ANNUAL REPORT

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

Oklahoma Nongame Fishes

Research and Management

[Area 045]

2025

ANNUAL REPORT

State: Oklahoma

Project Title: Oklahoma Nongame Fishes Research and Management

Period Covered: January 1 – December 31, 2025

Prepared by: Jason D. Schooley, Matt Pallett, Caleb Taylor, Tate Baumert, and Marcus Prull

Date Prepared: January 2026

EXECUTIVE SUMMARY

Management of Oklahoma's native nongame (NNG) fishes is a new focus for the Department with the development of the Paddlefish and NNG program in 2023. Activities in 2025 primarily included processing of samples acquired through collaboration with Oklahoma Fish Stickers bowfishing club tournaments in 2024. Some of the buffalofishes collected served as specimens for a collaboration with Oklahoma State University on the morphology and genetics of Oklahoma buffalofishes. To date, 1,949 buffalofishes have been examined for morphology, age (subset n=1,388), sex, and a subset of genetic samples analyzed to determine levels of hybridization while providing a confirmation for species identification. Use of published morphological characters to differentiate Smallmouth and Black buffalofishes in Oklahoma has been problematic and our data demonstrate inconsistent results based on character(s) used. Overall, visual identification to species, as validated by mtDNA, proved more accurate than a calculated metric based on body depth. A combination of opportunistic sampling paired with larger sample sizes provided by bowfishing tournament fish has expanded our abilities to perform stock assessments. We modeled population dynamics for Smallmouth Buffalo collected from nine stocks: Chimney Rock, Ft. Gibson, Grand, Hulah, Keystone, Shell, Tenkiller, Texoma, and the Verdigris River. Although certain samples may still be inadequate for robust interpretation, and age and growth varied across stocks, we found consistent estimates for annual mortality within an expected range (1-5%) for a long-lived species such as Smallmouth Buffalo. We found the age structure of Smallmouth Buffalo in Oklahoma lakes to span 1-75 years, recruitment to be irregular or episodic, and some evidence to suggest that recruitment may be linked to flood ecology. Many other samples from non-buffalofish species are still in progress and will inform future models. A statewide management plan for NNG fishes is in early development.

Oklahoma Nongame Fishes Research and Management - Annual Report 2025

Table of Contents

INTRODUCTION

Nongame fishes are officially defined in Oklahoma Title 29 by what they are not (§29-2-123). Whereas the definition of game fishes (§29-2-115) includes a qualifier that they are “normally sought after by sportsmen”, this is accompanied by distinct list of at least 15 species or hybrids, which includes multiple nonnative species. Regardless of a species’ emergent recreational or social status among sportsmen, “game fish” status is reserved only for those listed. Further, “sport fish” is not legally defined, however, many of Oklahoma’s nongame fishes are undeniably *de facto* game or sport fishes, as recreational fisheries have existed for many decades. Examples include the Paddlefish, Flathead Catfish, and Alligator Gar. All these fishes are managed with bag or size limits, among other regulatory measures.

§29-2-123. Nongame fish. "Nongame fish" are all fish not game fish.

§29-2-115. Game fish. “Game fish” is a fish normally sought after by sportsmen, and includes only largemouth bass, smallmouth bass, white bass, spotted bass, black crappie, white crappie, northern pike, trout, sauger, saugeye, striped bass, hybrid striped bass, walleye, blue catfish and channel catfish. Blue catfish and channel catfish are herein defined to mean “forked tail” catfish. The list of game fishes was modified in 2025 to include Hybrid Striped Bass as part of a legislative package in Senate Bill 777 enacted May 5, 2025.
https://www.oklegislature.gov/cf_pdf/2025-26%20ENR/SB/SB777%20ENR.PDF

As of 2026, many native nongame (NNG) fishes are not collectively afforded any bag limits or protections, and this trends nationwide (Figure 1). For a regulatory summary of bag limits for select nongame fishes, see Appendix A. Several Oklahoma NNG fishes are listed as Species of Greatest Conservation Need (SGCN, also known as Species of Special Concern). SGCN fishes are restricted to a daily bag limit of one (1) with mandatory reporting. Examples of NNG fishes falling under this SGCN bag limit regulatory umbrella include Shovelnose Sturgeon, Blue Sucker, American Eel, and others. Paddlefish and Alligator Gar are also SGCN fishes, however their individual species regulations are more restrictive (Table 1).

Oklahoma’s aquatic biodiversity includes approximately 177 fish species, with 16 considered game fishes (when considering “trout” as a collective term to include both Rainbow and Brown), 5 considered threatened or endangered species, and 56 regarded as SGCN (Table 2). ODWC has revised the Oklahoma Comprehensive Wildlife Conservation Strategy (ODWC 2016), to be renamed the Oklahoma State Wildlife Action Plan (SWAP), resulting in the downgrade/removal of American Eel from SGCN status in Oklahoma. During the peer-review process for the revision of this important statewide document, our program provided a memorandum advocating for continued conservation protection of American Eel through SGCN status (Appendix C). Ultimately, the decision was made to remove it for lack of meeting the minimum criteria, but there are plans to add American Eel to the list of Species of Special Concern in Oklahoma (§800:25-19-6) in 2026 or 2027. These species, by default, are afforded SGCN status and have a daily harvest limit of 1/day (§800:10-1-4-13). Therefore, the downgrade/removal will likely be temporary and may not have any practical effects due to their rarity.

Oklahoma’s remaining 100 species (56%) are other fishes that generally have no bag limits or harvest protections (Figure 2). In Oklahoma and other states, there is no clear regulatory distinction between NNG and nonnative invasive (NNI) fishes, particularly considering fishes deemed as naturalized (i.e., Common Carp and perhaps Grass Carp).

Figure 1. Summary of bag limit regulations in the United States. Table 2 from Rypel, et al. (2021).

Table 2. Summary of rough fish regulations in the USA. If different bag limits existed by species, we report the lowest limit. Some states had regional- or ecosystem-specific regulations, but present here only statewide regulations.

State	Bag limits of over 10 fish per day	Unlimited bag limits	Possession limit	Term used	Largemouth Bass bag limit
Alabama	Y	Y	N	Nongame fish	10
Alaska	Y	Y	N	Other	-
Arizona	Y	Y	N	Other species	6
Arkansas	Y	Y	N	Rough fish	10
California	Y	Y	N	Other	5
Colorado	Y	Y	N	Game fish	5
Connecticut	Y	Y	N	Other	6
Delaware	Y	Y	N	Other	6
Florida	Y	Y	N	Nongame fish	5
Georgia	Y	Y	N	Other	10
Hawaii	–	–	–	Other	10
Idaho	Y	Y	N	Nongame fish	6
Illinois	Y	Y	N	Other	6
Indiana	Y	Y	N	Other	5
Iowa	Y	Y	N	Rough fish	3
Kansas	Y	Y	N	Other	5
Kentucky	Y	Y	N	Rough fish	6
Louisiana	Y	25	50	Nongame fish	10
Maine	Y	Y	N	Other	2
Maryland	Y	15	30	Other	5
Massachusetts	Y	Y	N	Other	5
Michigan	Y	Y	N	Other	5
Minnesota	Y	Y	N	Rough fish	6
Mississippi	Y	Y	N	Other	10
Missouri	Y	50	100	Nongame fish	6
Montana	Y	Y	N	Nongame fish	5
Nebraska	Y	Y	N	Nongame fish	5
Nevada[1]	Y	Y	N	Other	-
New Hampshire	Y	Y	N	Other	5
New Jersey	Y	25	N	Other	5
New Mexico	Y	Y	N	Other	5
New York	Y	Y	N	Other	5
North Carolina	Y	Y	N	Nongame fish	5
North Dakota	Y	Y	N	Nongame fish	3
Ohio	Y	Y	N	Forage fish	5
Oklahoma	Y	Y	N	Other	6
Oregon	Y	Y	N	Nongame fish	5–6
Pennsylvania	Y	50	N	Other	6
Rhode Island	Y	Y	N	Other	5
South Carolina	Y	Y	N	Other	5
South Dakota	Y	Y	N	Rough fish	5
Tennessee	Y	Y	N	Nongame fish	5
Texas	Y	Y	N	Other	5
Utah	Y	Y	N	Nongame fish	6
Vermont	Y	Y	N	Other	5
Virginia	Y	20	N	Nongame fish	5
Washington	Y	Y	N	Food fish	5
West Virginia	Y	Y	N	Other	6
Wisconsin	Y	Y	N	Rough fish	5
Wyoming	Y	Y	N	Nongame fish	6

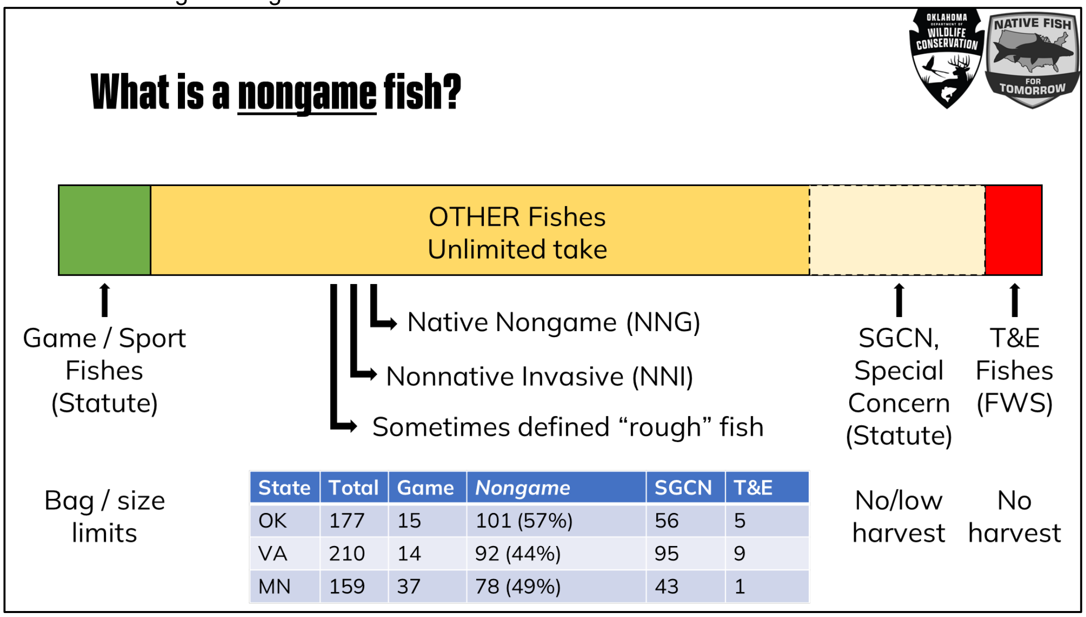
[1]Bag limits in Nevada vary exclusively by region, but several rough fish taxa are unregulated, so they were listed as unlimited bag limit.

A number of Oklahoma's NNG fishes are targeted by various fisheries, including hook and line, snagging, spearing/gigging, noodling, and bowfishing. Snagging is primarily practiced in the pursuit of Paddlefish and this species/fishery is addressed separately in a Paddlefish annual report. Noodling is primarily practiced for catfishes, including the nongame Flathead Catfish, and these fisheries are considered by regional management personnel. Anecdotal evidence from regional management suggests that snagging of Flathead Catfish using live sonar is growing in popularity, particularly among licensed fishing guides. This may be a fishery worth considering among the other harvest methods for these catfish. Gigging and bowfishing are relatively under-studied methodologies in Oklahoma and nationwide, however a recent study was completed on gigging in northeast Oklahoma (Zentner et al. 2023) and four studies were recently completed on bowfishing in Oklahoma (Scarnecchia and Schooley 2020; York et al. 2022; Montague et al. 2023; Zentner et al. in press). We completed an experimental bowfishing tournament study on Shell Lake in fall 2024, but this manuscript has not yet been prepared.

Table 1. List of select native nongame fishes of Oklahoma (taxonomically grouped) with conservation status, daily bag limit, and other details. SGCN fishes, unless otherwise regulated with a bag limit, are subject to a default daily limit of one (1) with mandatory harvest reporting. American Eel will lose SGCN status sometime in 2026, but will be proposed to be added to the Species of Special Concern list through the regular regulatory process in 2026 or 2027.

Common Name	Scientific Name	Conserv. Status	Daily Bag Limit and other protections
Alligator Gar	*Atractosteus spatula*	SGCN	1, seasonal closure, mandatory reporting
Longnose Gar	*Lepisosteus osseus*		Unlimited
Shortnose Gar	*L. platostomus*		Unlimited
Spotted Gar	*L. oculatus*		Unlimited
Bigmouth Buffalo	*Ictiobus cyprinellus*		Unlimited
Smallmouth Buffalo	*I. bubalus*		Unlimited
Black Buffalo	*I. niger*	SGCN	1
River Carpsucker	*Carpiodes carpio*		Unlimited
Highfin Carpsucker	*C. velifer*		Unlimited
Quillback	*C. cyprinus*		Unlimited
Freshwater Drum	*Aplodinotus grunniens*		Unlimited
Flathead Catfish	*Pylodictus olivaris*		5
Black Bullhead	*Ameiurus melas*		Unlimited
Brown Bullhead	*A. nebulosus*	SGCN	1
Yellow Bullhead	*A. natalis*		Unlimited
Blue Sucker	*Cycleptus elongatus*	SGCN	1
Golden Redhorse	*Moxostoma erythrurum*		Unlimited
River Redhorse	*M. carinatum*		Unlimited
Shorthead Redhorse	*M. macrolepidotum*	SGCN	1
Goldeye	*Hiodon alosoides*		Unlimited
Mooneye	*H. tergisus*	SGCN	1
Skipjack Herring	*Alosa chrysochloris*		Unlimited
Alabama Shad	*A. alabamae*	SGCN	1
American Eel	*Anguilla rostrata*	SGCN	1
Paddlefish	*Polyodon spathula*	SGCN	1, annual limit 2, mandatory reporting, etc.
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	SGCN	1

Figure 2. What is a nongame fish? Slide excerpted from American Fisheries Society annual meeting 2023 presentation titled- “The Complex Identities of ‘Other’ Fishes: How legal status and regulatory loopholes complicate the management and conservation of native, traditionally nongame fish species”. In 2025, Hybrid Striped Bass was moved from nongame to game fish status.



