Angler Practices and Preferences for Managing Alligator Gar in Texas

J. Warren Schlechte, *Texas Parks and Wildlife Department, 5103 Junction Highway, Mountain Home, TX 78058, USA*

Daniel J. Daugherty, *Texas Parks and Wildlife Department, 5103 Junction Highway, Mountain Home, TX 78058, USA*

Nathan G. Smith, *Texas Parks and Wildlife Department, 5103 Junction Highway, Mountain Home, TX 78058, USA*

David L. Buckmeier, *Texas Parks and Wildlife Department, 5103 Junction Highway, Mountain Home, TX 78058, USA*

Abstract: Some anglers have questioned Texas' statewide one-a-day alligator gar (*Atractosteus spatula*) regulation. Simulations suggested other regulations might be preferred; however, angler support for other regulations was unknown. Texas Parks and Wildlife Department (TPWD) administered an online survey in summer 2018 to measure attitudes and preferences of Texas alligator gar anglers. Respondents who fished for alligator gar ($n = 3980$) were primarily Texas resident anglers; 68% fished for gar using a rod-and-reel, but 23% used bow-and-arrow. Most anglers supported using length limits for reducing harvest, regardless of their primary gear. Whereas 40% of anglers fished for alligator gar to eat, most anglers rarely harvested fish, despite having the opportunity to harvest one fish daily. Overall, most anglers supported the use of localized catch-and-release regulations to promote trophy alligator gar fisheries; however, whereas rod-and-reel anglers strongly supported these regulations, bow anglers were more evenly split. Most anglers supported mandatory reporting of harvested alligator gar (68% of rod-and-reel anglers and 58% of bow anglers). Many anglers were unsure whether there was a consumption advisory on their primary waterbody, but 47% had concerns about the water quality where they fished. Of those, 43% agreed that poor water quality caused them to reduce their days fishing. Improving awareness of consumption advisories, regulating harvest to younger fish via length limits, or the development of catch-and-release only fisheries in some places may be useful and acceptable management options. To balance the resiliency of alligator gar stocks with the diversity of desires from constituents TPWD has a statewide one fish daily bag on most waterbodies, and in 2019 imposed a 122-cm TL maximum length limit along with an annual quota of no more than 160 alligator gar larger than 122 cm specifically on the Trinity River. Texas also has mandatory harvest reporting for most waterbodies.

Key words: Lepisosteidae, online survey, angler motivations, regulations

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In 2009, the Texas Parks and Wildlife Department (TPWD) instituted a precautionary statewide daily bag of one fish for alligator gar (*Atractosteus spatula*) based on concerns of possible overharvest and habitat loss (Ferrara 2001, Jelks et al. 2008). While direct evidence of overharvest of Texas stocks did not exist, other long-lived freshwater fish (e.g., sturgeon, paddlefish) can be sensitive to harvest, especially when paired with other stressors (Boreman 1997, Quist et al. 2002). Age estimates from Louisiana and Alabama, along with modeled sensitivity to harvest (Ferrara 2001), were key factors when TPWD decided to protect this species while it collected more data. In time, some anglers and biologists began to question whether the statewide approach provided the correct balance between opportunity and protection.

After 2009, TPWD staff conducted numerous studies to better understand alligator gar. Using validated aging techniques (Buckmeier et al. 2012, Daugherty et al. 2019a), it was shown that in Texas, the species can routinely reach 40 years old, with the oldest alligator gar aged in Texas to date at 63 (Smith et al. 2018, Daugherty et al. 2019a). Age structure assessments of alligator gar in Texas have suggested that populations are routinely dominated by a few year classes (Buckmeier et al. 2016, Robertson et al. 2018); likely because alligator gar recruitment is tied to specific hydrologic conditions (Buckmeier et al 2016, Smith et al. 2020). Assignment of age allowed TPWD to estimate growth rates of Texas' alligator gar stocks (Smith et al. 2018, Daugherty et al. 2019a, Daugherty et al. 2019b), as well as estimate age at maturity (Smith et al. 2018). Using all these findings, Smith et al. (2018) developed a dynamic pool model to compare catch-and-release to various length-limits (i.e., minimum, maximum, and slots). The model suggested that other regulations might outperform the current daily bag regulation of one fish, especially under higher exploitation.

