico still support commercial fisheries (García de León et al. 2001; Ferrara 2001; Irwin et al. 2001). Fish markets in Mississippi also purchase alligator gar meat (Ferrara 2001). Due to their large size, alligator gar are sought as a trophy species among some recreational fishermen.

We evaluated relative abundance, sampling methods, home-range, age, and, reproductive activity of alligator gar in the Red River, Oklahoma-Texas. This information is needed to help guide management aimed at preventing future declines of the Red River population.

CHAPTER II

STUDY AREA

We surveyed the alligator gar population in Lake Texoma, Oklahoma-Texas and a 64 river-kilometer (rkm) section of the Red River above the reservoir (Figure 1). Lake Texoma is formed by Denison Dam near Denison, Texas. The dam is the only major main channel obstruction between the river's headwaters in the panhandle region of Texas and Lock and Dam Number 5, southeast of Shreveport, Louisiana. At conservation pool (187.91 meters msl), the reservoir impounds 1.76 km^3 (1,430,445 acre-feet) of water on the Oklahoma-Texas border. The Red River flows approximately 860 rkm along Oklahoma's southern border with Texas before entering Arkansas. It is a typical prairie river, with sand and silt substrates and occasional woody debris. The Red River periodically reconnects with its floodplain during high flow events.

CHAPTER III

METHODOLOGY

We used an adaptive stratified random sampling design (Thompson 1991) to collect alligator gar in the Red River system to assess population abundance. Prior to sampling we digitized potential sample sites from aerial photos using ArcGIS 9.1 (ESRI, Inc.), and sites were randomly selected. Sampling was conducted from March 2006 to April 2007 and October 2007 to April 2008. Lake Texoma was divided into 1.6 kilometer shoreline sections based on the pool elevation in 2003 aerial photographs of the lake. Only near-shore habitats were sampled based on preliminary observations of telemetry tracked alligator gar. River sites also were divided into 1.6 km sections. We only sampled deep-water habitats in the river, based on limitations of sampling gear and observations of congregated gar. River samples were limited to the area between the confluence of the river with Lake Texoma and a point approximately 16.5 rkm west of the Interstate 35 Bridges (Figure 1). When one or more alligator gar were collected from a sample site, we continued sampling in the area on subsequent days until the end of the sampling session or when no alligator gar were collected or sighted in the area.

Adult and juvenile alligator gar were collected using multi-filament gill nets (31.1 m x 3.6 m; 64 mm, 76 mm, or 127 mm bar mesh) or multi-filament trammel nets (61.3 m x 3.6 m, 64 mm inner, bar mesh, 270 mm wall, bar mesh) from March 2006 to April 2008. Gill nets and trammel nets were set perpendicular to flow at various depths in the water column and weighted to maintain position in the river. In the lake, nets were also set at various depths and perpendicular to the shoreline. Gill nets and trammel nets were checked every one to two hours throughout sample periods to minimize escape and mortality due to stress and suffocation. Length of sampling at sites varied based on catch rates of gar. If no large gar were collected or witnessed surfacing near the sample sites we moved to the nearest random sample site. Because multi-filament nets were checked multiple times throughout a sampling period and each sampling period was not a standard length of time, we defined a unit of effort as one hour of soak time.

Young alligator gar were collected during warm water periods (>18 ºC) from September to October 2007 and in April 2008 with mini-fyke nets (0.6 m x 6.35 m; with 3.175 mm mesh, 3.81 m lead, 0.6 m x 1.92 m rectangular cab, and 510 mm metal throat). Mini-fyke nets were set in shallow (<1.0 m) areas of backwaters and coves in the evening and checked the following morning. Our defined unit of effort for this gear was individual net-nights. We also calculated soak time for comparison with gill and trammel net catch rates. We used factorial analysis of variance (ANOVA, $\alpha = 0.05$) to evaluate if net depth, presence of macrophytes, presence of woody vegetation, presence of large woody debris, cardinal direction of net alignment, habitat type or interactions among these variables were related to young alligator gar catch in mini-fyke nets. Net depth was measured with side imaging depth finder (Model 987c SI, Humminbird©). All other habitat characteristics were recorded based visual observations at sample sites.

Collected fish were weighed to the nearest 0.05 kg and measured to the nearest mm (total length). Large alligator gar were tagged with two individually numbered jaw tags, and small alligator gar were tagged with two individually numbered T-bar (Floy) tags for mark-recapture population estimates. One to three lateral scales were removed from each alligator gar just posterior to the pelvic fins for age determination. All fish incidentally killed while collecting were retained for otolith removal. We sacrificed additional fish to increase our otolith sample size to 20% of our total catch to minimize bias associated with the selection of incidental mortalities without impacting the population. Retained specimens were euthanized by inducing shock through rapid reduction of body temperature with ice.

Scales were aged using kernel (origin) sections (J. Boxrucker, Oklahoma Department of Wildlife Conservation, personal communication). Three readers with varying levels of experience ageing gar examined each scale section independently and without knowledge of fish length, weight, age, or sex (DeVries & Frie 1996). Because otoliths are considered the most accurate and precise method for determining age of temperate freshwater fishes and whole otoliths have previously been used to age gar (Ferrara 2001), ages were assigned to a sub-sample of 14 alligator gar otoliths by an expert reader. These determinations were used to evaluate structural bias of scale sections (Long & Fisher 2001). Precision of scale section age determinations was evaluated based on the sampling standard error among readers (Sharp & Bernard 1988). Unlike coefficient of variation, sampling standard error is not affected by fish age. Structural bias was assessed by comparing the mean age for scale sections with whole otolith ages from a sub-sample of alligator gar. We expected a 1:1 relationship between scale ages and otolith age if the structure was unbiased.

Twenty alligator gar were tagged in the Red River System between March 2006 and January 2007. Eleven wild alligator gar were fitted with external ultrasonic telemetry transmitters (Model CHP-87-L, Sonotronics, Inc.) (Sakaris et al. 2003) between March 2006 and November 2006 and released into the Red River. Due to the high conductivity

(> 1000 μS) of the Red River System, we were unable to use radio transmitters (Fisher & Wilkerson 1997). In September 2007 we attached transmitters to five hatchery brood-stock alligator gar, scheduled to be repatriated into Lake Texoma from Tishomingo National Fish Hatchery in Reagan, Oklahoma. Four wild alligator gar were also tagged between December 2006 and January 2007 in Lake Texoma. Each transmitter emitted a unique aural pulse that was used to distinguish individual fish. We used an ultrasonic receiver (Model USR-96, Sonotronics, Inc.) equipped with a directional hydrophone (Model DH-4, Sonotronics, Inc.) to search portions of Lake Texoma and the Red River monthly for tagged fish, circumstances permitting. Once detected, we determined the location of individual fish by triangulation of transmitter pings. The precise location of each fish was recorded with a GPS receiver. We also deployed submersible receivers (Model SUR-1-M-D, Sonotronics, Inc.) at strategic points in the lake to document fish passage and help focus searches (Figure 1).