State	Total	Game	*Nongame*	SGCN	T&E
OK	177	15	101 (57%)	56	5
VA	210	14	92 (44%)	95	9
MN	159	37	78 (49%)	43	1

Table 2. List of 56 nongame fishes classified as Species of Greatest Conservation Need (SGCN) in Oklahoma. Excerpted from the ODWC Oklahoma Comprehensive Wildlife Conservation Strategy (ODWC 2016). Common names prefixed by an asterisk (*) are regarded as under the generalized purview of the Paddlefish and Nongame Program (Area 45), whereas the remainder are under the purview of the ODWC Streams Program (Area 05).

Common Name	SGCN Tot. Score	Tier	Selection Criteria
*Alabama Shad	11	II	2, 3, 4
*Alligator Gar	11	II	2, 3, 4
*American Eel	9	III	4
Arkansas Darter	13	I	1, 2, 3
Arkansas River Shiner	14	I	1, 3, 4
Arkansas River Speckled Chub	11	III	2, 3
*Black Buffalo	9	III	2
Blackside Darter	9	III	2
Blackspot Shiner	13	I	3, 4, 6
*Blue Sucker	11	II	2, 3
Bluehead Shiner	12	II	2, 3, 4, 6
Bluntface Shiner	11	II	2
*Brown Bullhead	9	III	2
Cardinal Shiner	12	II	6
Chub Shiner	11	II	6
Creole Darter	11	II	6
Crystal Darter	12	II	2, 3, 4
Cypress Minnow	9	III	2
Flathead Chub	9	III	2, 4
Goldstripe Darter	11	II	2
Harlequin Darter	9	III	2
Ironcolor Shiner	11	II	2, 4
Kiamichi Shiner	12	II	2, 3, 4, 6
Least Darter	12	II	4, 6
Leopard Darter	14	I	1, 3, 4, 6
Longnose Darter	14	I	2, 3, 4, 6
*Mooneye	9	III	2
Mountain Madtom	10	III	2
Neosho Madtom	14	I	1, 3, 4, 6
Orangebelly Darter	11	II	6
Ouachita Mountain Shiner	12	II	2, 3, 4, 6
Ozark Cavefish	13	I	1, 3, 4, 6
Ozark Minnow	11	II	6
*Paddlefish	9	III	3, 4
Pallid Shiner (Chub)	12	II	2, 3, 4
Peppered (Colorless) Shiner	14	I	2, 3, 4, 6
Plains Minnow	12	II	5
Plains Topminnow	10	III	2, 3
Prairie Speckled Chub	13	I	2, 3
Red River Pupfish	10	III	6
Red River Shiner	10	III	6
Redfin Darter	11	II	6
Redspot Chub	12	II	3, 6
Redspot Darter	10	III	6
River Darter	9	III	2
Rocky Shiner	12	II	3, 4, 6
Scaly Sand Darter	10	III	3
*Shorthead Redhorse	10	III	2
*Shovelnose Sturgeon	12	II	2, 3
Silverband Shiner	11	II	3
Southern Brook Lamprey	11	II	2
Spotfin Shiner	9	III	2
Sunburst (Stippled) Darter	12	II	6
Taillight Shiner	10	III	2
Wedgespot Shiner	11	II	6
Western Sand Darter	12	II	3, 4

Many of Oklahoma's native nongame fishes are commercially fished in other states. While commercial fishing in Oklahoma remains legal in statute (§29-4-103), no commercial fishing permits have been issued since 1992. Prior to then, large total weights of numerous NNG fishes were taken annually. During the period 1961-1969, Mensinger (1971) reported that commercial harvests of buffalofishes (Bigmouth and Smallmouth) exceeded that of other species (carps, Flathead Catfish, Freshwater Drum, Paddlefish, River Carpsucker, White Bass, and gars). Commercial harvests were spread across 50-90 permits fishing 12 private or municipal lakes <500 acres and 19 reservoirs ≥500 acres with the largest annual harvest of buffalofishes occurring at Lake Texoma.

Although many of Oklahoma's native nongame fishes were historically seen to have commercial/economic value, this valuation has not been shared by anglers and the general public, resulting in these species being historically maligned, misunderstood, and in some cases, persecuted (Scarnecchia 1992; Rypel et al. 2021).

Additional harvest pressures on NNG fishes have been observed with the ascendence of sport bowfishing in recent decades (Scarnecchia and Schooley 2020). A recent boom in research focused on life history of nongame fishes has occurred in the last five years (Table 3). Some groundbreaking research on the revised longevity of Bigmouth Buffalo (Lackmann et al. 2019) forged a path for revised aging techniques and closer examination of many historically underappreciated fishes. Multiple studies in Oklahoma (Snow et al. 2020; Montague et al. 2023) found that longevity for several species was greater than previously known. In 2024, NNG fishes experienced a boost in published literature due to the development and execution of a special issue of *Environmental Biology of Fishes* with 24 articles focused on "Underappreciated Native Fishes of North America and their Management" https://link.springer.com/collections/jjggiicibc.

In 2025, it was decided that the ODWC Fisheries Division Nongame Committee was no longer necessary due to our program's development in 2023. Therefore, the committee was disbanded. The committee's original focus was to provide a forum for discussion, review, and facilitation of topics and actions relevant to Oklahoma's native nongame fishes and the fisheries that target them. This included, for example, regulatory changes and social media outreach. These activities largely lie within the mission of our program, therefore having a separate committee would have been unnecessary. This should not be assumed to represent a reduction in commitment by ODWC to the management and conservation of NNG fishes.

With a few exceptions, management of native nongame fishes in Oklahoma and many other states has been limited or nonexistent to date. However, ODWC has committed to living up to the Department mission by assigning value and dedicating resources towards the management of all native aquatic species, regardless of their legal status.

Table 3. Summary of published life history knowledge for select native nongame fish species. Studies with validated ages are noted with an asterisk (*).

Common Name	Max. Age	Age at maturity (sex)	Irregular Recruitment	References [State/Prov.]
Bigmouth Buffalo	>100	10 (F)	Yes	(Lackmann et al. 2019, 2023d, 2023b) [MN, AZ]
	58	10 (F)	Yes	(Lackmann et al. 2021)
	61			(Bryant 2024) [OK, AR]
	71			(Bohen 2025) [WI]
Smallmouth Buffalo	62			(Snow et al. 2020) [OK]
	101			(Lackmann et al. 2023c) [AZ]
	39	8-12 (M & F)	Yes	(Maxson et al. 2024) [MN, WI, IA, IL, MO]
	52			(Bryant 2024) [OK, AR]
	58			(Bohen 2025) [WI]
	75			(this report) [OK]
Black Buffalo	56			(Lackmann et al. 2019) [MN]
	54			(Montague et al. 2023) [OK]
	108			(Lackmann et al. 2023c) [AZ]
	45		Yes	(Bryant 2024) [OK, AR]
	68			(this report) [OK]
Alligator Gar	68*			(Daugherty et al. 2020) [TX]
	95*			(Andrews et al. 2024) [MS]
		5		(DiBenedetto 2009)[LA]
			Yes	(Buckmeier et al. 2013; Smith et al. 2020)
Longnose Gar	27			(McGrath et al. 2016) [VA]
	29			(Montague et al. 2023) [OK]
Quillback	44	8-9	Yes	(Lackmann et al. 2022b) [MN]
	49	3	Yes	(Woodling et al. 2024) [CO]
	51		Yes	(Lackmann et al. 2025) [WI]
River Carpsucker	>45			(Lackmann et al. 2022b) [MN]
	40		Yes	(Woodling et al. 2024) [CO]
	56		Yes	(Lackmann et al. 2025) [WI]
Paddlefish	29	8 (F)	Yes	(Scarnecchia and Schooley 2022) [OK]
	>60	16* (F)	Yes	(Scarnecchia et al. 2019) [MT, ND]
Bowfin	33		Yes	(Lackmann et al. 2022a) [MN]
Freshwater Drum	58*			(Davis-Foust et al. 2009) [WI]
	56			(Montague et al. 2024) [OH]
	62		Yes	(Stuart et al. 2024) [ND, MN, MB]
Shorthead Redhorse	20			(Reid 2009) [ON]
Golden Redhorse	17			(Lackmann et al. 2023a) [MN]
Blue Sucker	42			(Radford et al. 2021) [IN, IL]
	61			(Carlson 2022) [SD]

RESEARCH AND MANAGEMENT ACTIVITIES / METHODS

Native Nongame Collections – Only one new collection for NNG fishes was performed in 2025. In June 2025, Shell Lake was electrofished as a follow-up stock assessment to our experimental bowfishing tournament in August 2024. Over the course of two days June 4 and June 16, 2025, we electrofished the lake. Buffalofishes and Spotted Gar were injected with a PIT tag in the left dorsal musculature in addition to the standard protocols described below. All NNG species were collected, weighed, measured, and released. Common Carp, when uncommonly observed, were not collected.

Fish specimen examination / processing – With few exceptions, all shot and collected fish were processed fully using similar protocols, including total length (mm), weight (kg), and removal of otoliths (buffalofishes and Common Carp – lapilli, Freshwater Drum and gars – saggitae) for later mounting in epoxy and sectioning. Sex was determined internally with qualitative assessment of reproductive maturity for females (i.e., gravid or nongravid) and total gonad weights (kg) were recorded when in pre-spawn condition.

Morphology examination for buffalofishes was more extensive than for other species due to an ongoing grant with Dr. Guin Wogan, Oklahoma State University, examining the Genetic Identification and Estimation of Population Demographics for Oklahoma Buffalofishes. This partnership pairs the age and morphology (ODWC) of buffalofishes with the genetic speciation and characterization of hybridization (OSU) to determine the status and assemblage of the buffalofishes complex in Oklahoma reservoirs where they are targeted by bowfishers. Of specific interest is the detectable abundance of Black Buffalo (SGCN) among the more common and abundant Smallmouth Buffalo. Difficulties in visual identification of Black Buffalo have resulted in concerns that collateral harvest take of this rare species may be occurring among the unregulated and undocumented take of Smallmouth Buffalo due to similarity of appearance. Fisheries literature and personal communication with fisheries professionals within and without Oklahoma yield mixed opinions on the ability and accuracy of field identification for these two species. It is unknown if the difficulty is a local phenomenon due to similarity/overlap of characters or if the species are hybridizing in the wild, or both. As an example of problematic field identification techniques, Eddy and Underhill (1978) vaguely described Smallmouth Buffalo body depth as “back quite elevated” (p. 111), whereas Black Buffalo was described as “back not much elevated” (p. 112). Further, they described the mouth structures as similar between the species. However, Hubbs, et al. (2008) described several more complex measurements, which may be challenging in the field, especially for live specimens:

- Smallmouth Buffalo – SL > 5 times head width; “distance from the posterior tip of the maxillary to the front of the mandible less than eye length” (p. 25-26)
- Black Buffalo – SL < 5 times head width; “distance from the posterior tip of the maxillary to the front of mandible greater than eye length” (p. 25)

Each buffalofish was measured as follows in mm on a measuring board with the assistance of a metric measuring tape: total length (TL), standard length (SL), greatest pre-dorsal body depth (BD), and the longest dorsal fin ray (DFR). Weight was measured in kilograms on either a 4.5 or 18 kg capacity bench scale (whichever was appropriate) or a 113 kg hanging scale (when Paddlefish netting).

Fish were identified to sex by internal examination of the gonads. For females, gravidity was noted when eggs were present. In some pre-spawn collections, gonads and fat deposits were removed and weighed to calculate gonadosomatic index (GSI) and to assist in estimation of fecundity. Fish were externally examined for the presence of breeding tubercles and a tissue sample was removed from the pectoral or pelvic fin and preserved in 95% molecular grade ethanol for later genetic examination by OSU.

The nuchal hump was visually characterized as pronounced keel (P), moderate keel (M), or absent (A). All fish were *a priori* assigned to species by visual assessment (Bigmouth, Smallmouth, or Black) using several generalized rules of thumb (Table 5): 1) Fish with an anterior-facing mouth were recorded as Bigmouth, 2) Fish with a ventral-facing mouth and a pronounced keel were recorded as Smallmouth, and 3) Fish with a ventral-to-intermediate facing mouth and a moderate-to-absent keel were recorded as Black.

Hubbs, et al. (2008) suggested using the equation for depth index $D_i = {SL}/_{BD}$ to differentiate between the two similar species Smallmouth and Black buffalofishes, with deeper-bodied Smallmouth Buffalo having a D_i = 2.2 – 2.8 and more elongate-bodied Black Buffalo having a D_i = 2.6 – 3.3. These overlapping ranges necessitated a more distinct breakpoint between the species, therefore we split the difference and used $D_i \leq 2.75$ for Smallmouth Buffalo. This index was calculated for each fish for which both SL and BD measurements were present.

Table 5. Rules of thumb for a priori visual identification of Oklahoma buffalofishes.

Species	Mouth orientation	Keel	SL/BD
Bigmouth Buffalo	Terminal	A-M	> 2.75
Smallmouth Buffalo	Ventral	P	≤ 2.75
Black Buffalo	Ventral/Intermediate	M	> 2.75

A priori visual species ID and D_i species ID were summarized and compared. Genetic species ID will be later determined by OSU to inform the levels of accuracy with field sex ID from morphology and characterize any hybridization of buffalofishes in Oklahoma. Mitochondrial barcoding was used for a subsample of buffalofishes to determine influences of maternal species lineage.

Phillips and Underhill (1971) suggested utility of the length of the anterior dorsal fin rays to differentiate sexes for Smallmouth Buffalo, observing a significantly longer dorsal fin on females. Therefore, dorsal fin length (relative to SL) was compared for sexes within species, as identified by D_i. Additionally, this metric was calculated and compared for D_i species within each stock.

Paired lapilli otoliths were removed from each buffalofish for later age estimation. Preparation, mounting, sectioning, and aging of otoliths followed a combination of published literature (Long et al. 2023) and consultation with A. Lackmann at University of Minnesota, Duluth. For select samples, otolith mass was recorded on a balance to examine the relationship between otolith size and fish age. Natural logarithms of otolith mass and age were used in linear regression models, after (Woodling et al. 2024). Once an adequate number of fish from a reservoir had been assigned ages, population modeling was conducted using the Oklahoma Fisheries Analysis Tool (OFAT). Vital rates of the population were calculated from length, weight, and age data. Total annual mortality was calculated using a weighted catch curve (number of individuals at each age) (Miranda and Bettoli 2007). Growth was modeled using the Von Bertalanffy growth equation using mean length at age data (von Bertalanffy 1938).