Although TPWD has learned much about alligator gar biology since 2009, very little was known about alligator gar anglers in Texas. However, it is well known that both catch and non-catch attributes affect if and where anglers fish (Hunt et al. 2019). Among some of the more important attributes for making fishing decisions are fishing quality (e.g., high catch, high harvest, trophy), regulations associated with managing that fishery, and site quality (e.g., litter, water quality, crowding; Hunt 2005, Hutt et al. 2013, Hunt et al. 2019).

The two most recent statewide surveys of anglers estimated 70,500 to 123,250 of all Texas anglers fished for alligator gar each year (Kyle et al. 2014, 2016). However, little more could be done with these data because neither survey focused specifically on alligator gar anglers. Two localized surveys of alligator gar anglers have been conducted, however: Bennett et al. (2014) focused on bow tournament anglers, whereas the other was administered to anglers who used a variety of gears at Falcon International Reservoir (TPWD unpublished data). At Falcon International Reservoir, although some anglers practiced catch-and-release for alligator gar, many respondents suggested they harvested gar. Unfortunately, neither the motivation for harvest nor the fate of these harvested gar was specifically addressed. Anecdotally, it is known that some anglers harvest alligator gar to eat, whereas other anglers pursue and harvest them as trophies. We were interested in how common the harvest motivation is among alligator gar anglers, because if it is common, the results of the simulations generated by Smith et al. (2018) show that harvest may need to be limited. In addition, understanding the harvest motivation is important because alligator gar have been placed under consumption advisories in some Texas locations (Texas Department of State Health Services [TDSHS] 2015). Hence, it is useful for managers to understand angler motivations and which regulations are likely to be acceptable to anglers.

Rapid growth of the internet has increased its use to collect social research data (Schaefer and Dillman 1998, Kilinç and Firat 2017) and some fisheries data (Press et al. 2015, French et al. 2019). As of the 2016, over 80% of households in the US now have internet access, and while the poorest households are not well-represented, coverage across most other demographic metrics is consistent, high, and growing yearly (Ryan 2018). Online surveys provide an efficient, cost-effective way for respondents to express opinions openly and freely (Stanton and Rogelberg 2001) and allow access to difficult-to-reach populations and groups (Baltar and Brunet 2012).

To better understand Texas alligator gar anglers' desires, constraints, and habits, we developed and administered a voluntary online survey. Other surveys have shown that some trout (Holmes 1987, Hyman and McMullin 2018) and catfish anglers (Hyman et al. 2017) displayed a correlation between the gear used and the motivation for fishing (i.e., flies versus bait for trout, rod and reel versus set lines for catfish). Hyman and McMullin (2018) found that bait anglers fishing for trout were more focused on high catch rates, whereas fly anglers were more likely trophy oriented. Anecdotally, we knew that anglers used both rod and reel and bow and arrow to pursue alligator gar. However, because alligator gar are not designated as a game fish in Texas, they could also be captured using a variety of other gears (e.g., nets, spears, set lines). As fishing styles vary widely among gear types, we hypothesized that one correlate for motivational heterogeneity among alligator gar anglers might be their primary gear. As such, we examined whether angler responses were related to their primary gear of choice, including the number of days fished in the past 12 months. The primary objectives of our survey were to understand what gears Texas' alligator gar anglers used, how these gears might have influenced their motivations for fishing (e.g., consumptive harvest, trophy oriented), where anglers fished for alligator gar, and which regulation options were seen as appropriate by each angler type. We also sought to understand the impact of water quality and consumption advisories on angler practices (e.g., avidity and harvest).

Methods

Survey Development, Promotion, and Administration

We elected to use an online format, developed using SelectSurvey (ClassApps, Inc., Kansas City, Missouri). The survey consisted of a maximum of 59 questions (available upon request); however, all questions were optional. For those who self-identified as alligator gar anglers, we asked 52 questions about topics including fishing frequency, gears used, potential regulation options, motivations, catch and harvest, fishing location, water quality issues, and demographics. For questions that did not require a logical ordering of the responses, we allowed the responses to be randomly presented to respondents to reduce positional bias (Payne 1951). Most questions were close-ended, composed of Likert-scale, multiple choice, and dichotomous formats. For most closed-end questions, we allowed respondents to choose a neutral response to encourage continued participation. The program omitted questions that were unnecessary because of previous answers by a respondent.