We determined the home range area of alligator gar using the minimum convex polygon method. This method requires a minimum of three detection points to estimate home range. Precision of home range estimates increases with the addition of detection points. Murphy and Willis (1996) defined home range as the area over which an animal travels in its normal activities, exclusive of migrations. Using this definition, we excluded points that appeared to be associated with migration attempts. We estimated home range size using the Animal Movement Extension (Hooge & Eichenlaub 2000) for ArcView 3.2. We clipped the polygons created by this program to the boundaries of Lake Texoma. We measured linear home range of all alligator gar that were manually detected at least five times (Sakaris et al. 2003), including presumed migration attempts.

Sakaris et al. (2003) defined linear home range as the minimum linear distance between the outermost relocations. We also calculated average distance traveled per day between detections (Bahr & Shrimpton 2004) to evaluate movement trends throughout the detection period.

On 11 May 2007 Oklahoma Department of Wildlife Conservation (ODWC) personnel videoed alligator gar reproducing in Lake Texoma. We compared the spawning behavior observed on the video to accounts of other recent alligator gar spawns in the southeastern United States.

CHAPTER IV

RESULTS

Sixty-six alligator gar were collected from the Red River system. Forty-three alligator gar were collected during 535 trammel/gill-net hours, March 2006-April 2008 (Table 1). Nineteen alligator gar were collected in Lake Texoma and 24 were collected in the Red River using trammel or gill nets. Approximately half of the total trammel and gill net catch (51.5%) was collected at a single site in the Washita arm of Lake Texoma, 15 December 2006. Trammel nets were slightly more effective than the gill nets for collecting large alligator gar (CPUE = 0.09 and 0.07 gar/net-hour, respectively; Table 1). Thirty-three fish were collected using trammel nets, and 10 were collected in gill nets (Table 1). Large longnose gar were collected at many of the same sites as alligator gar. Longnose gar are abundant in Lake Texoma and the Red River and were collected in many of our samples, even when alligator gar were not. Very few shortnose gar and no spotted gar were captured in our samples due to the location and size selectivity of our trammel nets (Table 2); however, shortnose gar were identified by observers surfacing in the area of many of our sample sites.

Mini-fyke nets effectively caught age-2 and younger alligator gar (Table 3). Twenty-three young alligator gar were collected during 42 trap nights in October 2007 and May 2008 in shallow areas of Lake Texoma (Tables 1, 2, & 3). Mini-fyke nets set in backwaters of the Red River did not collect any alligator gar. Net depth (range 0.12-1.22 m), presence of macrophytes, presence of woody vegetation, presence of large woody debris, cardinal direction of net alignment, habitat type, and interactions among these factors were not significant predictors of young alligator gar catch (ANOVA, $F_{56, 3}$ = 4.25, N = 60, P = 0.13). None of the marked fish were recaptured in our sampling efforts; thus, we could not estimate population size.

We obtained scales (N = 64) and sagittal otoliths (N = 14) from 64 alligator gar between 15 December 2006 and 31 May 2008. Scale section ages ranged from 0 to 28 years at date of collection (Table 3). Otolith age was highly correlated with mean scale age (R^2 = 0.90) for the 14 alligator gar from which we were able to obtain both structures (Figure 2). Ages of these fish ranged from 0 to 18 years based on otolith ages. Mean scale age for these same fish ranged from 0 to 28 years (Table 4). Precision of scale age determinations tended to decrease with increased age. As the scale age increased, the standard error among readers also increased (Table 3 & Figure 3).

We analyzed length-weight relationships of 65 alligator gar, ranging in size from 361 mm to 2215 mm total length. Least squares regression analysis yielded the following model of this relationship: weight = 3.0×10^{-10} $\text{length}^{3.3981}$ (Figure 4). Our model is different than what was found by Garcia de Leon et al. (2004) in Vicente Gurrero Reservoir, Mexico (weight = 0.079 $\text{length}^{3.176}$). However, they noted that their model was skewed by an overabundance of males, which included 115 males, 25 females, and 25 unknowns. We were unable to determine the sex of all of our collected alligator gar, but we assume that our data better represents a wild population.

The length-frequency distribution for 65 alligator gar revealed three distinct size groups. Although our data set may not accurately represent the Red River population due to bias of our trammel net catch, missing and under-represented length groups in our data set indicate that spawning may not occur annually or with equal success (Figure 5).

Manual telemetry searches resulted in 44 locations of 10 alligator gar. Only two of 11 alligator gar were detected in the Red River after release, once each, while eight of nine alligator gar were detected in Lake Texoma from 1 to 9 times each. Seven alligator gar either died or expelled their transmitters immediately after release. Three alligator gar were never detected after release. The submersible receivers logged 76 detections of the eight alligator gar in Lake Texoma from 23 September 2006 to 24 August 2007. Six of the 10 detected fish were located more than the minimum detections (3) required for estimating home range area (Range 1-9 detections). Only one alligator gar was detected after the record flooding in July 2007 by a SUR on 24 August 2007 on the west end of the reservoir. No alligator gar were detected after that date. Home range area of the six alligator gar ranged from 4.93 to 17.13 km^2 from September 2007 to June 2008 (Table 5). Linear home range ranged from 5.77 to 49.72 km for the same period. Tagged fish congregated with longnose gar and shortnose gar during cold water periods (<12 ºC) at various locations in the Washita Arm of Lake Texoma. Congregated species were identified in trammel net catches or when individuals surfaced near observers. However, as water temperature increased we observed tagged fish dispersing to separate nearby locations. We did not observe any individuals returning to any specific congregation sites (i.e. site fidelity) when water temperatures dropped back below 12 ºC. However, we did observe fish forming smaller groups at other locations.

On 11 May 2007, ODWC personnel reported seeing approximately 50 fish in "pods" of 4 to 12 individuals "thrashing" around in an area of flooded spike rush (*Eleocharis spp.*) in Fobb Bottom Wildlife Management Area. Each group consisted of one large alligator gar (≥ 1.8 m, TL), presumably a female, accompanied by several smaller gar, presumably males, which is common in gar species (Suttkus 1963, Love 2004). Water depth (mean = 0.30 m) in the spawning area was not deep enough to cover the backs of the fish. This spawning event occurred following a flood that inundated the rushes in this wetland area. Age analysis of 24 juvenile alligator gar collected at the spawning site and adjacent areas in October 2007 and April 2008 suggests that this was a successful spawning event. Age analysis also indicates that another spawning event occurred in Lake Texoma during 2006.

CHAPTER V

DISCUSSION

Large alligator gar were primarily collected from pool habitats in the Red River during cold water periods of the year. Alligator gar were found in portions of the river that were relatively deep (1.8-9.1 m) compared to the average depth (typically < 1.0 m) of the Red River. Alligator gar typically inhabit backwaters and sluggish pools of large rivers (Boschung & Mayden 2004, Robison & Buchanan 1988, Pflieger 1975), but specific habitat preferences of large alligator gar have not been thoroughly examined.

Approximately half of our trammel net catch (51.5%) came from a single site in the Washita Arm of Lake Texoma on 15 December 2006. This along with low catch rates during warm water periods indicates an increased susceptibility to harvest of alligator gar during cold weather. Tagged fish tended to form groups with other large gar when water temperatures were less than 12 ºC. We were unable to identify habitat characteristics that distinguished this large congregation site from other sites in the lake. The site averaged 6.1 m deep, but it was not distinctly deeper than other nearby areas, and mid-column water temperatures at this site were not warmer than other nearby sites. Gar were observed using the entire water column at this site; thus, we concluded that a mid-column temperature would best represent the range in temperatures at the sample sites. Large congregations of gar, including longnose, shortnose, and alligator gar, were observed at this site on multiple occasions during cold water periods. As water temperatures increased, we observed fish dispersing to other locations in the lake, either alone or with a smaller group.