Other Native Nongame Projects - Additional nongame projects are ongoing statewide, facilitated by various programs (Table 6). Our program aims to collaborate with other programs on any future nongame projects. A planning and coordination meeting is warranted between the Paddlefish and Native Nongame and the Streams programs to better define how these programs can work in tandem and reduce overlap in species or habitat focus.

Table 6. Summary of select projects occurring statewide related to native nongame fishes and not directly facilitated by Area 45.

Nongame Fish Species Studied	Principal Investigator(s)	Locality	Objective(s), Status Updates for 2025
Shovelnose Sturgeon	ODWC Northeast Regional Management, ODWC Holdenville Hatchery	Arkansas River, NE Oklahoma	Develop and refine capture techniques and locations for Shovelnose Sturgeon such that a pilot hatchery rearing program can be initiated with wild broodstock. No collections have been performed to date.
Skipjack Herring	ODWC Southeast Regional Management (Porter Office)	Arkansas River, R.S. Kerr Reservoir	Developing baseline life history information for the species (age and growth) in consideration for informing a managed fishery. Validating otolith aging with marginal incremental analyses. Collected diets and analyses are ongoing. Evaluating sabiki rigs as a standardized collection method, targeting seasonal movements into tailwater thermal refuges.
Blue Sucker	ODWC Durant Hatchery, US Fish and Wildlife Service	Lower Kiamichi River, Red River	Investigate husbandry, rearing, and captive propagation requirements for this and other SGCN fishes. Protocol development is ongoing with trial and error for this river species in a hatchery pond environment.
Golden Redhorse	ODWC Southwest Regional Management (Lawton Office)	Medicine Creek watershed, Wichita Mountains Wildlife Refuge	Revision of historical species distribution and abundance with new collections and additional localities. Collections are opportunistic and ongoing.
Goldeye	OFRL (Norman Office) and South-Central Region Management (Durant Office)	Texoma Lake	Determine otolith and opercle aging precision for refinement of life history for the species. This study has completed, with >100 age samples collected and the manuscript is in final preparation for publication.
Misc. (all species)	ODWC South-Central Region Management (Durant Office) and Southeastern Oklahoma State University	Texoma Lake Washita River arm upstream of Roosevelt Bridge	Examination of fish community impacts of reservoir siltation when compared to historical collections (Patton and Lyday 2008). Community sampling was completed in 2023 and data analysis is ongoing.
Misc. (gars, buffalofishes, carps)	ODWC Human Dimensions and Communication and Education Division	Statewide	Examine and determine baseline social perceptions of native nongame fishes as we try to better communicate about these species (Figure 3). The Gar Week social media campaign has been instrumental in messaging on NNG social issues (see outreach section of this report).

Figure 3. Excerpts from the 2023 statewide angler survey with multiple questions related to social value and perception of native nongame fishes.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
One or more species of native nongame fish are important to my recreational fishing experience.	○	○	○	○	○
All native nongame fish species in Oklahoma should be subject to bag limits determined by the Wildlife Department.	○	○	○	○	○
One or more species of native nongame fish are desirable for human consumption.	○	○	○	○	○
Native nongame species are important to healthy ecosystems in Oklahoma.	○	○	○	○	○
All species of fish and wildlife should be used in beneficial ways (table fare, fertilizer, etc.) and not discarded as waste.	○	○	○	○	○

29. We are interested in your feelings (either positive or negative) in response to the following species of fish. First, we would like to ask about <u>your</u> feelings towards each of the following types of fish.

	Negative -2	-1	Neutral 0	+1	Positive +2
Gar	○	○	○	○	○
Trout	○	○	○	○	○
Black Bass	○	○	○	○	○
Buffalo	○	○	○	○	○
Carp	○	○	○	○	○
Catfish	○	○	○	○	○

30. Now, please respond with how you think <u>other anglers you know</u> feel about each of the following types of fish.

	Negative -2	-1	Neutral 0	+1	Positive +2
Gar	○	○	○	○	○
Trout	○	○	○	○	○
Black Bass	○	○	○	○	○
Buffalo	○	○	○	○	○
Carp	○	○	○	○	○
Catfish	○	○	○	○	○

RESULTS / DISCUSSION

<u>Bowfishing Tournament Collaboration with Oklahoma Fish Stickers</u> – Although lines of communication remained open between ODWC and OFS in 2025, no distinct collaborations occurred. Many samples collected in 2024 were examined or analyzed in 2025.

<u>Shell Lake NNG Stock Assessment</u> – Electrofishing on Shell Lake in June 2025 yielded the capture of 212 NNG fishes (106 Smallmouth Buffalo, 44 Spotted Gar, 38 River Carpsucker, 16 Freshwater Drum, 4 Bigmouth Buffalo, 3 Black Buffalo, and 1 Spotted Sucker). Recapture of PIT tagged buffalofishes and Spotted Gar contributed to a multi-year assessment of these populations (Table 7).

Table 7. Capture summary for Shell Lake buffalofishes and Spotted Gar electrofished in June 2025.

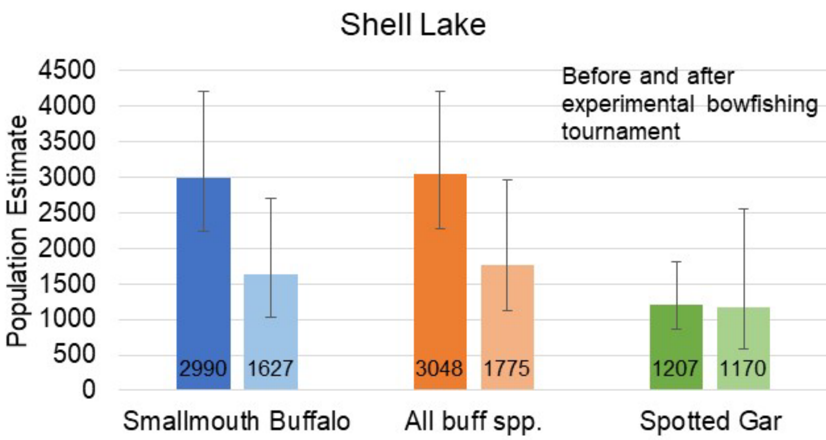
Species	Total catches[1]	Recaptured	Marked
Bigmouth Buffalo	4	0	4
Black Buffalo	3	0	3
Smallmouth Buffalo	106	17	85
Spotted Gar	44	7	36
Totals	157	24	128

Between PIT tagging efforts in 2024 and multiple recapture opportunities during 2024 and 2025, we were able to examine daily growth for buffalofishes and Spotted Gar. A total of 38 buffalofishes (37 Smallmouth Buffalo and 1 Black Buffalo) were at large for a range of 42-356 days in Shell Lake. Their average daily growth in length was -0.14mm per day and their average daily growth in weight was zero. For growth to be essentially absent for buffalofishes in Shell Lake is a reasonable observation, considering the age and growth patterns observed in this population (see population dynamics for Smallmouth Buffalo in Shell Lake below). Paired captures for 14 Spotted Gar over the period of 46-356 days at large yielded positive growth in length with an average of 0.11mm per day, though daily growth in weight was zero. When age assignment for Spotted Gar are completed, we will be better equipped to examine population dynamics for the species in Shell Lake.

[1] Catch totals includes five fish that were not PIT tagged, including four Smallmouth Buffalo (one mortality and three fish not properly tagged prior to release) and one Spotted Gar (not properly tagged prior to release).

During the course of 2024-2025, assessments of population abundance were made for Smallmouth Buffalo and Spotted Gar in Shell Lake. A combination of estimation methodologies were used to estimate abundance prior to and after an experimental bowfishing tournament in August 2024. Follow-up electrofishing was performed in June 2025.

Figure 4. Population abundance estimates for Shell Lake. Using a combination of methodologies, we estimated that a decline in abundance for Smallmouth Buffalo was associated with the take of 220 individuals in the experimental bowfishing tournament. Catches of Spotted Gar were inadequate to demonstrate a significant impact from the tournament.



Determination of whether or not the tournament had a significant impact on the population abundance of Smallmouth Buffalo was complex because 1) there is overlap in the confidence intervals around the estimates, and 2) methods for comparing two independently-derived estimates of abundance are not well-represented in the literature. Three inquiries for comparing these estimates were suggested by the Oklahoma Fisheries Research Lab in Norman. First- what is the percent of overlap in confidence intervals between the pre-tournament and post-tournament estimate? To do this, we took the difference between the lower bound of the pre-tournament estimate and upper bound of the post-tournament estimate (476). Next, we calculated the difference between upper bound of pre-tournament estimate and lower bound of post-tournament estimate (3,181) to calculate the percent of overlap for the two 95% confidence intervals (15%). The second suggested inquiry was to examine the change in points pre- and post-tournament. All values declined somewhat symmetrically (estimate: -1,363, lower bound: -1,212, and upper bound: -1,493), indicating that the certainty in the pre-tournament estimate is similar to the post-tournament estimate. Lastly, the third suggested inquiry involved calculating an overlap statistic for the distributions around the estimates. This latter methodology is still under review at the time of this reporting, however, it is simply a more complex “area under the curve” (AUC) statistical procedure that requires a more in-depth literature review. Overall, the two techniques used would lead to a conclusion that the abundance of Smallmouth Buffalo was significantly decreased after the tournament.

<u>Statewide Population Data for NNG</u> – Assignment of ages to a backlog of otolith samples collected in 2024 was a priority in 2025. By the 2024 annual report, only 226 of buffalofish otoliths had been processed. In 2025, an additional 1,164 fish were completed, with significant progress made on most lakes (Table 8).

Table 8. Summary status of buffalofish otoliths collected from 12 Oklahoma reservoirs / populations[2] with sample counts, aged counts, and % complete in parentheses.

Population	Bigmouth Buffalo	Black Buffalo	Smallmouth Buffalo	Totals
Chimney Rock	1, 1 (100%)	0	65, 26 (40%)	66, 27 (41%)
Eufaula	16, 0 (0%)	0	18, 0 (0%)	34, 0 (0%)
Ft. Gibson	2, 0 (0%)	2, 0 (0%)	197, 146 (74%)	201, 146 (73%)
Grand	10, 1 (10%)	1, 1 (100%)	250, 235 (94%)	261, 237 (91%)
Heyburn	17, 0 (0%)	0	0	17, 0 (0%)
Hulah	49, 46 (94%)	0	33, 33 (100%)	82, 79 (96%)
Kaw	43, 0 (0%)	0	117, 0 (0%)	160, 0 (0%)
Keystone	4, 1 (25%)	2, 2 (100%)	229, 197 (86%)	235, 200 (85%)
Shell	1, 1 (100%)	2, 2 (100%)	220, 212 (96%)	223, 215 (96%)
Tenkiller	0	0	418, 335, (80%)	418, 335 (80%)
Texoma	2, 1 (50%)	0	173, 107 (62%)	175, 108 (62%)
Verdigris River	5, 3 (60%)	0	72, 38 (53%)	77, 41 (53%)
Totals	150, 54 (36%)	7, 5 (71%)	1,792, 1,329 (74%)	1,949, 1,388 (71%)

Population Dynamics of Smallmouth Buffalo in Oklahoma Reservoirs - Using similar analyses, age assignments from nine populations were used to generate population dynamics models for Smallmouth Buffalo. In the tables below, value ranges for length, weight, and age are displayed in parentheses, whereas 95% CI for mean relative weight is displayed in brackets.

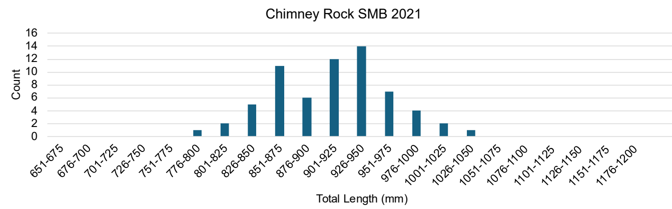
[2] Summary excludes two Smallmouth Buffalo taken from a bowfishing tournament with specific origins unknown.

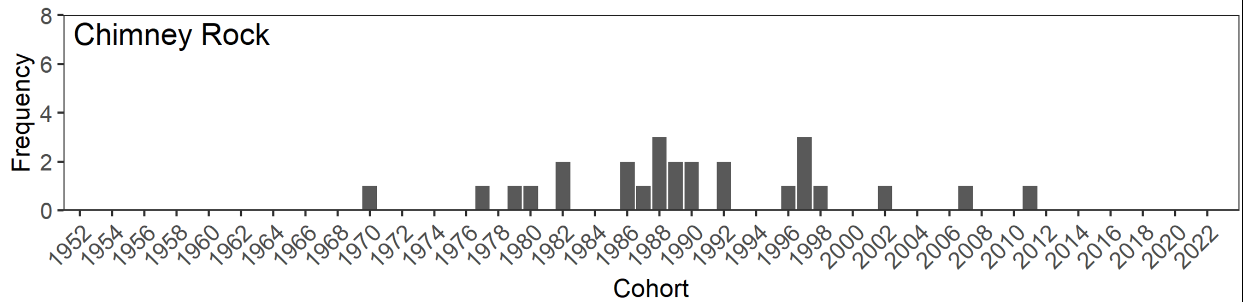
Chimney Rock

Species: Smallmouth Buffalo	**Length:** 887 (775-1,011, n=65)	**Age:** 31.0 (10-51, n=26)
Samples: 2021 (n=65)	**Weight:** 13.9 (9.3-20.6, n=65)	**Wr:** 95.7 [93.0-98.4, n=26]

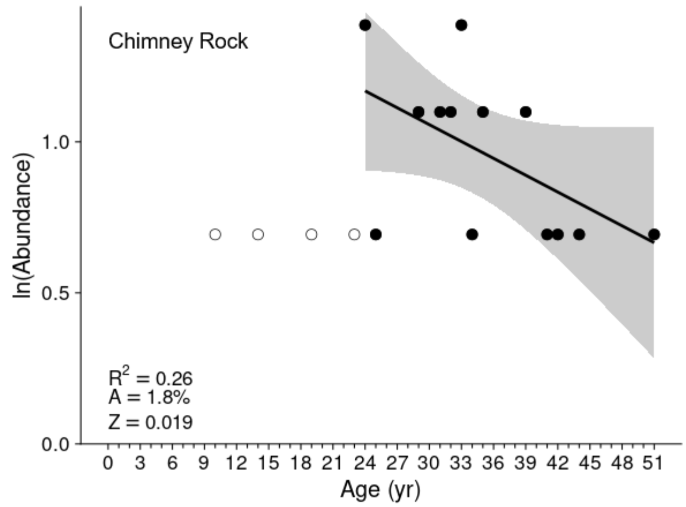
Population Dynamics:

Size structure: The catch size structure of Chimney Rock indicates a population of old, large fish. While this may largely be an artifact of our catch methodologies (i.e., large mesh Paddlefish gillnets), electrofishing was also performed along shorelines, resulting in no observations or catches of buffalofishes. Additional targeted collections with large and smaller mesh gillnets may be required to confirm the size structure of the stock. However, the SMB observed here represent the largest we have collected statewide. Specifically, *every* SMB captured from Chimney Rock to date is larger than *all* of the SMB captured from Hulah, Shell, Tenkiller, Texoma, Verdigris River combined (n=969). With the limited sample size of 26 aged SMB to date (39 remain to be aged), we were not able to resolve a von Bertalanffy growth curve. The broad age distribution and lack of SMB <10 years old may indicate that our collection methods were not adequate to detect smaller, younger fish. Data are at this time inadequate to determine if any *in situ* recruitment is occurring. Regardless, the proximity and connection to Hudson likely allows for two-way migration of fish between the two waterbodies. The average size and age of SMB in Chimney Rock likely renders it a potentially world-class fishery for the species. Preservation of this stock by limiting harvest may be warranted, but this determination will require additional data.