In early 2018, to both educate the public about this species and to promote the online angler survey, TPWD began a months-long promotion of alligator gar using internal and external traditional (radio, newspapers) and contemporary (TPWD web-hosted videos, Facebook, Twitter, and Instagram) media. This culminated in June 2018 with a week-long promotion called #GARWEEK. The TPWD's social media posts reached more than 700,000 people, nearly 150,000 people watched TPWD's educational videos online, and 23 different news outlets published stories on alligator gar while also promoting the survey (A. Buzek, TPWD Communications, personal communications). At the conclusion of #GARWEEK, we opened the voluntary online survey. This survey was open from 15 June until 31 July 2018.

Data Analyses

Responses were downloaded from the SelectSurvey framework into SAS Enterprise Guide (SAS Institute 2017). To reduce the potential for biases introduced by a respondent answering multiple surveys, we removed any surveys thought to be duplicates from the database: we did this by assuming that no two people would answer all 59 questions the same, and if we found surveys with identical responses throughout, we counted the survey only once. For the purposes of this study, we focused our analyses on those respondents that identified as alligator gar anglers, excluding fishing guides. We characterized alligator gar angler demographics, practices, and perceptions by calculating summary statistics and comparing response distributions among groups (e.g., angler types) using a Pearson's chi-square test. For proportions, we used the multinomial estimate of variance to produce standard errors. Whereas we report results of the statistical tests and associated *P*-values, readers should be aware that with the large sample sizes, even small differences in the point estimates can be declared significant. As such, we ask readers to pay attention to the actual differences in the point estimates. All statistical analyses were considered significant at $P \leq 0.05$.

Results

Survey Participation

A total of 12,985 people accessed the online survey, and 8625 provided responses. After removing 442 duplicate surveys, we ended up with 8183 unique responses. Most duplicates arose because people began the survey, answered a few screening questions, then stopped answering questions. Since those responses were identical, and they were screening questions, they were assumed to be duplicate responses and removed from the analysis. Because all questions were optional, most questions had a different number of total responses.

Respondents ($n = 8183$) were primarily Texas residents who fished (91%, SE = 0.003). We were able to classify 4012 of those responses as Texas alligator gar anglers. We did not include in that number the 32 respondents who identified themselves as alligator gar guides. The other respondents also dropped from analyses were those who self-identified as non-gar anglers or non-anglers.

Alligator gar angler respondents were overwhelmingly male (96%, SE = 0.004; $n = 2756$), and Caucasian (94%, SE = 0.004; $n = 2734$). Based on zip codes, 68% of respondents (SE = 0.008; $n = 3690$) lived within Texas' five major metropolitan areas (i.e., Houston, Dallas, Austin, San Antonio and Fort Worth). Respondents' reported ages ranged from 7 to 99 (Table 1).

Table 1. Age demographics by gear type for the current alligator gar angler survey and for the Texas 2015 statewide angler survey. The question of primary gear in this survey allowed respondents to pick from a list or add their own gear type. The row labeled "All (current survey)" includes all respondent gears, including rod-and-reel, and bow. Row totals may not equal 100% due to rounding.

	Age group (%)					
Primary gear	**≤19**	**20–29**	**30–39**	**40–49**	**50–59**	**≥60**
Rod and reel	1.4	8.0	17.7	18.5	21.4	33.1
Bow and arrow	1.8	12.7	24.8	23.1	20.5	17.0
All (current survey)	1.4	8.6	19.2	19.2	21.1	30.3
All (statewide)	2.4	19.8	22.6	23.2	24.3	7.7

Gear Preferences, Motivations, and Alligator Gar Fishing Practices

One of our primary objectives was to better understand whether the gear an alligator gar angler primarily used affected their responses. Because 95% (SE = 0.004; $n = 3779$) of anglers used either a rod and reel (RR) or bow and arrow (bow) when fishing for alligator gar, we focused only on these two gear types for comparisons. Most anglers primarily used a RR (68%, SE = 0.008; $n = 3779$), but 23% primarily used a bow (SE = 0.007). Most respondents (82%, SE = 0.008; $n = 2560$) who reported RR to be their primary gear further indicated RR was the sole gear they used. In contrast, only 61% (SE = 0.016; $n = 875$) of bow anglers stated a bow was their only gear; 36% (SE = 0.016; $n = 875$) further reported that they also fished for alligator gar using RR. Other gears reported included jug lines, set lines, trot lines, and spears.