We collected juvenile alligator gar during warm water periods using mini-fyke nets. We were not able to identify significant habitat features related to the locations of young alligator gar. Despite our inability to identify habitat characteristics, mini fyke nets contained many young alligator gar, which makes this a good gear for collecting this size class. Very few young alligator gar have been reported in historic (Pigg & Gibbs 1996, McCarley & Hill 1979, May & Echelle 1968) or recent Oklahoma collection records (K. Kuklinski, ODWC Fisheries Research Lab, Norman, Oklahoma personal communication). Large fyke nets may collect more or larger specimens in the same habitat, although this needs to be confirmed.

We tracked the movements and distribution of alligator gar for nine months. Initially we attempted to tag wild-caught individuals of varying size, age, and gender, but low capture rates lead to only a few wild fish being tagged, so we focused on tracking movements of five hatchery fish that were to be repatriated. Tagged fish moved considerably longer distances (linear home range, range 5.77-49.72 km, mean 15.3 km) than what was observed by Sakaris et al. (2003) (range 2.73-12.25 km, mean 6.57 km) for six alligator gar in the Mobile drainage of Alabama. In Alabama, fish primarily stayed within the river portions of the drainage and were all wild-caught fish. These fish had access to Mobile Bay and were tracked for a longer period of time (13 months). Our farthest traveling fish was wild caught and had a linear home range of 49.7 km. Sakaris et al. (2003) reported that smaller alligator gar exhibited site fidelity to a small tributary to the Mobile River, Alabama, which they hypothesized was an important nursery habitat and potential spawning area.

There is a need for an accurate, non-lethal method for evaluating age and growth of rare and declining species, such as alligator gar. Initially we attempted to age alligator gar with branchiostegal rays, because it has been used extensively for ageing other gar species (Netsh and Witt 1962; Klaassen and Morgan 1974; Johnson and Noltie 1997; Love 2001; Love 2004). However, in alligator gar and large longnose gar these structures become opaque (Ferrara 2001). We sectioned the articulating process, where the structure originates, to help reveal these early annuli. We found that these structures were pitted, which removed many of the annuli (Figure 5). We subsequently began collecting scales as a surrogate structure (J. Boxrucker, ODWC personal communication). Ferrara (2001) determined ages of 225 alligator gar collected along the gulf coastal United States by examining the surface of whole otoliths. While this method is presumably accurate, it requires that specimens be sacrificed. We found that scale ages were typically greater than otolith ages. If both otolith and scale structures produced similar growth patterns, we would expect age determinations derived from these structures from the same individual to be within one year of agreement. Standard error among scale readers ranged widely, indicating that age determinations varied significantly among readers. Scale ages were not very precise and age determinations tended to higher than otolith age determinations. Future research comparing these structures will need to verify if presumed annuli are in fact annual marks (Beamish & McFarlane 1983) and scale readers will require some structure specific training to precisely and accurately evaluate sectioned scales. Alternatively, mark-recapture of chemically marked, wild alligator gar should be used for verification of annual marks. This method eliminates biases associated with use of hatchery reared fish.

Our description of alligator gar spawning is consistent with reports of other observed events. Other witnesses similarly report seeing several groups of 4-12 fish spawning in shallow (< 60 cm) backwater areas of recently flooded vegetation. The species of vegetation present varies by account and does not seem to be an important factor, although all species described are long, narrow, "grass-like" herbaceous vegetation that occurs in wetland habitats. In an estuary region of Louisiana alligator gar were witnessed spawning in saltmeadow cordgrass (*Spartina patens*) (Q. Fontenot, Nicholls State University, Thibodaux, Louisiana, personal communication). Richard Campbell (USFWS, Pvt. John Alan National Fish Hatchery, Tupelo, Mississippi, personal communication) witnessed alligator gar spawning over common cocklebur (*Xanthium strumarium*) and water primrose (*Ludwigia* spp.) in a backwater of the Mississippi River after recent flooding. In these accounts, the vegetation was also living and recently flooded to a depth of 0.6 m or less. This indicates that alligator gar use spring flooding as a cue for spawning and is consistent with other documented spawning events in Oklahoma. Pigg and Gibbs (1996) collected 21 young-of year alligator gar in a shallow floodwater area after a spring flood event on the Arkansas River in 1993. May & Echelle (1968) collected two young-of-year alligator gar in Lake Texoma in 1965, which were estimated to have been spawned in early May. The consistency of shallow depths and backwater locality of spawning sites described in the personal accounts and published literature indicates that alligator gar prefer shallow areas away from flow for spawning. These habitat characteristics contribute to the view that a major factor limiting alligator gar populations is restricted access to floodplain spawning habitats due to floodplain alteration (i.e. levee construction and channel dredging). Based on these accounts, reproducing alligator gar populations seem to consistently occur in drainages where either relatively little floodplain development has occurred or suitable backwater habitats are available during periodic flood events, such as the Red River, Oklahoma-Texas; Estuaries in Louisiana; and the Lower Mississippi River. Successful spawns have also been documented in channelized systems during extraordinary high flow events (Pigg & Gibbs 1996, L. Lewis, USFWS personal communication). Future research should examine the proportional availability of shallow ($\leq$ 0.6 m) backwater habitats and timing and periodicity of flooding events in river systems that contain alligator gar populations. We did not survey habitat in spawning areas (i.e. backwaters and flood terraces of tributary streams) to assess the availability of spawning habitat in this system. This information would be valuable to fisheries managers to assess alligator gar spawning habitat in systems where population reestablishment or augmentation is a goal.

Our research provides some basic information for management of alligator gar populations. Based on our catches of alligator gar, fisheries managers could develop standard protocols that include sampling with multi-filament trammel or heavy-twine gill nets and trap nets to catch multiple size classes. To increase catch rates, sampling with trammel/gill nets should also be conducted when alligator gar are congregated, during cold water periods or just prior to spawning. Trap nets should be set in shallow, vegetated backwaters and reservoir coves near river confluences between June and October. Based on conversations with other researchers and observed fish mortalities during our research, we advise researchers and managers to keep alligator gar in aerated tanks with tempered water at all times, check nets at least every hour, and cover the eyes of alligator gar during work-up, to minimize stress on collected fish.

Future research can also build on our ageing experience with scales. Despite the observed bias and low precision, we think that with additional training of readers and annuli verification this structure could be used as a non-lethal method for ageing gars. Precision and biases associated with other structures, such as fin spines, fin rays, sectioned vertebrae, and sectioned otoliths should also be examined.

Based on length-frequency distributions of the fish we collected, it seems alligator gar do not spawn successfully on an annual basis in the Red River system. Paired with old age at sexual maturity, inconsistent spawning increases the risk of overexploitation of alligator gar populations. Managers will have to take this into account when setting harvest regulations in this system. For the alligator gar population in the Red River system, interagency cooperation, particularly between Oklahoma Department of Wildlife Conservation and Texas Department of Wildlife and Parks, will be needed to provide adequate spawning areas in Lake Texoma and the Red River and to protect these areas from harvest during spawning.