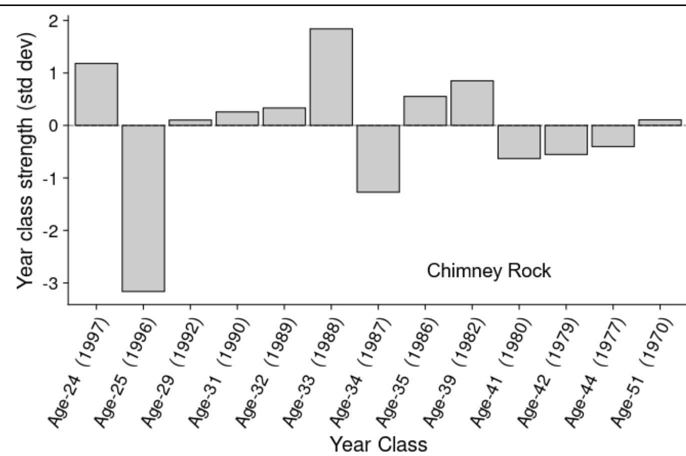




Annual mortality: Despite a low sample size generating the catch curve, our results are typical of what we would expect for a long-lived buffalofish. Annual mortality is very low; second lowest only to 2024 collections of SMB on Keystone Lake. In a low to absent harvest fishery, this life history may persist over time, especially if any recruitment or immigration from Hudson is occurring.



Recruitment: Various abiotic factors may influence recruitment in Chimney Rock. As the reservoir is pumped to fill and gravity drained to capitalize on hydroelectric generation rates, the reservoir does not follow natural hydrological patterns. This may result in unnatural patterns of shoreline vegetation. However, prolonged periods of reservoir drawdown can allow for a resurgence of shoreline vegetation, providing ecological food web benefits and recruitment for buffalofishes. The reservoir may reasonably serve as a source or a sink for buffalofishes (and other species), depending on whether the spawning occurs in Hudson (pumped in) or Chimney Rock (pumped out).



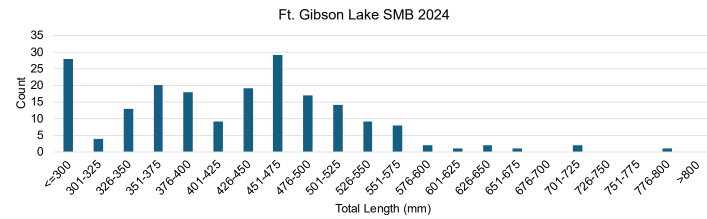
Summary: The buffalofish stock (chiefly SMB) in Chimney Rock is uniquely consisted of large, old individuals and recruitment is unknown. Long-term monitoring of this stock is warranted, in addition to estimation of abundance, tracking of individuals using PIT tags, and preserving the population structure through cautious harvest management. While the population is not practically isolated from Hudson Lake, further investigation is warranted to determine the status of *in situ* recruitment. In order to perform a more thorough stock assessment, additional netting should be considered to target smaller individuals if electrofishing continues to fail in this regard. Perhaps collaboration with Area 13 using SSP gillnets may provide additional catches of smaller buffalofishes.

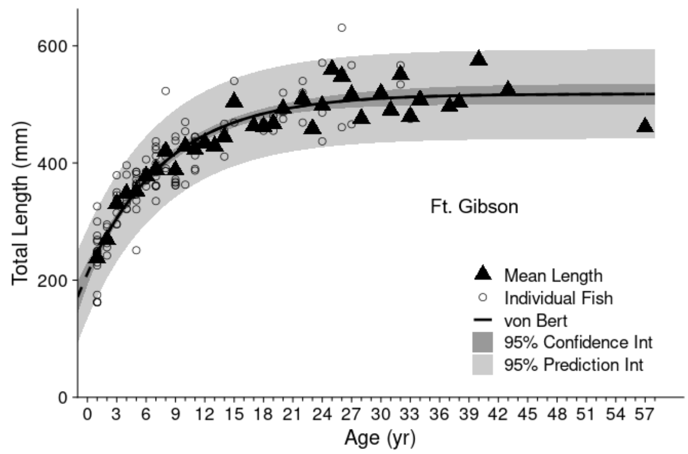
Ft. Gibson

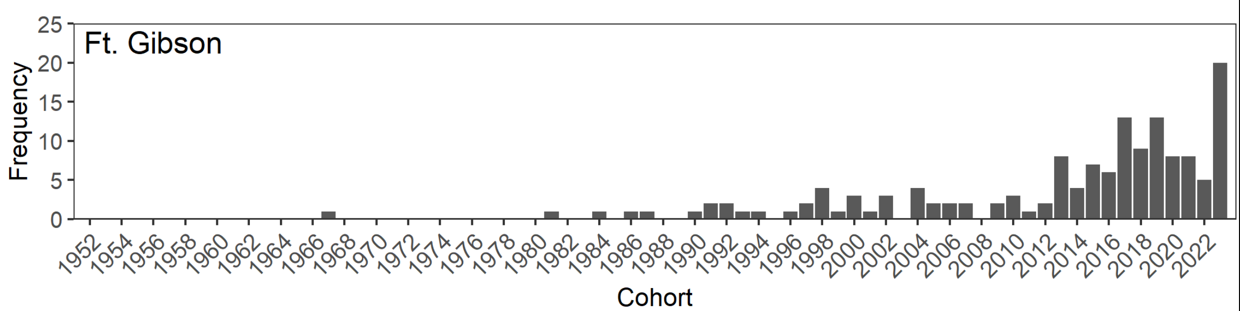
Species: Smallmouth Buffalo	**Length:** 422 (162-782, n=197)	**Age:** 11.3 (1-57, n=146)
Samples: 2024 (n=197)	**Weight:** 1.2 (0.06-7.7, n=197)	**Wr:** 76.6 [74.9-78.2, n=146]

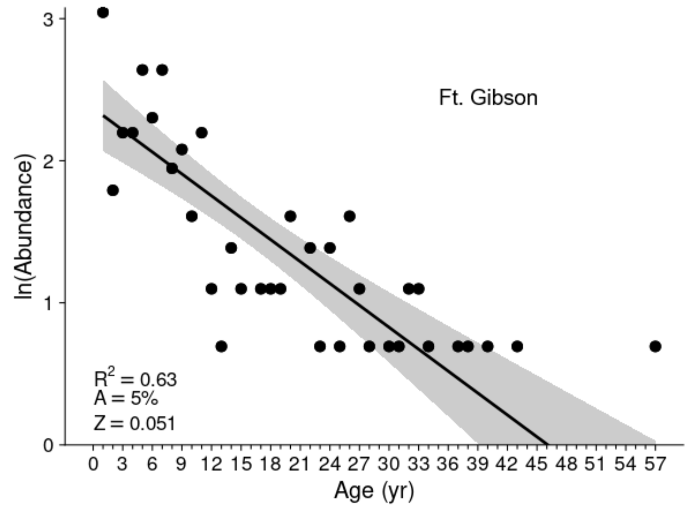
Population Dynamics:

Age and Growth: Collections of SMB on Ft. Gibson have encountered far more young fish than on other reservoirs. This is due to a combination of targeted electrofishing for small buffalofishes and the occurrence of multiple bowfishing tournaments being held on the lake at different times of year and using different formats (i.e., “numbers” format and “little 20” format, where small fishes contribute to team success). These influences may bias an assessment of population size structure; however, young fish are essential to development of the VB growth curve below. Large SMB and individuals older than 40 are rare in Ft. Gibson, which may indicate size/age truncation through long-term take by bowfishing.







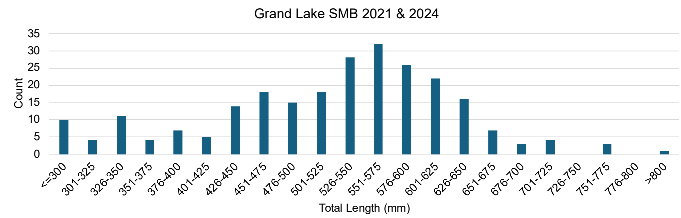
<table>
<tr>
<td>Annual mortality: Catches on Ft. Gibson for SMB result in expected values for the catch curve, yielding a low estimate for annual mortality (5%). This aligns with the life history of long-lived species, where weak annual recruitment or episodic recruitment events are adequate for maintaining the population.</td>
<td>
</td>
</tr>
<tr>
<td colspan="2">Recruitment: Unfortunately, the catch curve model above has one or more values for which a residual cannot be calculated. Therefore, the year class strength plot cannot be produced. However, examination of age and size structure may provide clues about recruitment of SMB in Ft. Gibson, which may be more regular than in other populations (i.e., Shell Lake). A bimodal distribution in the size structure plot above may indicate two or more cohorts. Alternatively, this size distribution could be the artifact of multiple tournaments on Ft. Gibson in 2024, which had different formats targeting different size classes of fish. The fish <300 mm TL were the result of targeted collections using electrofishing.</td>
</tr>
<tr>
<td colspan="2">Summary: As one of Oklahoma’s more prominent destinations for bowfishing, a tradition spanning decades, Ft. Gibson may represent a population of SMB where the effects of bowfishing take have long manifested. The size and age structure within the samples are generally skewed toward smaller/younger individuals, perhaps indicating some harvest truncation through selective removal of larger, older fish.</td>
</tr>
</table>

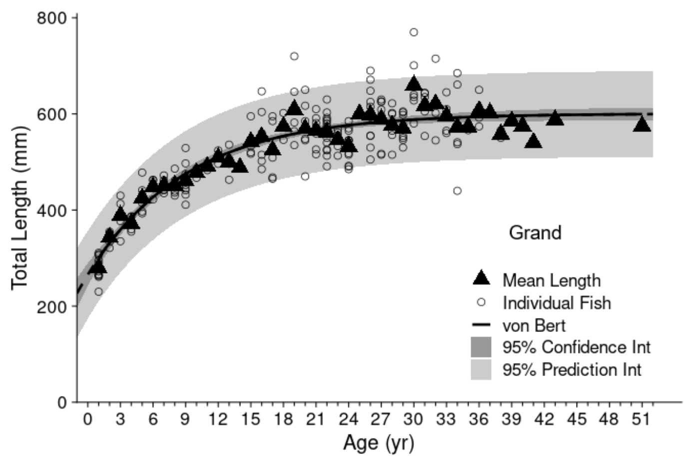
Grand

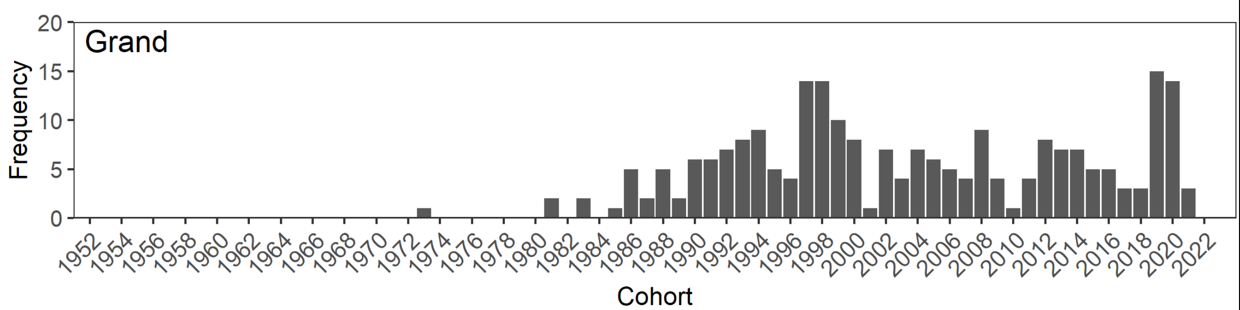
Species: Smallmouth Buffalo	**Length:** 523 (230-849, n=248)	**Age:** 18.9 (1-51, n=233)
Samples: 2021 (n=138), 2024 (n=112)	**Weight:** 2.5 (0.2-10.1, n=249)	**Wr:** 83.1 [82.0-84.2, n=233]

Population Dynamics:

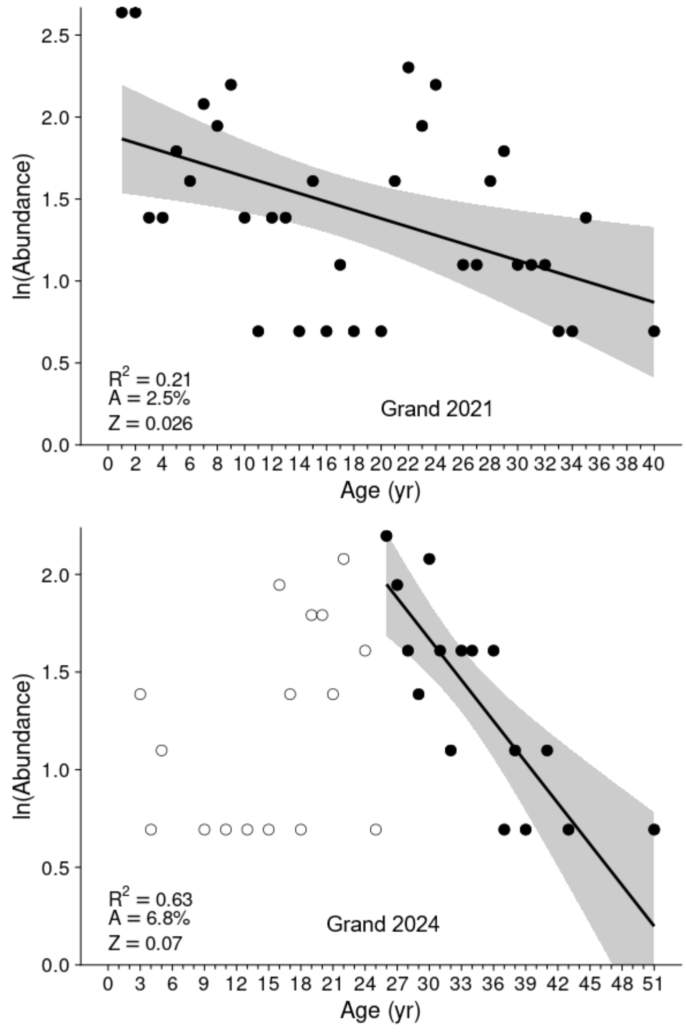
Age and Growth: Grand has a highly diverse size structure with the 2nd largest range between the minimum and maximum length observed. Age structure on Grand is spread out across cohorts with every cohort between 1985-2021 represented in our ageing samples. This would indicate that some level of natural recruitment has been occurring every year since 1985 (no gaps in cohorts). Given the high frequency of fish from the 1997 and 1998 cohorts still present in the population 20+ years later, reproduction during those years was likely very high. The high frequency of fish from the 2019 and 2020 cohorts is promising for the future stability of this stock. The high sample size of collections from Grand in addition to its diverse age structure allowed for a good fit for the von Bertlanffy growth curve. There is some variability at older ages, likely due to lower numbers of fish at older ages. Additionally, sexual dimorphism may play into this as well. Grand was responsible for the 2nd highest L_∞ value across all systems sampled, indicating the potential for large individuals in this population.



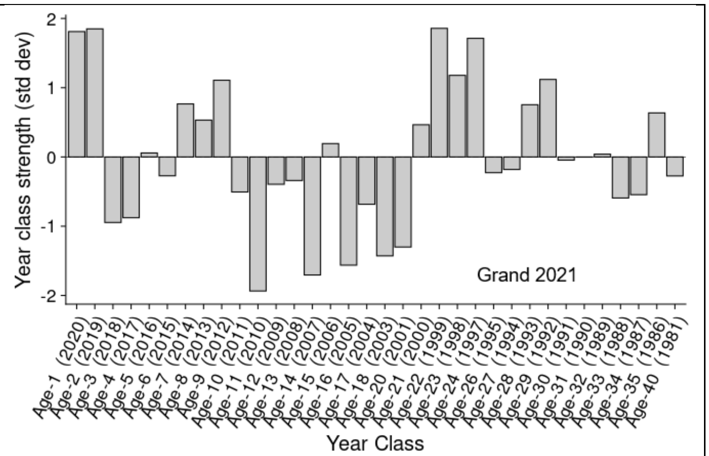


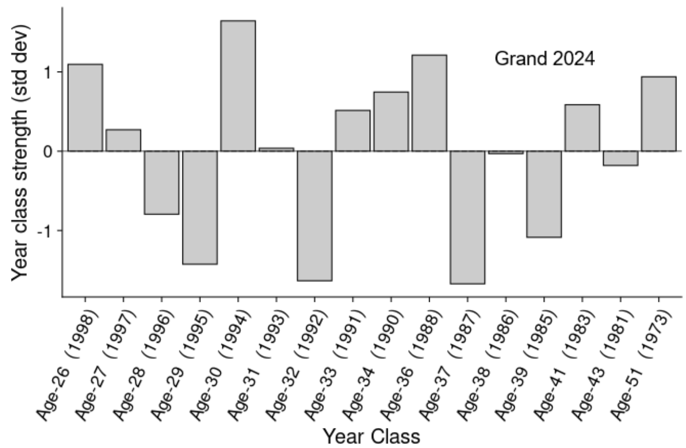


Annual mortality: Estimates of annual mortality differed based on collection year. Annual mortality estimated from 2021 collections (A=2.5%) is more in line with what is seen statewide and for long-lived buffalofish. The annual mortality rate estimated from 2024 collections (A=6.8%) would be the 2nd highest annual mortality rate only after 2023 Keystone Lake. While these two models are generated from two independent samples yielding different conclusions, when the same range of age (i.e., >20) is considered across years, the data appear quite similar. However, both estimates are within the range of expected values for a species with a life history such as SMB.



Recruitment: Year class strength for fish collected in 2021 provides a much clearer and informative view of recruitment of Grand Lake over the past few decades. Year class strength appears to have been well above average between 1997-1999, which we also see in our cohort-frequency data. Recruitment appears to have been below average for many years from 2001-2011; however, more recent strong year classes in 2019 and 2020 are promising for this stock.





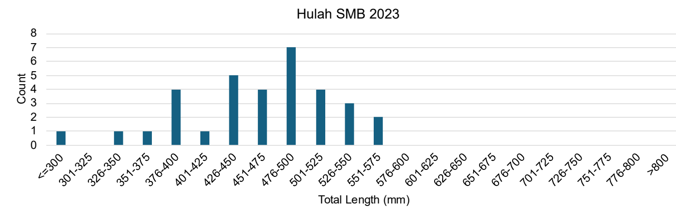
Summary: Grand represents a stock categorized by a large diversity of size and age structure, high growth, and evidence of consistent recruitment of new fish into the population. Year class strength appears to be variable over time, with the best year classes occurring during 1997-1999 and 2019-2020. Mortality estimation for SMB on Grand was difficult and investigating how to effectively estimate annual mortality for this stock may be an appropriate next step.

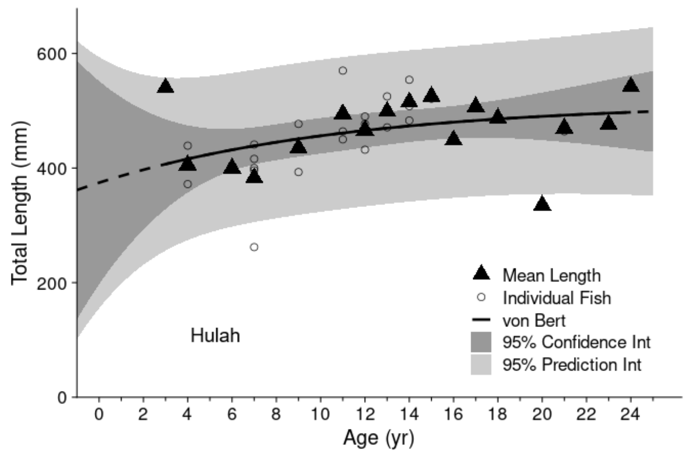
Hulah

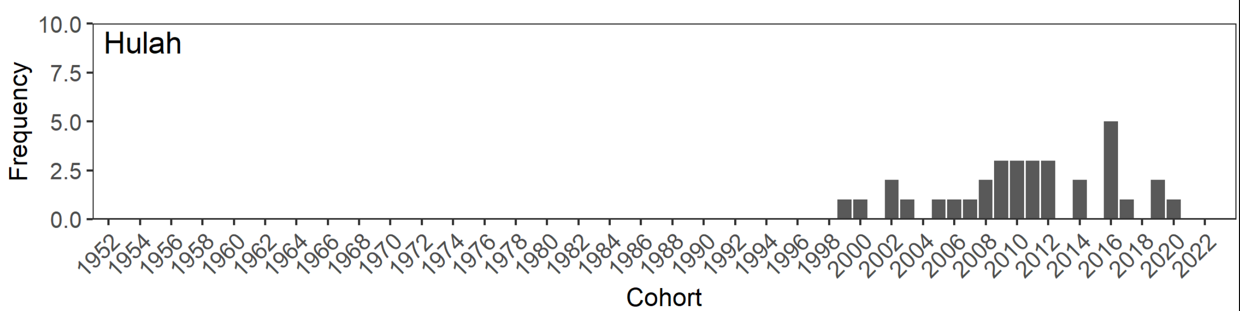
Species: Smallmouth Buffalo	Length: 462 (262-570, n=33)	Age: 12.4 (3-24, n=33)
Samples: 2023 (n=33)	**Weight:** 1.46 (0.2-2.5, n=33)	**Wr:** 77.8 [75.0-80.7, n=33]

Population Dynamics:

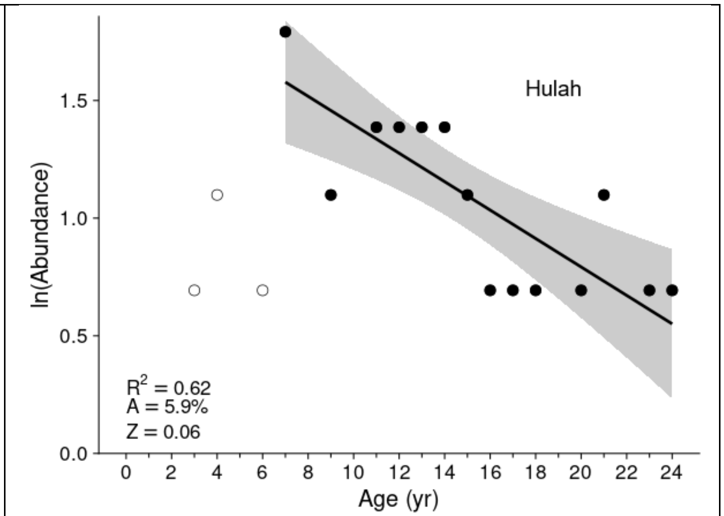
Age and Growth: The maximum size in Hulah was the smallest out of all systems sampled for Smallmouth Buffalo. It also had the 2nd tightest range between the minimum and maximum observed length. Hulah appears characterized by smaller fish with minimal top end capability (no fish over 570 mm were collected); however, low sample size could be biasing these results. The maximum age seen for Hulah was 24, which was the lowest maximum age seen across all systems sampled for Smallmouth Buffalo. It is unclear whether these “older” fish don’t exist in the population or if they were simply not collected. A von Bertalanffy growth curve from OFAT was able to be output; however, uncertainty in the output is high. Future collection of Smallmouth Buffalo from Hulah will reduce this uncertainty.



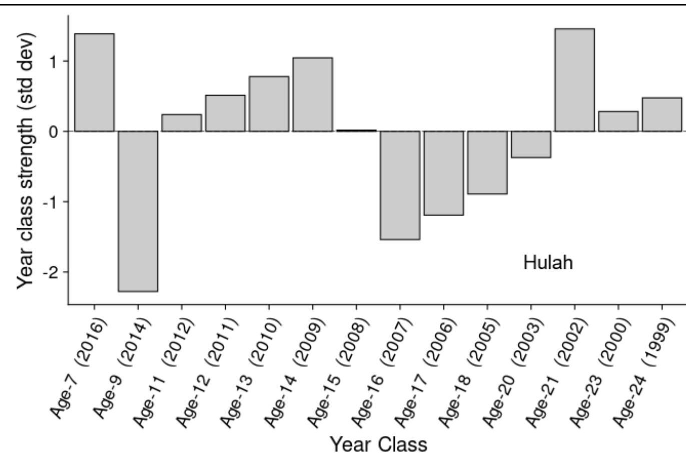




Annual mortality: Hulah's 5.9% annual mortality represents the 3rd highest among our 12 annual mortality estimates. The fit of the catch curve appears to be fair (R^2=0.62) relative to other mortality estimates constructed; however, low sample size could be driving this estimate. Future sampling, especially if older fish are collected, may lower the annual mortality estimate from the catch curve.



Recruitment: Year class strength is not very intuitive for analysis as many year classes are represented by only 1 or 2 individuals. Further collection will allow for meaningful conclusions about year class strengths over time at Hulah.



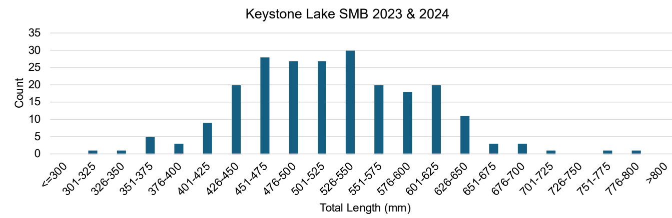
Summary: At this point in time, Hulah appears to be a young population with a low observed maximum age (24) and a constricted length distribution relative to other populations in Oklahoma (no fish >570 mm). Further collection of SMB will help create a more reliable growth curve, estimate of annual mortality, and estimates of year class strength over time. Given we only collected 33 fish, constructing a meaningful population assessment of Hulah is difficult at this time.