Anglers targeted alligator gar for a variety of reasons. Slightly more anglers said they fished for trophy alligator gar (Table 2) compared to those who fished for consumption. Very few anglers fished in tournaments; however, bow anglers were twice as likely to have fished a tournament compared to RR anglers. Most anglers found fishing for alligator gar a challenge and a thrill, whereas few pursued gar simply because they were rare (Table 2).

Angler practices were fairly consistent regardless of primary gear. The Trinity River system was the most frequently named destination (Figure 1); however, of those who fished in rivers, only 26% of RR anglers (SE = 0.01; $n = 1426$) and 34% of bow anglers (SE = 0.01; $n = 560$) claimed to have fished there within the past five years. We saw no significant difference (χ^2= 7.34), df = 7, $P < 0.394$) in the number of days fished between primary gear; both RR and bow anglers ($n = 1308$) had fished a median of 5–10 days over the past 12 months. There was little difference in catch rates by the primary gear, and most respondents harvested few fish. Although 90% (SE < 0.008; $n = 1640$) of anglers caught at least one alligator gar per year, bow anglers tended to harvest more fish annually (χ^2=196.9, df = 7, $P < 0.001$; Figure 2). Only 40% (SE = 0.014; $n = 1207$) of RR anglers harvested at least one fish annually compared to 77% (SE = 0.020; $n = 431$) of bow anglers.

Table 2. Responses to the online survey by alligator gar anglers using three primary gear categories. Respondents are the number of people in each category that answered the question. Standard errors are in parentheses. Due to rounding, row totals may not equal 100 %.

Reason for fishing	Primary gear	Respondents	Agree (%)	Neutral (%)	Disagree (%)
To catch a trophy	Rod	2260	45.4 (0.01)	26.3 (0.01)	28.3 (0.01)
	Bow	765	59.1 (0.02)	25.9 (0.02)	15.0 (0.01)
	Other	296	40.5 (0.03)	26.0 (0.03)	33.5 (0.03)
To eat	Rod	2275	38.1 (0.01)	19.9 (0.01)	42.0 (0.01)
	Bow	759	43.9 (0.02)	24.0 (0.02)	32.2 (0.02)
	Other	306	46.1 (0.03)	18.0 (0.02)	35.9 (0.03)
Challenging to catch	Rod	2291	82.4 (0.01)	11.1 (0.01)	6.5 (0.01)
	Bow	774	79.6 (0.01)	13.6 (0.01)	6.8 (0.01)
	Other	305	65.6 (0.03)	17.1 (0.02)	17.4 (0.02)
For the thrill	Rod	2289	85.8 (0.01)	8.3 (0.01)	6.0 (<0.01)
	Bow	772	85.1 (0.01)	11.0 (0.01)	3.9 (0.01)
	Other	303	72.6 (0.03)	12.9 (0.02)	14.5 (0.02)
They are rare	Rod	2268	15.6 (0.01)	26.2 (0.01)	58.2 (0.01)
	Bow	755	10.1 (0.01)	24.6 (0.02)	65.3 (0.02)
	Other	302	10.3 (0.02)	28.5 (0.03)	61.3 (0.03)
In tournaments	Rod	2270	10.6 (0.01)	25.1 (0.01)	64.3 (0.01)
	Bow	767	19.8 (0.01)	29.9 (0.02)	50.3 (0.02)
	Other	302	13.9 (0.02)	22.2 (0.02)	63.9 (0.03)

Angler Perceptions of Regulations and Water Quality

About half of the respondents were satisfied with TPWD's current one fish daily bag limit, regardless of their primary gear. Bow anglers were slightly less satisfied (χ^2= 24.9, df = 2, $P < 0.001$;49% satisfied, 26% unsatisfied, 25% neutral; $n = 850$) than rod-and-reel anglers (58% satisfied, 19% unsatisfied, 23% neutral $n = 2463$). Additionally, 43% (SE = 0.009) of RR anglers and 50% (SE = 0.009) of bow anglers were open to localized regulation alternatives ($n = 3297$). When asked about alternative regulatory options (Table 3) anglers primarily supported the new regulation options. Interestingly, the percent of bow anglers who supported CR did not change much (38% supported, 42% opposed, 20% neutral) when we examined responses of bow anglers who only fished using a bow. The only option that fewer than half the anglers supported was a requirement for a permit to harvest alligator gar. Comments from individual anglers suggested they felt that the annual license should be sufficient.