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APPENDICES

Table 1 Alligator gar catch rates in the Red River System, OK-TX by sampling method, 2005-2008.

Project Year	Method	Trap Nights	Effort (hhh:mm)	Water Body	Number caught	CPUE
2005	Gill Net		7:53	Lake Texoma	0	0.00
2005	Gill Net		143:21	Red River	10	0.07
Total			151:14			0.07
2006	Trammel Net		115:16	Lake Texoma	20	0.17
2007	Trammel Net		41:50	Lake Texoma	1	0.02
2006	Trammel Net		168:00	Red River	6	0.04
2007	Trammel Net		58:51	Red River	6	0.10
Total			383:57			0.09
2007	Mini-Fyke Nets	42	552:08	Lake Texoma	24	0.55

Table 2 Species associations and relative abundances at alligator gar collection sites in the Red River System, OK-TX, 2006-2008. *Not all fish were identified and counted to minimize handling stress on the alligator gar that were collected at this site.

Species	Collection event															Total
	1	2*	3	4	5	6	7	8	9	10	11	12	13	14	15	
Mini-Fyke Net																
Alligator Gar						7	4	1						7	4	23
Black Crappie						7		9						4	6	26
Bluegill						42	23							17	27	109
Bluntnose Minnow						1	1							4		6
Common Carp														26	1	27
Freshwater Drum						1		1							2	4
Gizzard Shad						7	3								1	11
Highfin Carpsucker								38							1	39
Inland Silverside						35	166							9	2	212
Largemouth Bass						1								22	7	30
Lepomis spp.														2		2
Logperch														2		2
Longear Sunfish														5		5
Longnose Gar														2		2
Mosquitofish						11	5	1						3	1	21
Orangespotted Sunfish						1	4								1	6
Pomoxis spp.														36	29	65
Red Shiner															1	1
River Carpsucker						5										5
Shortnose Gar						2										2
Spotted Gar						1		1						12	14	28
Striped Bass																

Table 2 Continued.

Species	Collection event 1	2*	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Threadfin Shad															2	2
Cyprinid spp.							4									4
Warmouth						1		4							1	6
White Crappie						14	7							1	2	24
Trammel Net																
Alligator Gar	1	16	4	1	4				1	2	1	2	1			33
Bigmouth Buffalo				2	11					9	4	1	1			28
Black Buffalo										15	5	1				21
Blue Catfish											1					1
Channel Catfish					1						1					2
Common Carp				1	10						1					12
Flathead Catfish												1				1
Gizzard Shad					5					8	9	2	7			31
Grass Carp											1					1
Longnose Gar	1	25	1	1					1	2		2	3			36
Paddlefish					1											1
River Carpsucker		1	3	16	2				1	5		2	3			33
Shortnose Gar				7								1	3			11
Smallmouth Buffalo	1		1	58	24					7	13	4	4			112
Striped Bass	1									2	12	1	3			19
Hybrid Striped Bass										1						1
White Bass										2	1	1	1			5
Non A.Gar Total	3	26	5	85	54	129	213	54	2	51	48	16	25	145	98	

Table 3 Age determinations from scale sections of alligator gar collected from the Red River System, OK-TX, 2006-2008 and standard error of age determination among readers. (D = Donation, TR = Trammel Net Catch, MF = Mini-Fyke Net Catch, SC = Scavanged).

ID	Total Length (mm)	Mass (kg)	Girth (mm)	Collection Method	Age Mean	Age Range	Age SE
1	2210	74.84	–	D	23.0	5-37	12.77
2	2235	83.46	–	D	28.0	4-36	7.00
3	2215	35.60	834	TR	19.0	4-26	6.08
4	1881	23.55	775	TR	21.0	4-23	2.65
5	1158	4.15	425	TR	6.3	3-9	2.52
6	1428	9.40	521	TR	6.3	4-9	2.52
7	1486	21.75	583	TR	8.2	3-10	2.84
8	1155	8.55	423	TR	6.0	2-8	3.46
9	1460	20.15	614	TR	9.7	3-12	2.52
10	1402	8.10	565	TR	9.0	3-11	2.00
11	1227	11.85	484	TR	9.3	3-14	5.69
12	1591	27.35	667	TR	11.3	4-15	4.73
13	1588	11.35	642	TR	13.7	5-21	7.51
14	1876	21.36	794	TR	20.3	5-29	7.51
15	1469	9.05	579	TR	7.7	3-10	3.21
16	1052	8.55	410	TR	7.5	2-9	1.50
17	1564	25.85	645	TR	8.2	4-11	2.57
18	1577	25.70	635	TR	8.7	5-12	2.89
19	1564	10.65	637	TR	9.7	5-12	2.08
20	1497	20.50	594	TR	9.0	4-14	4.36
21	1915	47.90	804	TR	14.7	7-23	7.23
22	1980	47.50	806	TR	9.7	4-16	5.69
23	2036	52.90	845	TR	14.0	9-19	4.58
24	1262	25.35	629	TR	10.7	5-18	6.43
25	996	6.35	382	TR	7.3	2-10	3.79
26	780	–	211	D	2.8	1-4	1.61
27	2057	41.73	–	D	15.7	6-22	7.09
28	2032	39.92	–	D	14.0	6-18	3.46
29	–	–	–	SC	20.7	6-25	5.13
30	–	–	–	SC	14.7	8-15	0.58
31	–	–	–	SC	15.3	10-16	0.58
32	–	–	–	D	13.0	10-14	1.00
33	–	65.32	–	D	17.7	9-23	5.03
34	1929	45.45	784	TR	15.3	6-21	6.66
35	1756	34.20	709	TR	15.3	8-19	5.51
36	587	–	201	MF	1.0	0-1	1.00
37	1997	47.65	804	TR	19.7	5-29	12.10
38	1473	20.60	588	TR	9.0	4-14	4.58

Table 3 Continued.

ID	Total Length (mm)	Weight (kg)	Girth (mm)	Collection Method	Age Determinations		
					Mean	Range	SE
39	1786	40.15	755	TR	12.7	6-18	5.51
40	1819	40.95	764	TR	18.0	6-26	6.93
41	1757	32.15	684	TR	10.3	5-14	4.73
42	384	—	128	MF	0.7	0-2	1.15
43	655	1.65	247	MF	1.3	1-2	0.58
44	444	0.40	155	MF	0.7	0-1	0.58
45	515	0.75	200	MF	0.3	0-1	0.58
46	459	—	159	MF	0.7	0-1	0.58
47	453	—	144	MF	1.0	0-2	1.00
48	680	—	243	MF	1.3	1-2	0.58
49	441	—	169	MF	1.0	0-3	1.73
50	607	—	202	MF	1.3	0-3	1.53
51	361	0.20	126	MF	0.7	0-1	0.58
52	378	0.20	118	MF	0.3	0-1	0.58
53	451	0.23	149	MF	1.0	0-2	1.00
54	382	0.20	109	MF	0.7	0-2	1.15
55	412	0.20	118	MF	1.3	0-2	1.15
56	481	0.35	134	MF	1.0	0-3	1.73
57	677	1.25	216	MF	0.7	0-2	0.58
58	527	0.59	126	MF	1.0	1-2	0.00
59	668	1.19	208	MF	1.3	1-2	0.58
60	358	—	93	MF	0.7	0-1	0.58
61	410	0.17	123	MF	0.7	0-1	0.58
62	531	0.60	156	MF	1.3	1-2	0.58
63	479	0.45	154	MF	0.0	0-1	0.00
64	524	0.60	151	MF	0.7	0-2	0.58

Table 4 Comparison of age determinations using whole otoliths and scale sections from a sub-sample of 14 alligator gar collected from the Red River System, OK-TX, 2005-2008. (M = Male, F = Female).