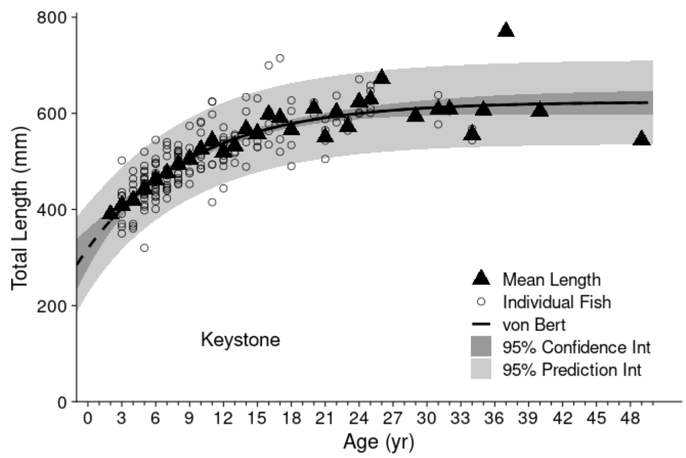
Keystone

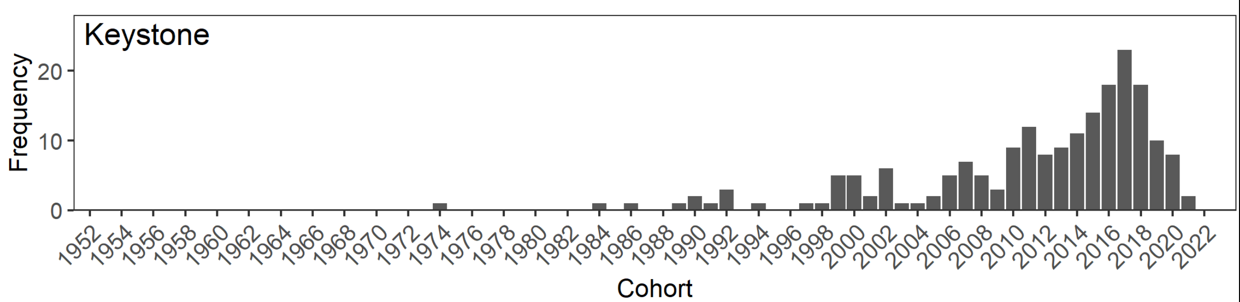
Species: Smallmouth Buffalo	**Length:** 523 (320-795, n=229)	**Age:** 11.8 (2-49, n=197)
Samples: 2023 (n=174), 2024 (n=55)	**Weight:** 2.4 (0.5-7.5, n=229)	**Wr:** 84.8 [83.7-86.0, n=197]

Population Dynamics:

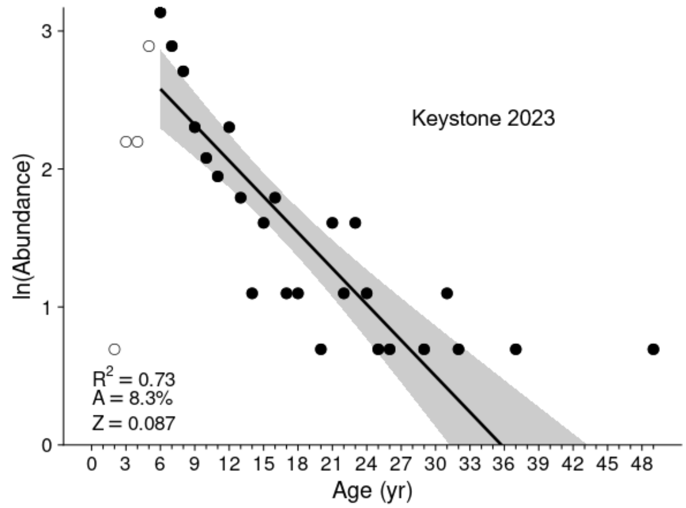
Age and Growth: Size structure of SMB in Keystone Lake was dominated by fish between 400-600 mm. A lack of small fish could be an artifact of bias by bowfishers, however, more sampling may be warranted to assess the recruitment of young fish into this population. Age at Keystone is heavily skewed towards fish less than 20 years old; however, some older individuals were observed. No age-1 fish were observed in this population, however, given that the collection method for these fish was bowfishing, age-1 individuals may not be targeted and/or vulnerable to bowfishers at age-1. Despite its young population age structure, Keystone appears to have high growth potential for Smallmouth Buffalo, having the highest asymptotic growth parameter of all lakes able to construct a von Bertalanffy curve. The curve fits extremely well until older ages (>20) after which mean length at age becomes more variable. Further collection of older individuals in the population may refine these results.

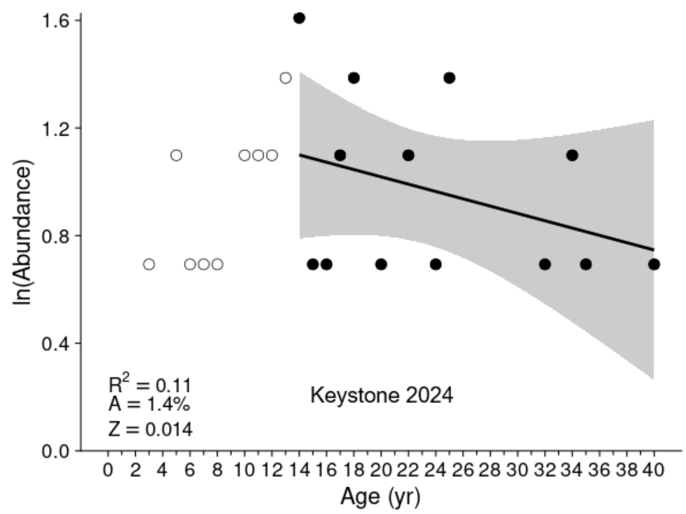




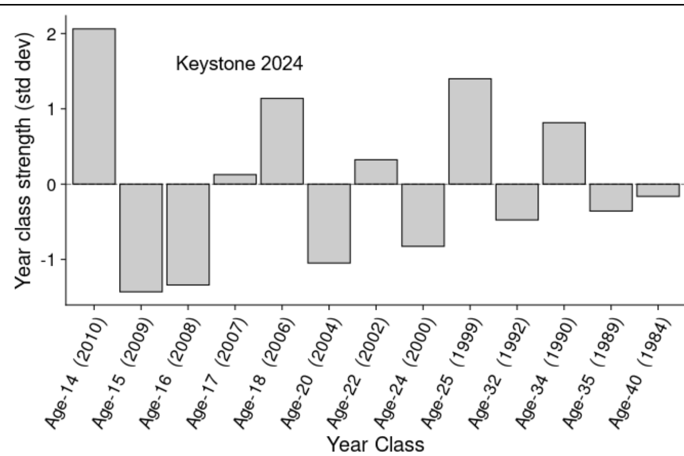


Annual mortality: Fish collected in 2023 vs 2024 by bowfishing on Keystone resulted in variable estimates of annual mortality. This variability in annual mortality is likely due to the format in which these fish were harvested. In 2023, collected fish were from a “numbers” tournament which would logically result in less size selectivity by bowfishers. In 2024, collected fish were from a “big 10” tournament where bowfishers attempted to collect the 10 biggest fish possible, which would bias towards shooting larger/older individuals. 8.3% mortality represents the highest annual mortality out of all waterbodies sampled for SMB. Conversely, the 1.4% annual mortality estimate from fish collected in 2024 represents the lowest annual mortality estimate across all waterbodies sampled for SMB. More investigation into how annual mortality estimates from bowfishing compares to estimates from traditional capture methods may be helpful in analyzing what our results mean in the context of these populations, and address how bowfishing biases results.





Recruitment: At a glance, year class strength on Keystone Lake appears to oscillate with 1-2 years of above average year classes followed by 1-2 years of below average year classes. However, a year class strength plot was only fitted for 2024 and not 2023. We collected far more fish in 2023 than 2024 and had a much higher diversity of cohorts, but the failure to calculate residuals from the 2023 catch curve likely caused this failure.



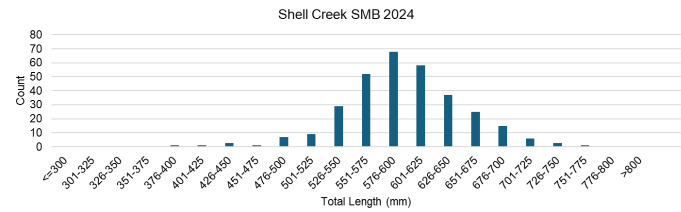
Summary: Keystone Lake is home to a wide variety of size classes and age groups of SMB with high growth potential for fish that reach older ages. The steep decline in the number of fish from older cohorts is concerning, especially when paired up with an annual mortality estimate of 8.3%, which represents the highest we estimated in this report. At this point, it is unclear whether this is due to natural processes, truncation of older fish by anglers, or sampling bias, but careful watch of this population may be necessary.

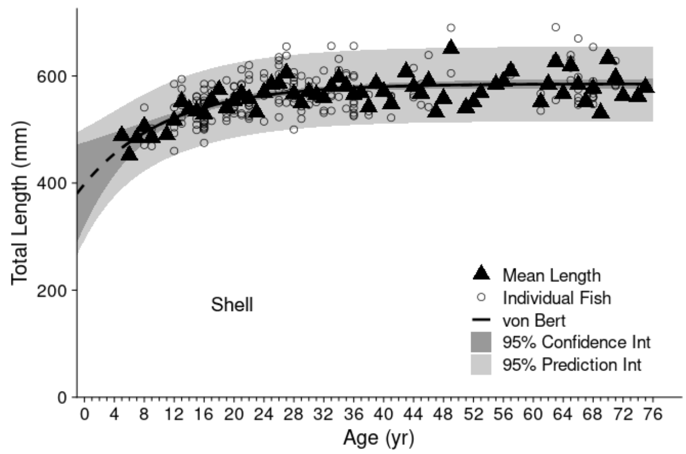
Shell

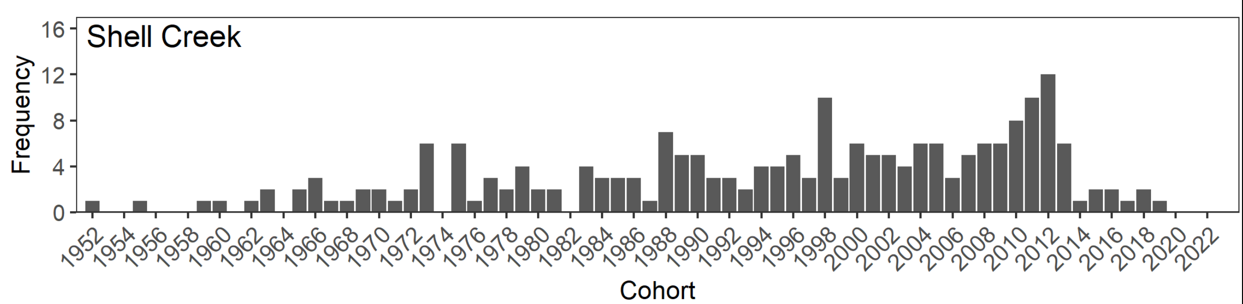
Species: Smallmouth Buffalo	**Length:** 572 (370-729, n=316)	**Age:** 33.1 (5-75, n=212)
Samples: 2024 (n=220), 2025 (n=97)	**Weight:** 2.9 (0.8-7.5, n=315)	**Wr:** 82.8 [81.6-84.0, n=212]

Population Dynamics:

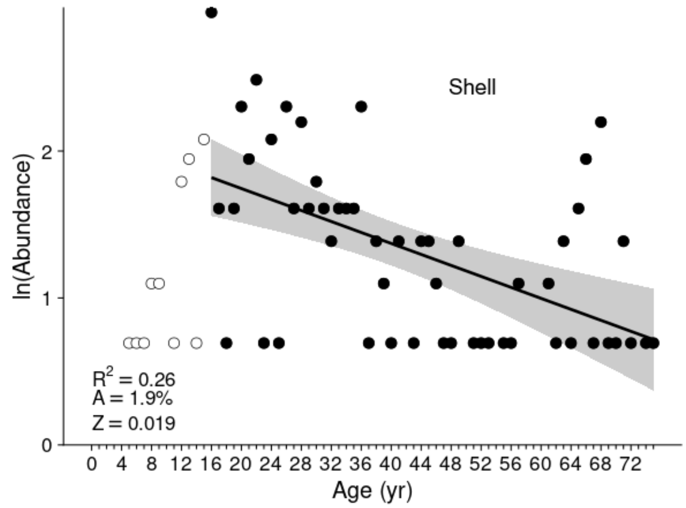
Age and Growth: Size structure of Shell Lake SMB is remarkably “normal”, although few small fish have been observed. This long-lived population is generally reaching asymptotic length at 16 years of age and growing very little over the subsequent 60 years. Shell Lake contains the oldest of buffalofishes in our database, with 43 of the oldest 50 fish. Ages represent a broad distribution of cohorts since 1952, potentially indicating relatively consistent annual recruitment. The absence of young, small fish in collections and the apparently low numbers of fish younger than the 2014 cohort may indicate a period of low recruitment.



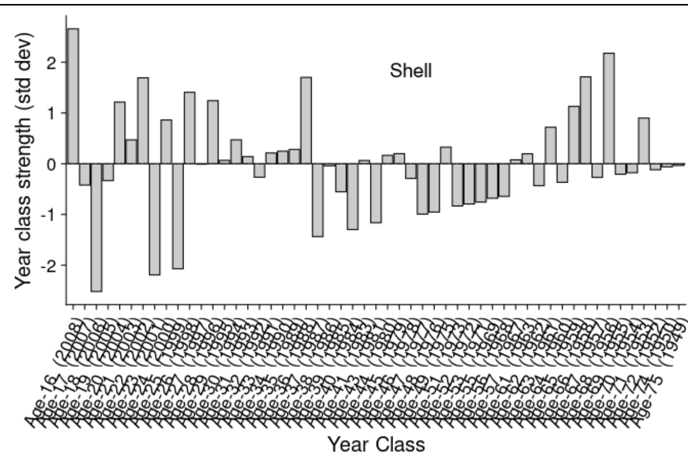




Annual mortality: Although the catch curve model has a relatively poor fit, a low estimate of annual mortality (1.9%) is within the range of expected values for long-lived buffalofishes in Oklahoma. Populations with low recruitment and low annual mortality are sensitive to overfishing. Our examination of the impacts of bowfishing on this population indicated that these impacts can be acute with minimal effort (e.g., one tournament).



Recruitment: Wide annual swings between strong and poor year classes indicates intermittent recruitment. This reproductive strategy is buffered by long lifespan and low annual mortality. Long gaps in recruitment have been observed in northern stocks of buffalofishes. The apparent ~25 year period of low to poor recruitment may be evidence that this population of old fish may persist similarly. The putative recruitment gap not reflected here (2014-2022, above) may represent a natural cycle of recruitment gaps or be related to water levels in this reservoir. This warrants further investigation.



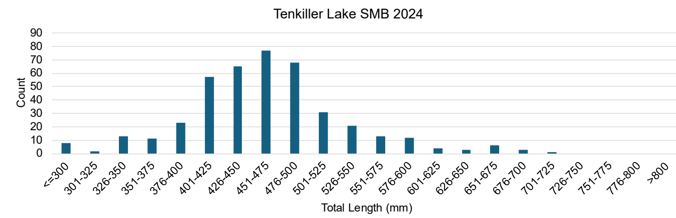
Summary: Shell Lake was impounded in 1920, resulting in >100 years of isolation for this population of SMB from the greater Arkansas River basin. Among the stocks examined here, this represents the longest isolation we have observed. Pensacola Dam, impounding Grand Lake, is the next oldest reservoir studied here, though it impounds a much larger river system with origins in central Kansas. Continued study and preservation of this relic population of old buffalofishes is warranted. Research evidence indicates that maintaining a prohibition of bowfishing in this stock would be prudent.