Irrespective of gear, 47% of anglers (SE = 0.011; $n = 2253$) had concerns about the water quality where they fished. Of those ($n = 1038$), 43% (SE = 0.018) agreed, compared to 48% (SE = 0.019) disagreed, that poor water quality has reduced the number of days they fished. When asked whether there was a consumption advisory on their primary waterbody, most (52%, SE = 0.011) were unsure, and only 36% (SE = 0.010; $n = 2227$) claimed there was not.

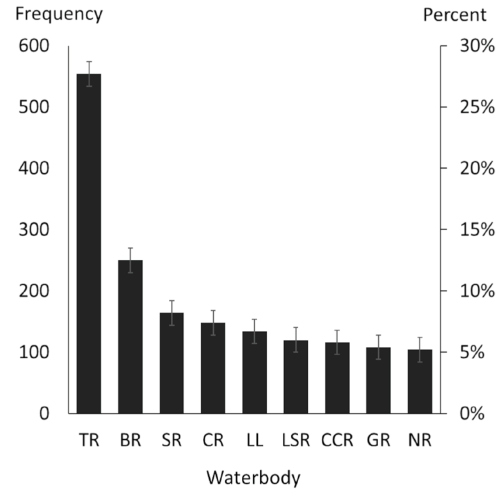

Figure 1. Waterbodies within Texas where anglers reported fishing for alligator gar. Both the frequency of responses and the percentage are plotted. Error bars reflect the standard error of the estimate. Based on the properties of variance, the error bars are valid on either scale. Abbreviations within the figure are: Trinity River (TR), Brazos River (BR), Sabine River (SR), Colorado River (CR), Lake Livingston (LL), Lake Sam Rayburn (LSR), Choke Canyon Reservoir (CCR), Guadalupe River (GR), and Nueces River (NR).

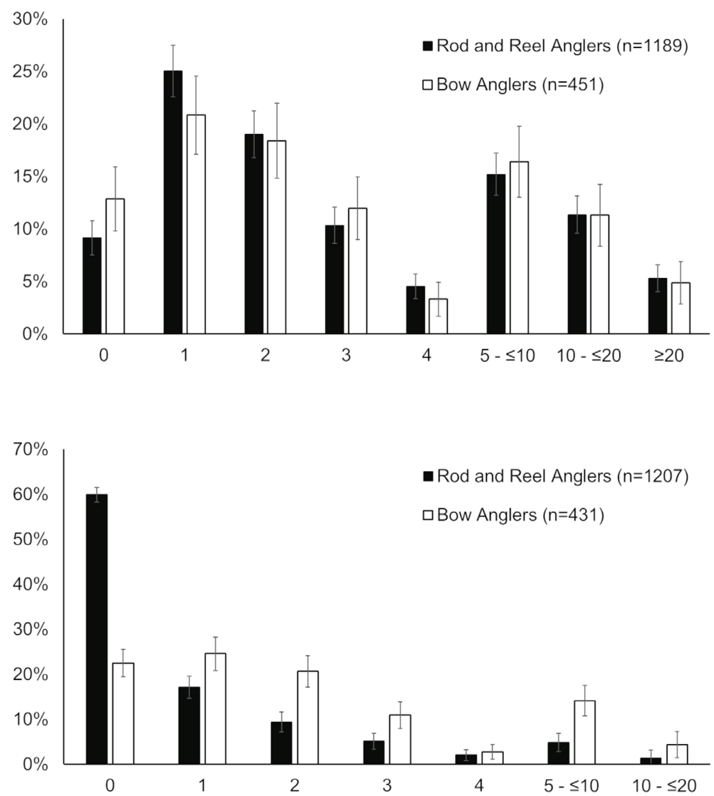

Figure 2. Average number of alligator gar reported to be caught (top) and harvested (bottom) annually by respondents to the online survey, along with an estimate of the 95% CI. Although responses are categorized by the primary gear the angler used, responses include all alligator gar harvested regardless of gear type. Responses were pooled and categorized for total number of fish over five due to limited data.

Table 3. Responses to the online survey by alligator gar anglers using three primary gear categories. Respondents are the number of people in each category that answered the question. Standard errors are in parentheses. Due to rounding, row totals may not equal 100 %.