ID	Sex	Total Length (mm)	Weight (kg)	Girth (mm)	Age Scale	Age SE	Age L Otolith	Age R Otolith
1	F	2210	74.84	–	23.0	12.77	17	15
2	F	2235	83.46	–	28.0	7.00	18	–
3	F	2215	35.60	834	19.0	6.08	18	18
6	M	1428	9.40	521	6.3	2.52	6	6
7	M	1486	21.75	583	8.2	2.84	7	7
8	F	1155	8.55	423	6.0	3.46	6	6
9	M	1460	20.15	614	9.7	2.52	8	8
11	M	1227	11.85	484	9.3	5.69	5	5
12	M	1591	27.35	667	11.3	4.73	8	9
17	M	1564	25.85	645	8.2	2.57	6	10
26	M	780	–	211	2.8	1.61	3	3
34	M	1929	45.45	784	15.3	6.66	16	17
53	M	378	0.20	118	0.3	0.58	0	0
59	F	527	0.59	126	1.0	0.00	0	0

Table 5 Telemetry statistics of 20 alligator gar tagged in the Red River System, OK-TX, 2006-2008. (* Brood stock from Tishomingo National Fish Hatchery, Reagan, Oklahoma, + never redetected, x assumed mortality).

	Tag Date	Last Detection	Detection Days	Manual Detections	Total Length (mm)	Weight (kg)	Average Daily Distance (km/d)	Linear Home Range (km)	Home Range Area (km^2)
x	24-Mar-06	—	0	0	1184	9.05	—	—	—
x	24-Mar-06	—	0	0	1080	6.00	—	—	—
x	24-Mar-06	—	0	0	1362	16.90	—	—	—
+	24-Mar-06	—	0	0	1426	16.15	—	—	—
+	25-Mar-06	—	0	0	1444	16.65	—	—	—
	25-Mar-06	25-May-06	0	1	1074	7.50	—	—	—
x	25-Mar-06	—	0	0	1175	10.00	—	—	—
x	25-Mar-06	—	0	0	1362	13.65	—	—	—
x	8-Apr-06	—	0	0	1495	16.90	—	—	—
	8-Apr-06	25-May-06	0	1	1348	14.55	—	—	—
+	11-Nov-06	—	0	0	1083	7.00	—	—	—
*	20-Sep-06	4-Mar-07	65	5	1302	12.10	0.17	11.01	9.19
*	20-Sep-06	27-Apr-07	160	5	1595	23.80	0.05	5.77	4.93
*	20-Sep-06	27-Apr-07	186	6	1312	13.50	0.32	11.37	11.17
*	20-Sep-06	1-Jun-07	251	8	1249	9.75	0.16	12.30	14.37
*	20-Sep-06	9-May-07	228	9	1154	8.35	0.30	10.10	17.13
*	15-Dec-06	20-Jun-07	166	6	1970	46.05	1.59	49.72	13.44
x	15-Dec-06	—	0	0	2201	72.20	—	—	—
	6-Jan-07	17-May-07	8	2	1469	9.05	5.53	—	—
	6-Jan-07	4-Mar-07	0	1	1876	21.36	—	—	—
	Mean		118	4.67	1570	24.02	0.53	16.71	11.71

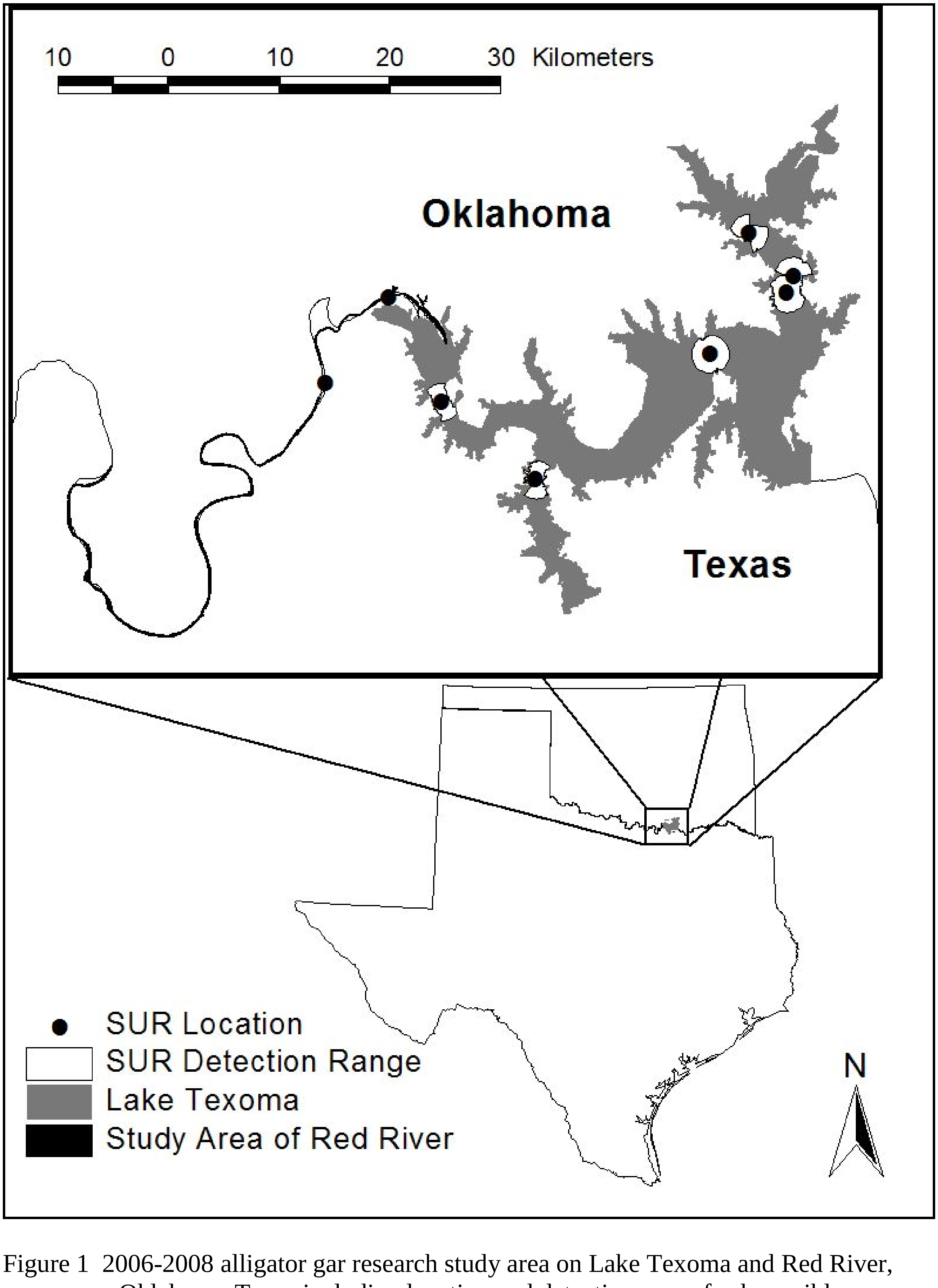

Figure 1 2006-2008 alligator gar research study area on Lake Texoma and Red River, Oklahoma-Texas including location and detection area of submersible ultrasonic receivers (SUR).