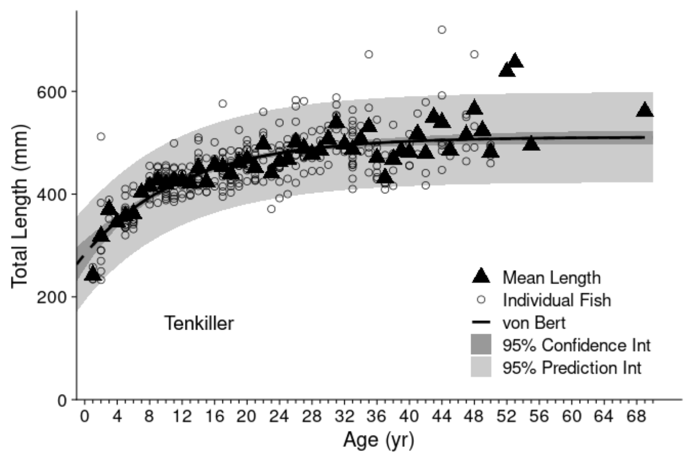
Tenkiller

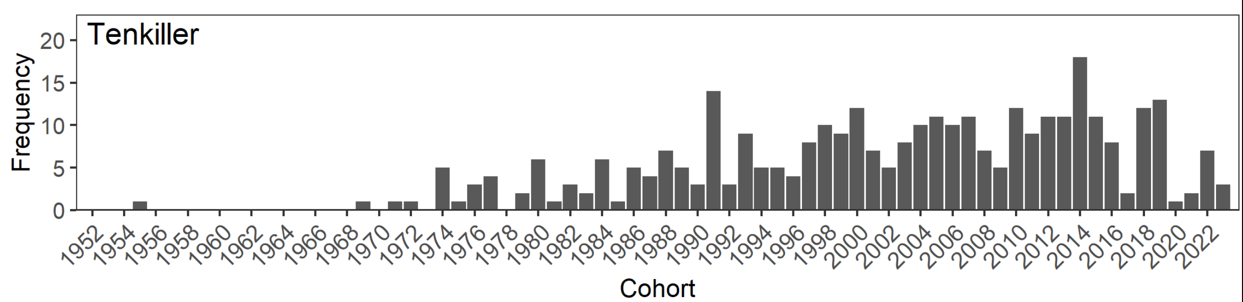
Species: Smallmouth Buffalo	**Length:** 463 (233-720, n=418)	**Age:** 21.8 (1-69, n=335)
Samples: 2024 (n=418)	**Weight:** 4.5 (0.1-5.1, n=416)	**Wr:** 76.6 [75.7-77.4, n=335]

Population Dynamics:

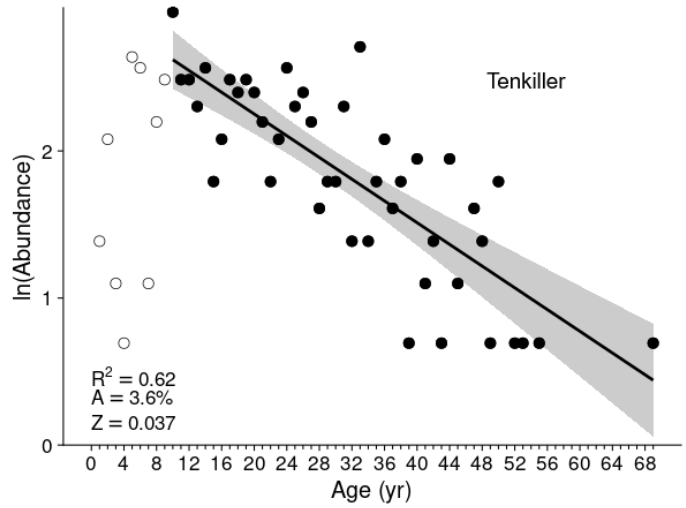
Age and Growth: SMB from Tenkiller exhibit typical patterns of fish age and growth for low productivity systems. Tenkiller possessed a length distribution centered around smaller length classes with slow growth, low average maximum size (lowest asymptotic growth parameter statewide), and was tied for the lowest average relative weight statewide. Yet, Tenkiller had an extremely wide age distribution (1-69) and only 3 cohorts from the 50+ year span of 1969-2023 were missing in our ageing samples. This would indicate natural reproduction is consistently occurring in this system (and has been for a long time).



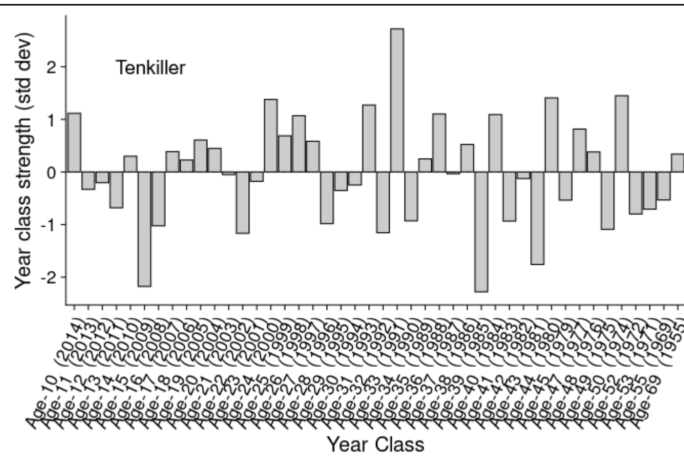




Annual mortality: Mortality estimation for SMB on Tenkiller was low (3.6%) and aligns with previous research of mortality for long lived buffalofishes.



Recruitment: Although natural reproduction is happening on a consistent basis on Tenkiller, the year class strength of each cohort appears to vary quite a bit from year to year. Several years of above average year classes appear to be followed by years of below average year class strengths. This variability in year class strength is consistent with what we have seen in other reservoirs in the state.



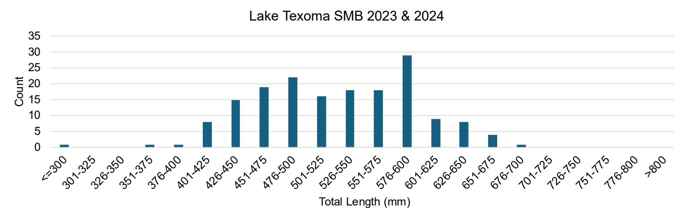
Summary: SMB in Tenkiller possess population dynamics typical of low productivity systems with slow growth, low maximum size, smaller average lengths, and lower condition/relative weight. With that said, it does appear that some level of natural reproduction is occurring on a yearly basis, mortality is low, and fish are surviving to old ages, which is indicative of a relatively stable population.

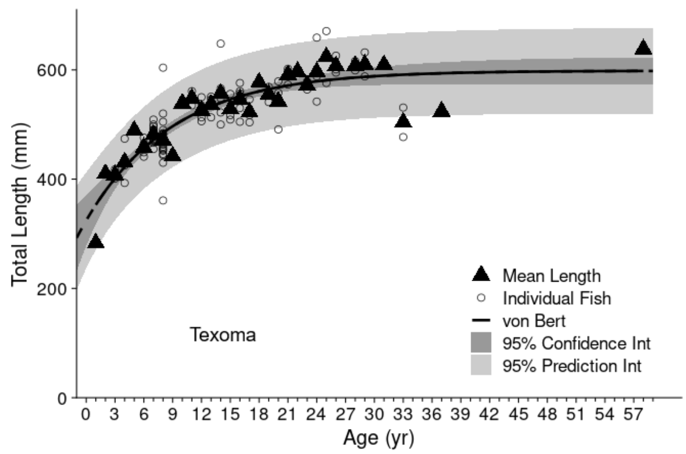
Texoma

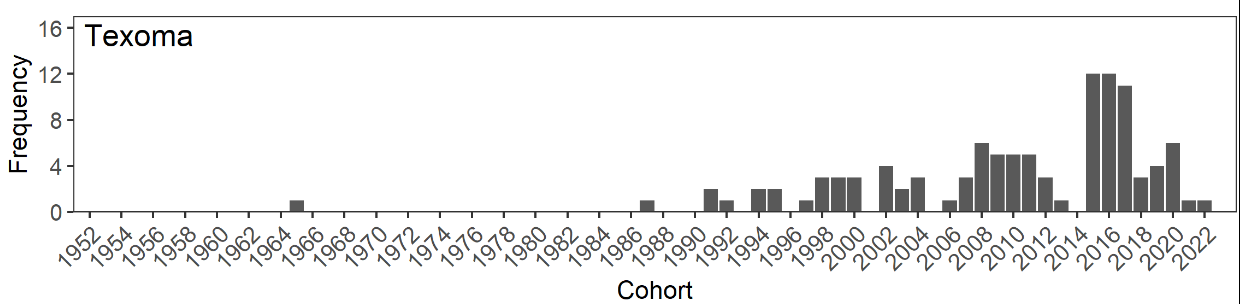
Species: Smallmouth Buffalo	**Length:** 526 (283-685, n=170)	**Age:** 13.7 (1-58, n=107)
Samples: 2023 (n=63), 2024 (n=110)	**Weight:** 2.5 (0.4-5.1, n=173)	**Wr:** 90.0 [88.3-91.8, n=107]

Population Dynamics:

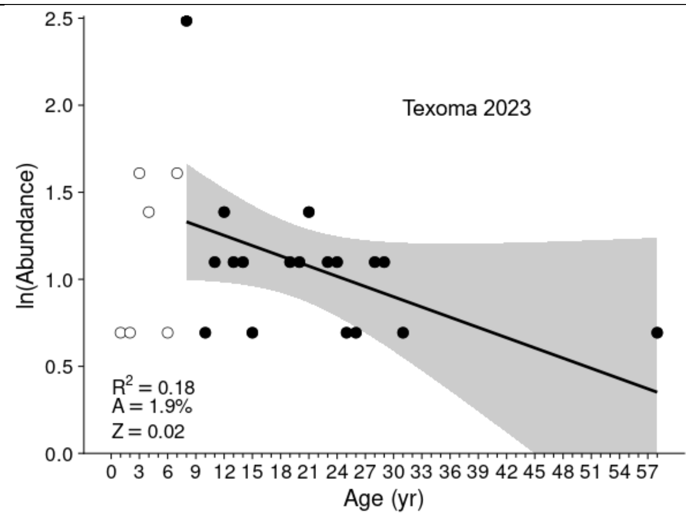
Age and Growth: Age and growth of Texoma SMB yielded peculiar results. We collected a wide variety of length and age groups; however, the frequency of cohorts follows a strange trend of clumps of cohorts with consistent gaps between them. This could be an indication of a lack of recruitment with regular periodicity, or simply a bias in sampling gear. These fish were sampled with SSP gillnets and collection bias of these nets for buffalofishes is not known. Fish collected from Texoma had the 2nd highest relative weight statewide; however, these fish were collected from November-February, whereas fish were collected at other times of the year for the other waterbodies in this report, further complicating comparisons across lakes.

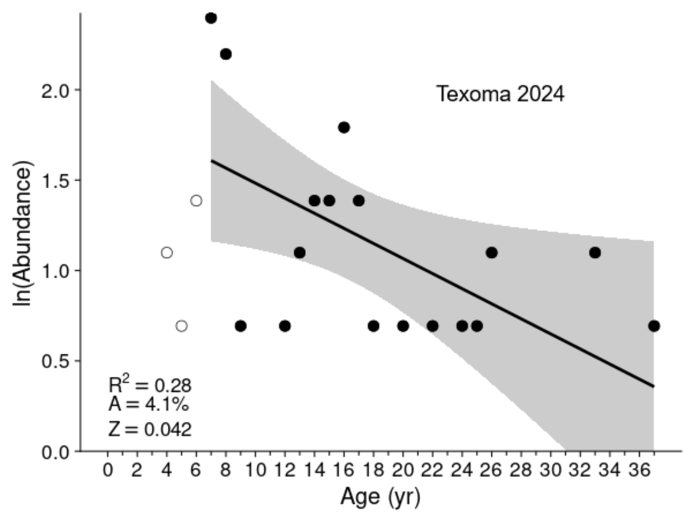


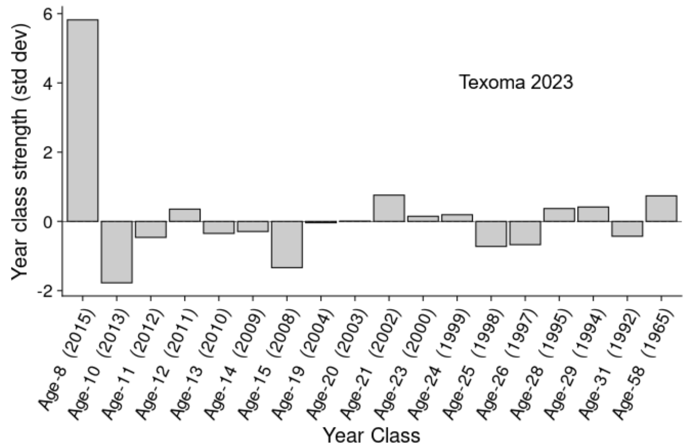
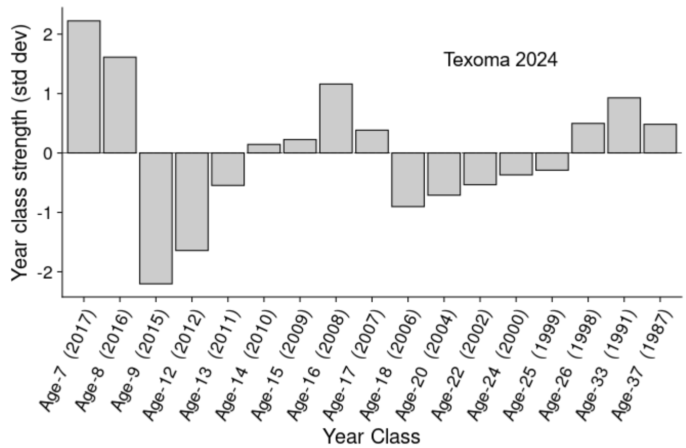




Annual mortality: Estimates of annual mortality for SMB on Texoma are within the expected range for long-lived buffalofish. The year-to year difference between plots (in reality, this represents November 2023 compared to January and February 2024) may represent different sampling areas within the lake. However, the capture of one fish in 2023 that was substantially older than all the rest is weighting the mortality estimate downward. We would expect, knowing the longevity of the species in Oklahoma, that the 2023 estimate of 1.9% to be closer to the true value, as it considers the single 58-year-old fish. Additional collections targeting larger fish would likely corroborate this assumption.