Question	Primary gear	Respondents	Support (%)	Neutral (%)	Oppose (%)
Support for use of length limits	Rod	2293	77.8 (0.01)	10.3 (0.01)	11.9 (0.01)
	Bow	775	54.8 (0.02)	16.9 (0.01)	28.3 (0.02)
	Other	308	63.0 (0.03)	12.0 (0.02)	25.0 (0.02)
Support for catch-and-release	Rod	2463	62.6 (0.01)	17.4 (0.01)	20.0 (0.01)
	Bow	853	38.8 (0.02)	21.1 (0.01)	40.1 (0.02)
	Other	334	45.5 (0.03)	17.4 (0.02)	37.1 (0.03)
Support for mandatory harvest reporting	Rod	2360	67.5 (0.01)	15.3 (0.01)	17.2 (0.01)
	Bow	796	58.4 (0.02)	16.0 (0.01)	25.6 (0.02)
	Other	315	55.2 (0.03)	15.6 (0.02)	29.2 (0.03)
Support for harvest permit	Rod	2367	43.1 (0.01)	14.1 (0.01)	42.8 (0.01)
	Bow	798	36.5 (0.02)	14.4 (0.01)	49.1 (0.02)
	Other	315	34.6 (0.03)	12.1 (0.02)	53.3 (0.03)

Most respondents (80%, SE = 0.008; $n = 2236$) stated that if they knew there was a consumption advisory, they would likely reduce their consumption of fish from those waterbodies.

Discussion

Fisheries management should incorporate demographic and sociological data into the decision-making process (Quinn 1992). While historically these data were collected using mail surveys, today more of these surveys are being conducted online (Gallagher et al. 2015, Press et al. 2015), especially when the sample frame is difficult to construct. For this survey, the lack of a complete or efficient sampling frame for our target audience made an internet survey a reasonable way to reach the group in which we were most interested. Unfortunately, no survey approach, regardless of how well it is designed, gives a completely unbiased and representative sample of anglers (Beam 2012). The most recent Texas statewide angler survey (Kyle et al. 2016) was a probability-based survey with a well-defined frame. It was time-consuming and expensive, taking about two years to complete and cost US$55,000 (TPWD, unpublished data). Despite this, it had only 948 responses (i.e. a response rate of 20%; Kyle et al. 2016).

There is little reason to assume engagement will improve in future mail surveys as nonresponse bias will likely continue to be an issue (Connelly et al. 2003). Even with a solid design, surveys require model-based bias adjustments (Armstrong and Overton 1977, Fisher 1996); however, often these are insufficient (Groves 2006). For example, model adjustments of nonresponse routinely adjust the survey weights based on a few easily measured characteristics (Fisher 1996, Groves 2006). Nonresponse is commonly associated with each specific question, and therefore biases can vary across questions. A survey-wide, model-based adjustment likely does not properly adjust for each question's bias. Though some biases may be identified and corrected, other nonresponse biases are likely missed. We recently found that those who buy licenses most frequently are much more likely to respond to the statewide survey (TPWD unpublished data), but no adjustment for loyalty bias has been used. Despite these known biases, mail-based surveys like these are routinely used by managers to inform policy. Given that all surveys are inherently biased anyway, we suggest internet surveys at least can potentially result in larger samples as well as be administered at far less expense than other kinds of surveys. Our internet survey allowed us to collect input from more than 4000 alligator gar anglers, took less than one year to complete, and including required software, cost less than US$500 (TPWD, unpublished data).

The similarities in respondent demographics between our internet survey and the last Texas statewide angler survey (Kyle et al. 2016) suggested that our approach likely surveyed similar user groups but had a far greater sample size. Most survey respondents were primarily Caucasian (92% for our survey compared to 91% for the statewide) and were between 30 and 60 years old. Males were likely over-represented in both surveys (96% for our survey compared to 80% for the statewide survey); male representation in Texas angling surveys is usually high and has been increasing (Lu et al. 2009, Hunt et al. 2012). Males were also the predominant respondents to two internet-based surveys of shark anglers (Gallagher et al. 2015, Press et al. 2015) and a mixed-mode mail-email survey (Murphy et al. 2019). However, national surveys suggest female participation in fishing is likely around 30% (U.S. Fish and Wildlife Service and U.S. Census Bureau 2012, Recreational Boating and Fishing Foundation and The Outdoor Foundation 2015). All of these suggest more needs to be done to get input from female anglers.