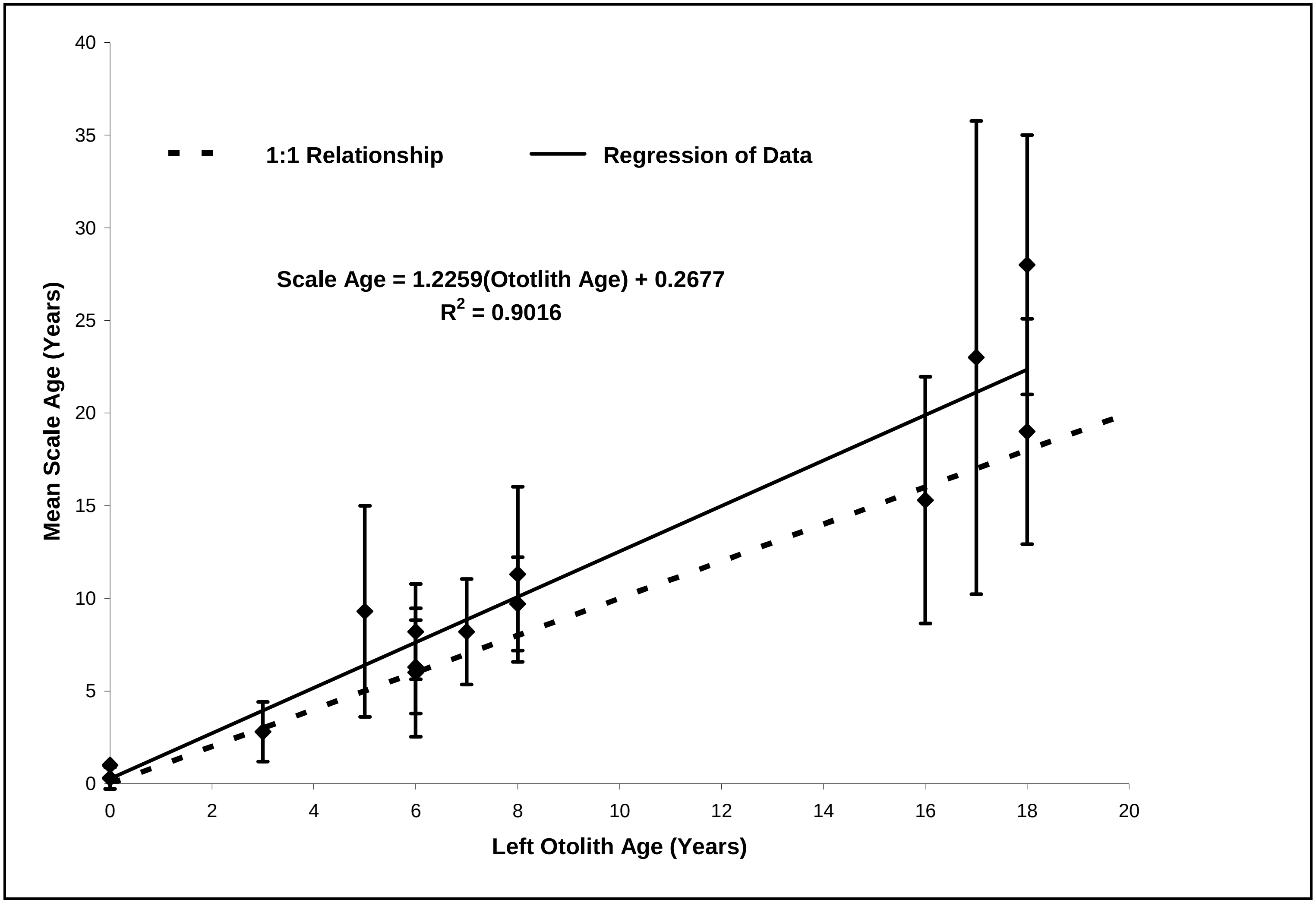

Figure 2 Comparison of otolith ages and mean scale determinations for 14 of alligator gar collected from the Red River System, OK-TX, 2006-2008, as a measure of bias of scale age determinations. Error bars represent the sampling standard error among readers for each structure.

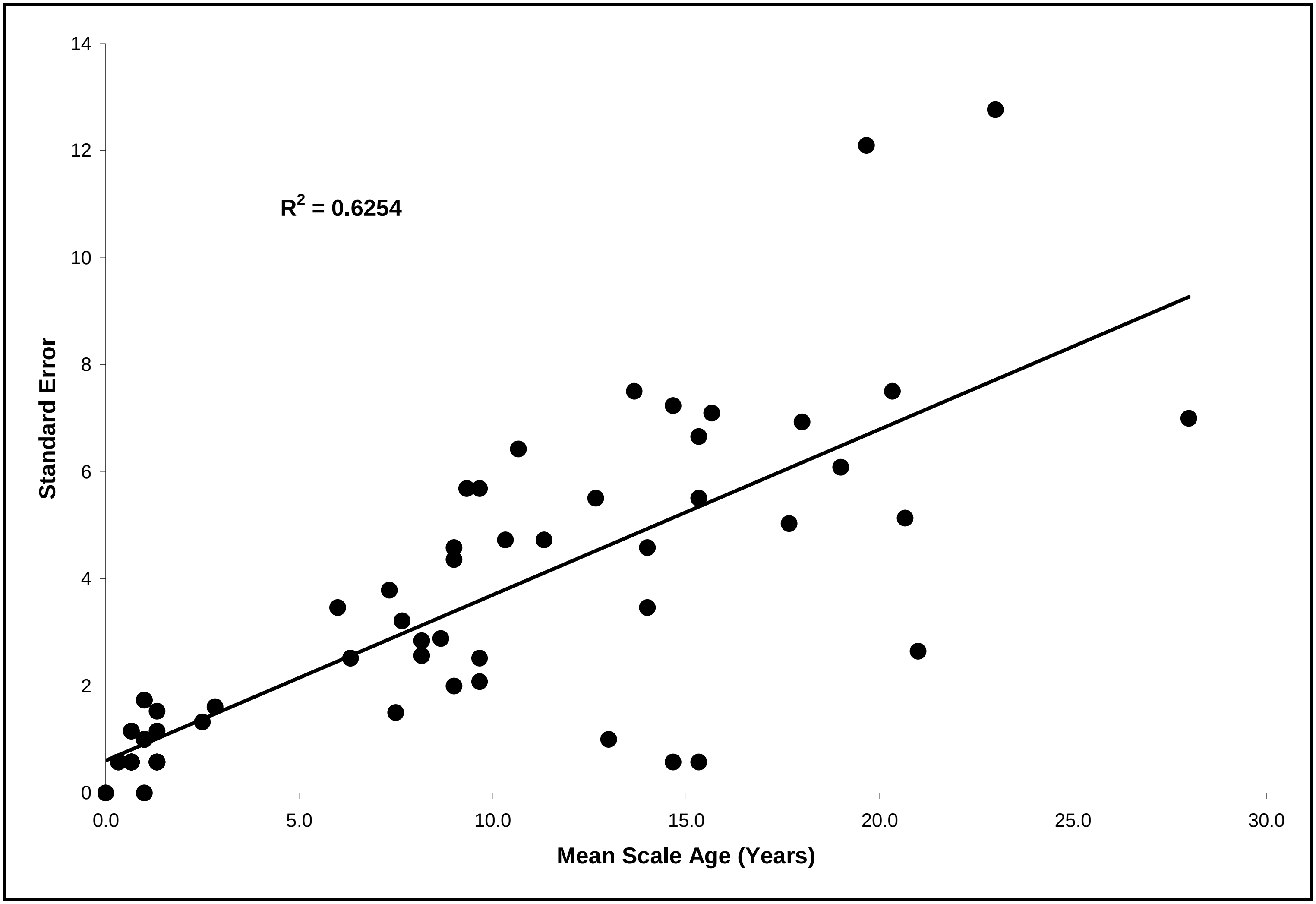

Figure 3 Comparison of standard error among three readers with mean age of alligator gar scale sections for 64 specimens collected from the Red River System, OK-TX, 2006-2008, as a measure of precision for age determinations.

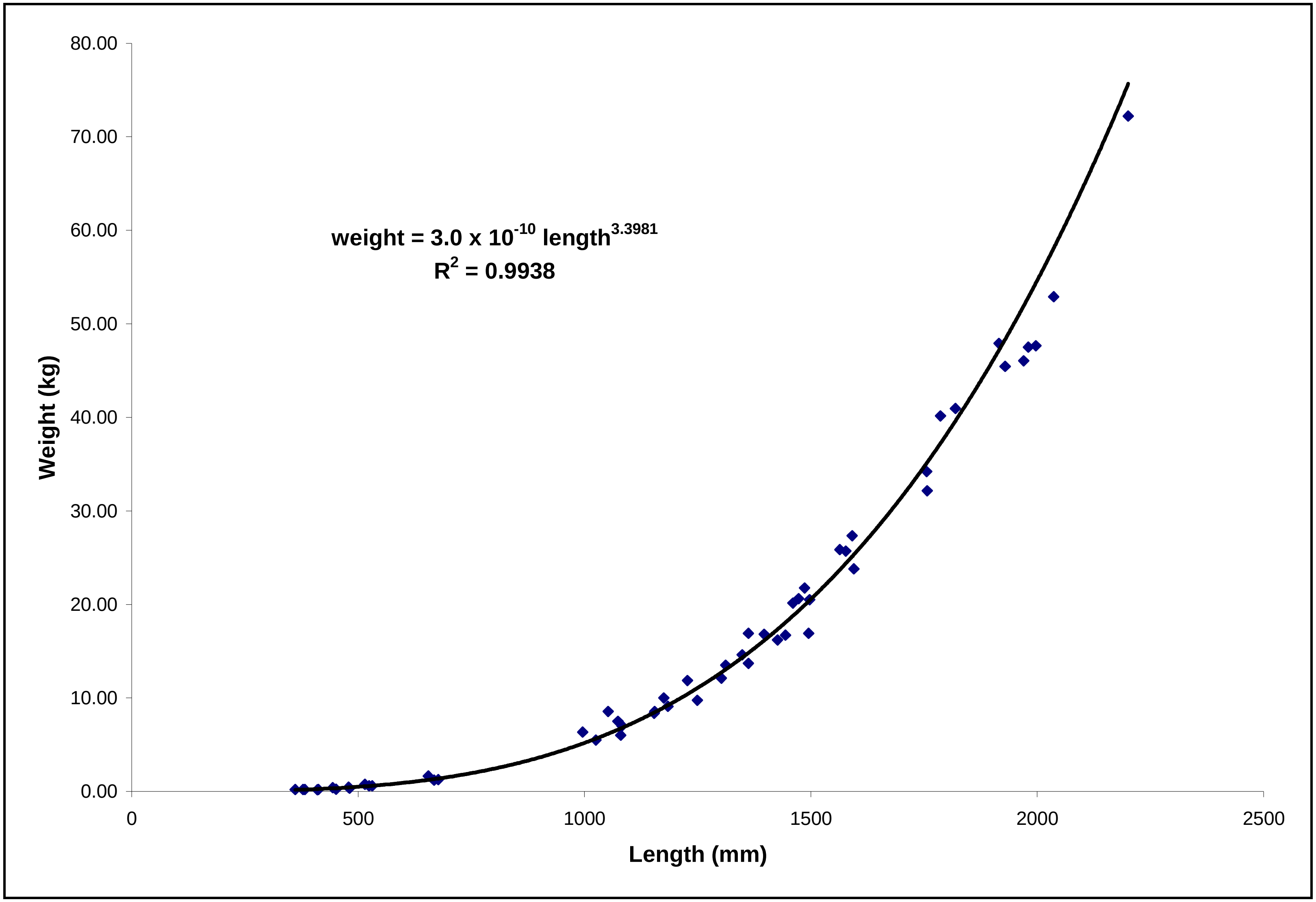

Figure 4 Length-weight relationship of the Lake Texoma-Red River, OK-TX alligator gar population, 2006-2008.