We, like Bennett et al. (2014), noted some demographic differences between bow-anglers and the statewide anglers. For example, Bennett et al. (2014) noted bow anglers were younger compared to statewide anglers, as did we; respondents less than 50 years of age comprised 45.9% of RR anglers, but 62.4% of bow anglers. However, a higher percentage of people over 60 responded to this survey than were present in either the Texas statewide (Kyle et al. 2016) survey or the Bennett et al. (2014) survey. It seems an online angler survey is likely to yield more respondents and more perspectives with comparable biases to other survey approaches (Fleming and Bowden 2009, Olsen 2009). Because most Texas angler surveys were heavily skewed towards middle-aged, non-Hispanic, white males (Lu et al. 2009), results of this survey and previous mail surveys probably most closely reflect the opinions of that demographic.

Respondents to this survey suggested they were comfortable with a variety of proposed regulation options. One reason TPWD imposed a daily bag limit on alligator gar in 2009 was the assumption that bow anglers would not accept either CR or length limit regulations. We were surprised by the support of these regulations by bow anglers, as CR is obviously incompatible with bow angling, and releasing a bow-angled fish is illegal in Texas. Support of CR regulations by bow anglers, even those solely using that gear, seemingly reflects both their willingness to accommodate other anglers and their willingness to use other gears that would allow live release. Future surveys should refine questions to bow anglers about CR to understand whether they would continue to fish CR areas with other gears or leave that fishery; and if the latter, how far they would be willing to travel. Our results suggest that regulation options traditionally considered more compatible with RR fisheries (e.g., length limits and CR), could provide effective alternatives to the creel limits currently imposed on most alligator gar stocks. Further, both approaches can provide options to either reduce harvest or restructure the harvest and the population. Creatively combining length limits with annual bag limits could allow managers to have localized regulations that better match both local stock dynamics and angler preferences. Recently, TPWD imposed a 122-cm maximum length limit to protect the trophy fishery within the Trinity River, with a one-fish daily bag limit and an annual quota of no more than 160 alligator gar above 122-cm (TPWD 2020). In stark contrast, Falcon Reservoir has a five-fish daily bag limit, and the most recent survey detected very few trophy alligator gar (Myers et al. 2019).

This survey identified both trophy and consumptive motivations among both rod-and-reel and bow anglers. Regardless of motive, data from this survey and from Bennett et al. (2014) suggest that most anglers are harvesting only a few fish each year. Bennett et al. (2014) found that 57% of bow anglers reported harvesting at least one alligator gar in the previous 12 months; and the average number harvested was three. In this survey, 77% of bow anglers suggested they harvested at least one gar per year, and the median number harvested was two fish per year. Bow angling has been thought to constitute most of the recreational harvest of alligator gar (Bennett and Bonds 2012) and results of this survey suggested bow anglers are more likely to harvest alligator gar. However, although bow anglers may harvest more fish per angler, overall harvest of alligator gar could be slightly skewed towards RR anglers because RR anglers appear to greatly outnumber bow anglers. Given the current low harvest rates and the support we observed for alternative regulations by both user groups, regulations should be considered that better meet both trophy and harvest motivations, are agreeable to these user groups, and provide protection to the population, much like what has been done within the Trinity River.

Considering the periodic life-history strategy of the alligator gar (Winemiller and Rose 1992, Buckmeier et al. 2016, Smith et al. 2018), longevity (Daugherty et al. 2019a), and slow adult growth (Daugherty et al. 2019b), meeting both trophy and consumptive angling motivations is likely to require system-specific, length-based management. Texas anglers generally consider alligator gar 1828- to 2134-mm TL or greater to be of trophy size (Bennett et al. 2014). Daugherty et al. (2019b) found that fish of this size are predominantly female, and require an average of about 16 and 32 years to attain 1828 cm and 2134 cm, respectively. Male fish rarely exceed 1524-mm TL, resulting in a stockpiling of male fish below this length in populations (Daugherty et al. 2019b). Thus, a 1524- to 1828-mm TL protected slot regulation may provide the greatest balance between harvest and trophy potential (Smith et al. 2018), and the results of this study suggest such a regulation may be acceptable to all angler groups.