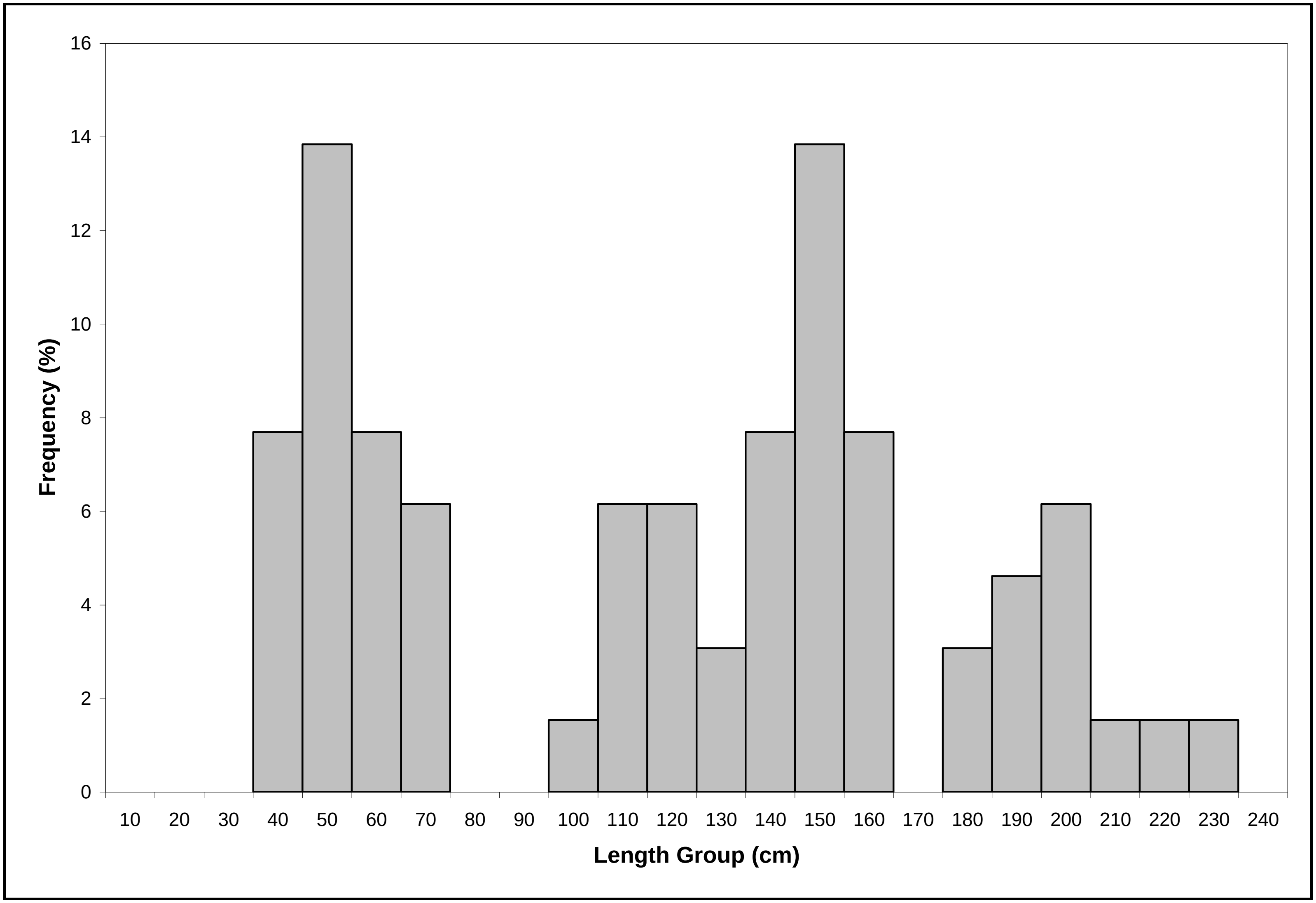

Figure 5 Length-frequency distribution of alligator gar collected in Lake Texoma-Red River, OK-TX, 2006-2008.

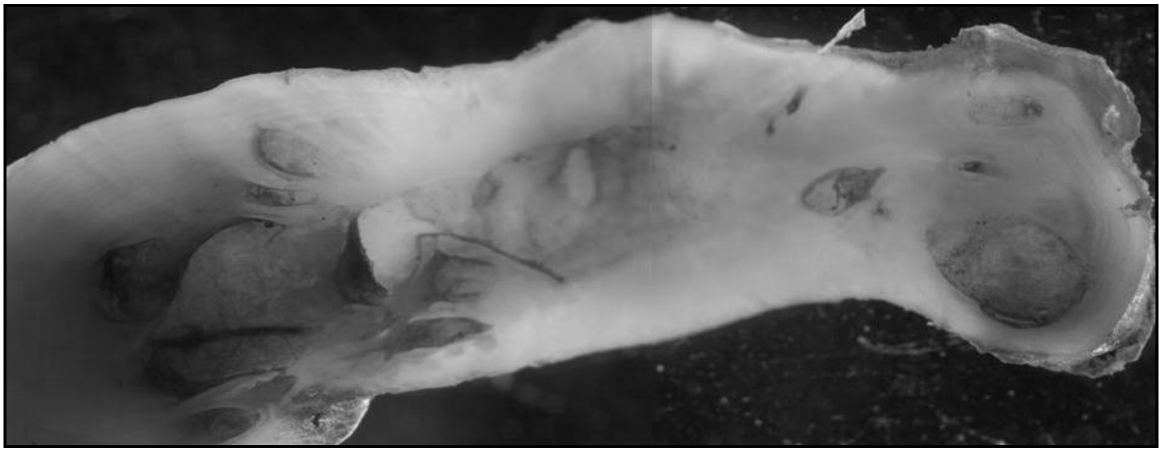

Figure 6 Sectioned articulating process of a branchiostegal ray from a female alligator gar illustrating how pitting removes annuli.

VITA

Eric Lee Brinkman

Candidate for the Degree of

Master of Science

Thesis: CONTRIBUTIONS TO THE LIFE HISTORY OF ALLIGATOR GAR, *ATRACTOSTEUS SPATULA* (LACÉPÈDE), IN OKLAHOMA

Major Field: Natural Resource Ecology and Management

Biographical:

Personal Data: Born in Houston, Texas February 15, 1979, son of Don E. Brinkman and Mary M. Callaway. Married to Mindy L. Clowers in De Queen, Arkansas, May 30, 1998. Father of Jake D. and Madilyn A. Brinkman.

Education: Graduated from Malvern High School, Malvern, Arkansas in May, 1997; received Bachelor of Science in Biology from Arkansas Tech University, Russellville, Arkansas in December, 2003; completed the requirements for the Master of Science or Arts in Natural Resource Ecology and Management at Oklahoma State University, Stillwater, Oklahoma in December, 2008.

Experience: Fisheries Technician, Arkansas Tech University Fisheries Lab, November 2002-January 2004; Aquatic Ecologist, Layher BioLogics RTEC, Inc., February 2004-June 2005; Graduate Research Assistant, Oklahoma Cooperative Fish and Wildlife Research Unit, July 2005-June 2008; Fisheries Management Biologist, Arkansas Game and Fish Commission, Camden Regional Office, June 2008-present.

Professional Memberships: American Fisheries Society; Oklahoma Chapter of the American Fisheries Society; Arkansas Chapter of the American Fisheries Society.

Name: Eric L. Brinkman Date of Degree: December, 2008

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: CONTRIBUTIONS TO THE LIFE HISTORY OF ALLIGATOR GAR, *ATRACTOSTEUS SPATULA* (LACÉPÈDE), IN OKLAHOMA

Pages in Study: 37 Candidate for the Degree of Master of Science

Major Field: Natural Resource Ecology and Management

Scope and Method of Study:

Alligator gar populations are declining in the southeastern United States and Mexico resulting in efforts by state and federal agencies to actively manage populations. We assessed the life history of the alligator gar population in the Red River drainage of Oklahoma. We estimated relative population abundance using an adaptive stratified random sampling design. Movements and home-range were examined using ultrasonic telemetry. We assessed the accuracy and structural biases of sectioned scales for determining age and growth of alligator gar. Scale sections were aged by three readers, and a subsample of these determinations were compared to whole otolith ages, determined by an expert reader. We compared reproductive behavior of alligator gar spawning, observed in 2007, to other recent spawning events in the southeastern United States.

Findings and Conclusions:

Catch rates for larger alligator gar were highest using multi-filament trammel nets during cold water periods, whereas mini-fyke nets were effective for collecting young alligator gar in warm water periods. Alligator gar exhibited logistic growth devoting early growth to increasing length and later growth towards increasing mass. Home range area of six individuals ranged from 4.93 to 17.13 km^2 during a nine month period. Linear home range of these individuals ranged from 5.77 to 49.72 km. Ages of 64 alligator gar ranged from 0 to 28 years at date of capture. Age data indicated that successful spawning occurred in 2006 and 2007, and spawning in Lake Texoma was documented in spring 2007. Age determination of alligator gar, using scale sections proved to be imprecise and biased towards overestimation of age in adults. The alligator gar population in Lake Texoma and the Red River above the reservoir, was represented by a range of age and length classes. Future stability of Red River alligator gar populations will be dependent on availability of shallow, flooded herbaceous vegetation and proper management of exploitation.

ADVISER'S APPROVAL: William L. Fisher