It is encouraging to learn that mandatory harvest reporting was supported by most anglers. Whereas managers can use creel surveys to estimate harvest of many recreational species, because of low pressure and low harvest, a creel approach for alligator gar is likely to be highly inefficient and yield low precision. Despite the noted weaknesses of self-reported data (Nov et al. 2014), the use of these data is increasing. Voluntary angler diaries (Cooke et al. 2000, Bray and Schramm 2001) and Citizen Scientist apps like iSnapper (Stunz et al. 2014) and iAngler (Jiorle et al. 2016) have demonstrated that self-reported data can be useful, if sometimes limited. Several studies have found that angler reporting rates increase for more memorable events (Westat 1989, Mazurkiewicz et al. 1996). Our survey suggests that the harvest of alligator gar is a rare event. In addition, alligator gar can routinely reach weights in excess of 45 kg (Smith et al. 2018); likely a memorable event in freshwater fishing. Thus, we expect that these characteristics of alligator gar fishing could lead to high self-reporting rates. TWPD came to realize that if even only a fraction of the harvested alligator gar were to be reported, the data collected would allow a better understanding of the minimum numbers harvested. Therefore, Texas instituted mandatory harvest reporting on all systems beginning in September 2019, except Falcon International Reservoir. Although there is no estimate of the reporting rate, anglers across the state entered over 900 harvest reports from more than 200 waterbodies in the first year of the self-reporting program.

The TWPD mandatory reporting program provides a means to identify where harvest occurs and the size of fish harvested. These are important data considering this survey indicated that a substantial proportion of anglers were unsure if a consumption advisory existed on the waters they fished, much like elsewhere (Macdonald and Boyle 1997, Jakus et al. 1998). Fish size, age, and trophic position are known to be positively related to body burdens for many common contaminants (Phillips et al. 1980, MacCrimmon et al. 1983, Francesconi and Lenanton 1992). The potential for bioaccumulation of contaminants in alligator gar is high, and the harvest of large fish for consumption is of particular concern. Data collected via harvest reporting could serve to inform regulatory policies and angler awareness needs. For example, the Trinity River was identified in this survey as the most popular angling destination for alligator gar in Texas yet has a "Do Not Eat" consumption advisory for all gar due to high levels of dioxins and polychlorinated biphenyls (Texas Department of State Health Services [TDSHS] 2015). Further, numerous other waterways in Texas do not specifically name gar but do have consumption advisories for other piscivorous fish (TDSHS 2015). Self-reported harvest data could help managers to direct future tissue sampling of alligator gar to better understand which waters have fish that are safe for consumption.

Because 40% of our survey respondents said they fished for gar for food, using harvest monitoring to identify where anglers are harvesting fish from impaired waters could help manager prioritize areas for remediation or could be used to improve communications to discourage take. As found in previous studies (Montgomery and Needleman 1997, Jakus et al. 1998, Parsons et al. 1999), a substantial fraction of anglers in this survey suggested that water quality influenced where and how often they fished. Because clean water attracts anglers and other water enthusiasts, improving water quality, while expensive, is normally expected to have a net economic benefit (Montgomery and Needleman 1997). Managers could also impose regulations to influence where harvest is either promoted or discouraged.

Our survey increased our understanding of alligator gar anglers. While most angler respondents were satisfied with the current statewide regulation, many suggested they supported having localized regulations tailored to meet different motivations or different population characteristics. Further, most respondents claimed to support a variety of regulation options that would give managers the flexibility to create positive experiences for anglers, regardless of whether they are catch or harvest oriented. Finally, we learned that many anglers do not know whether the places they fish have poor water quality or consumption advisories. For those anglers who did know, those concerns resulted in a decrease in fishing. Ultimately, a primary goal of fisheries managers should be to provide the maximum angler benefit within the biological constraints of the species. Improving public awareness of system-specific consumption advisories, shifting harvest to smaller, younger fish via length limits, or the development of catch-and-release only fisheries in some places may be useful and acceptable management options as Texas alligator gar fisheries continue to develop. As noted, TPWD has already used the results of this survey to impose statewide harvest reporting and to guide recent regulation changes within the Trinity River. As fisheries managers begin to fine-tune management of this species, we suggest they work closely with these different angler groups to understand which regulations to apply to specific waterbodies. Future surveys should be conducted to understand angler satisfaction with any regulation changes. Further, as mandatory reporting is the sole estimate of harvest, an estimate of non-reporting would be useful.

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