Recruitment: When comparing year class strength for SMB in Texoma across two sampled years, the results are somewhat contradictory. Data from 2023 indicate a potentially massive recruitment event in 2015, which aligns with a major hydrological event in Texoma. For the 4th time in the reservoir's history, Denison Dam spillway was crested. Inundation of floodplain habitats were prolonged in summer 2015, undoubtedly providing a local surge in SMB recruitment. In contrast, the 2024 year class strength plot paints a different picture, with 2015 reflected as a poor recruitment year.	 

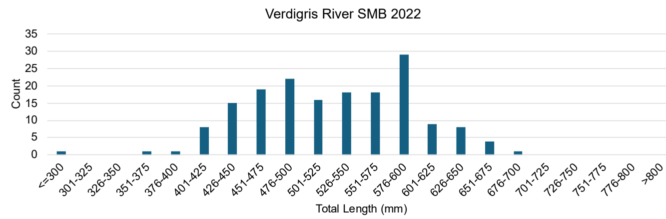
Summary: Texoma SMB collections were acquired from community sampling gillnets rather than targeted samples for buffalofishes or bowfishing. Therefore, some sampling size biases may be reflected in the size and age structure. All fish were acquired in winter (November-February), therefore they may be considered "pre spawn", explaining the elevated relative weights compared to other stocks. Clusters of fish in the age structure plot may be an artifact of sampling or may represent intermittent recruitment. While the 2023 year class strength plot accurately represents the likely reality of a large recruitment episode during a historic flood year (2015), contradictory assessments across subsequent years challenges interpretation of results. Annual mortality of this SMB stock is well within expected range of values for a long-lived species, however, the ages represented by the data appear to be truncated, with few older fish in the population. This may be a result of sampling bias, with mesh sizes of gillnets not effectively targeting larger specimens.

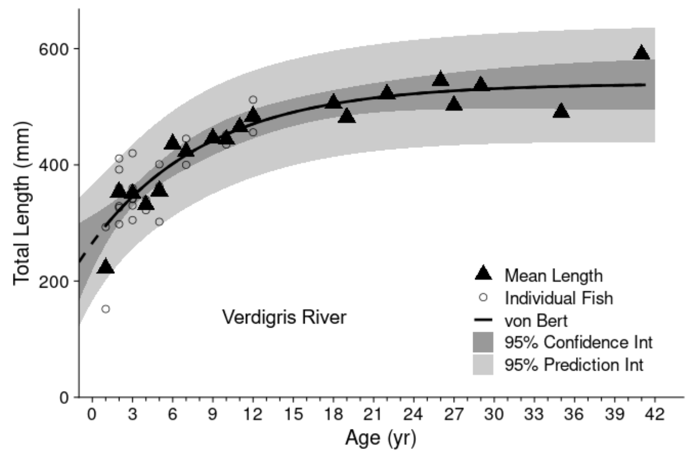
Verdigris River

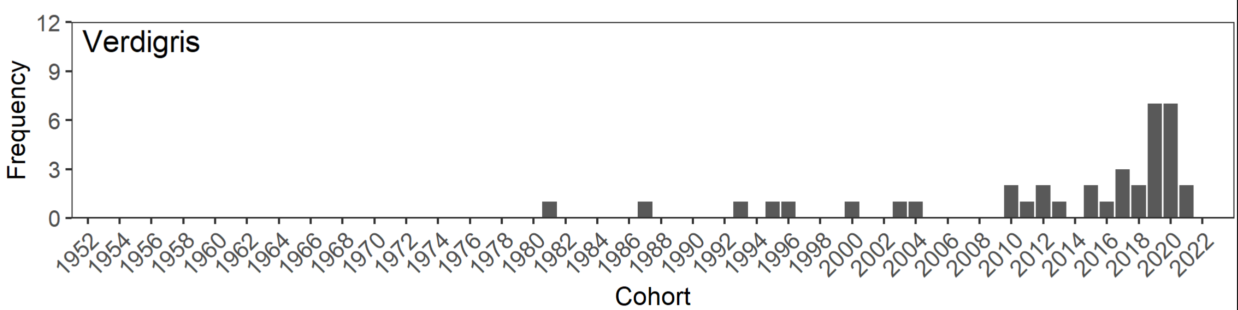
Species: Smallmouth Buffalo	**Length:** 355 (152-590, n=72)	**Age:** 9.5 (1-41, n=38)
Samples: 2022 (n=72)	**Weight:** 0.8 (0.6-3.3, n=72)	**Wr:** 91.1 [88.5-93.6, n=38]

Population Dynamics:

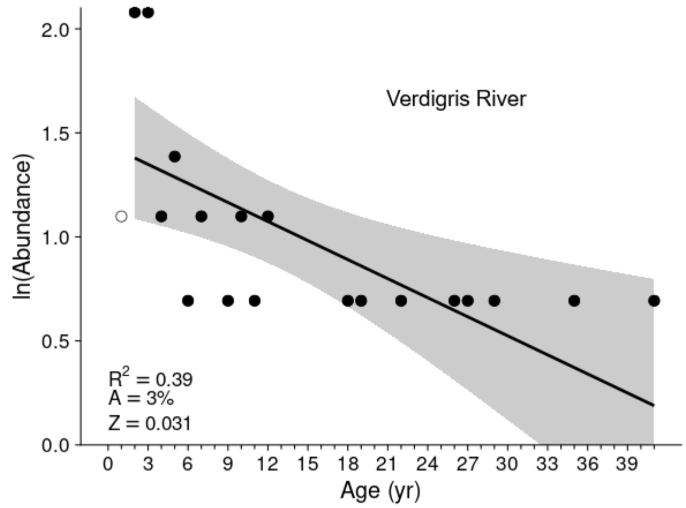
Age and Growth: Age structure of the Verdigris River represents the youngest Smallmouth Buffalo population sampled in the state with an average age of only 9.5. Some older individuals were collected; however, all cohorts prior to 2010 (>12 years old) were represented by either 1 or 0 individuals. Annual mortality of this population is low (see below), meaning that fish are likely reaching older ages but were simply not collected by our gear. This could be a case of sampling location bias where older fish are not present in the oxbow habitat (where these fish were collected), rather, they may be more abundant in the mainstem Verdigris. Further collection of fishes from the Verdigris River may be warranted to refine population dynamics of this population.



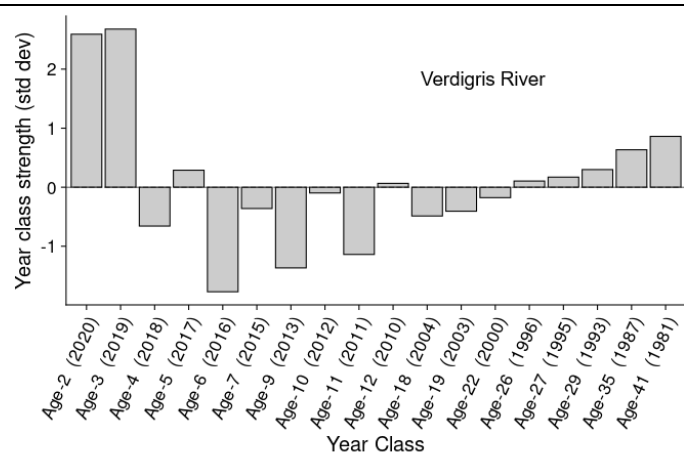




Annual mortality: The relatively small sample from the Verdigris River still produces an estimate of annual mortality that is within the expected range of values for a long-lived buffalofish. However, with additional aged specimens or additional collections, it is likely that more larger, older fish would be encountered, impacting the model and biasing the estimate to a lower value.



Recruitment: This population of SMB differs from others in that it resides in a side-channel/oxbow of the Verdigris River with free access to upstream and downstream river habitats for reproductive mixing within a larger population. Therefore, it is surprising that the samples here reflect a multi-decadal period of average to below-average recruitment followed by recent recruitment pulse in 2019. Widespread flooding in 2019 likely had a positive impact on recruitment in fish species such as buffalofishes, who capitalize on floodplain habitats for reproduction. We would expect that flooding in 2015 would have the same influences on recruitment, though it is not reflected in this plot.



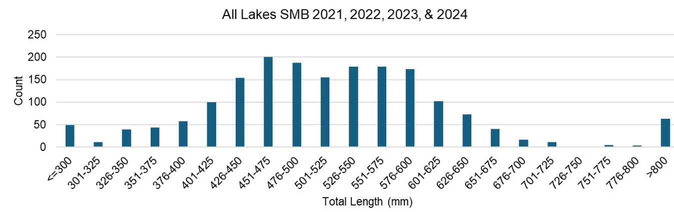
Summary: This population of SMB is unique among others described in this report, given that the fish are not impounded, have access to a large river system, and freedom of movement. However, our expectations of higher annual mortality and lower relative weights for fish in these life conditions are not being met. The partial age-assessment (38 of 72 fish) may limit our interpretation of age- and size-structure results at this time.

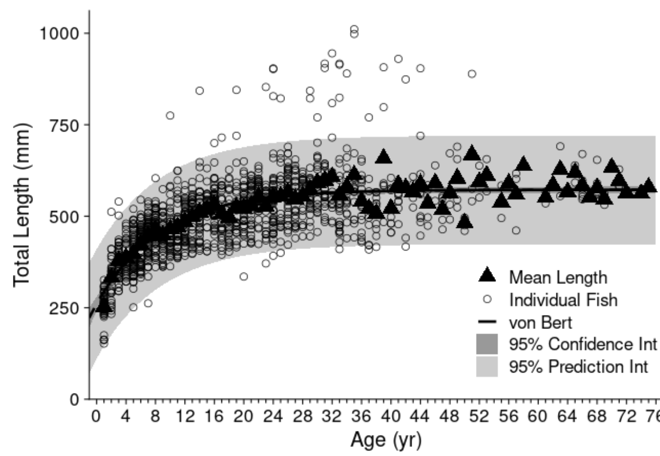
Statewide

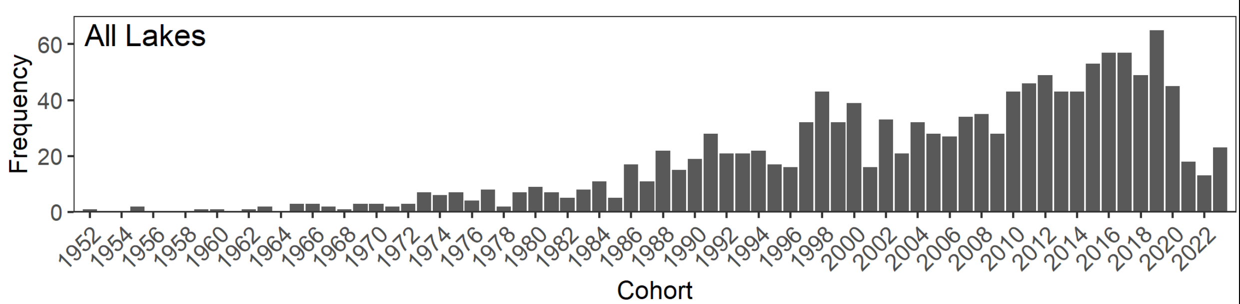
Species: Smallmouth Buffalo	**Length:** 514 (152-1011, n=1,895)	**Age:** 19.4 (1-75, n=1,327)
Samples: 2021 (n=203), 2022 (n=72), 2023 (n=270), 2024 (n=1247), 2025 (n=97)	**Weight:** 2.5 (0.06-20.6, n=1,896)	**Wr:** 81.9 [81.3-82.4, n=1,313]

Population Dynamics:

Age and Growth: Pooling data statewide is of limited utility, but it offers us a larger perspective on the life history of the species. As described above in individual reservoir sections, different size and age structures are observed, with some skewed towards younger and smaller fish (Keystone and Ft. Gibson), others skewed towards older fish (Shell Lake), and Chimney Rock skewed towards larger fish. Biases in collection methodology may exacerbate these apparent differences. Although general patterns in length at age are consistent across stocks, with asymptotic length achieved at around 16-20 years. Excepting Hulah and the Verdigris River, all samples included SMB ≥49 years old. However, all 37 individuals aged ≥60 were from Shell Lake. A number of the exceptionally large-for-their-age individuals from Chimney Rock appear to lie outside of the 95% prediction interval for the statewide von Bertalanffy plot.







Annual mortality: In general, annual mortality was low across the state with our lowest and highest estimates being 1.8% (Chimney Rock) and 8.3% (Keystone) and averaged approximately 4% statewide. This holds true to what is seen in other buffalofish populations across the US (and Canada). Select lakes need to be investigated further to help strengthen or revise mortality estimates, especially in lakes with minimal sample sizes. The 8.3% annual mortality rate for Keystone is a bit of an outlier and may require further evaluation. Evaluation

of how different sampling gears (i.e. bowfishing, electrofishing, SSP nets, etc.) biases estimates of mortality could help build more meaningful comparisons across waterbodies even when different collection methodologies are used.
Recruitment: Age structure within and across populations indicates generally that annual recruitment is low with episodic pulses, often coarsely aligned with hydrological events (e.g., 2015 in Texoma, 2019 in Verdigris River). Deeper investigation into periods of prolonged floodplain inundation as a predictor of year class strength may be informative, given the ability to retrospectively examine cohort strength many decades after spawning. Regional or watershed trends may be evident. Investigation of more robust tools to evaluate year class strength may be worthwhile. Several populations examined here with large sample sizes were not able to resolve the year class strength plot in OFAT analysis tool, presumably due to the inability to calculate one or more residuals from the catch curve plot.
Summary: Continued efforts on completing age estimation for stocks examined here and others yet to be examined will assist in building our perspectives on buffalofish population dynamics in Oklahoma. Though minor nuanced differences exist across stocks, they largely follow the expected patterns of extreme longevity (up to ~80 years), large size potential, decades of no growth once reaching asymptotic length, low annual mortality (generally 2-5%), and episodic recruitment influenced by ecological factors. These life history characteristics parallel those in the published literature for buffalofishes range-wide, and are therefore not surprising. However, local information on population dynamics is essential for the future management of buffalofishes for sustainability in emerging harvest fisheries.

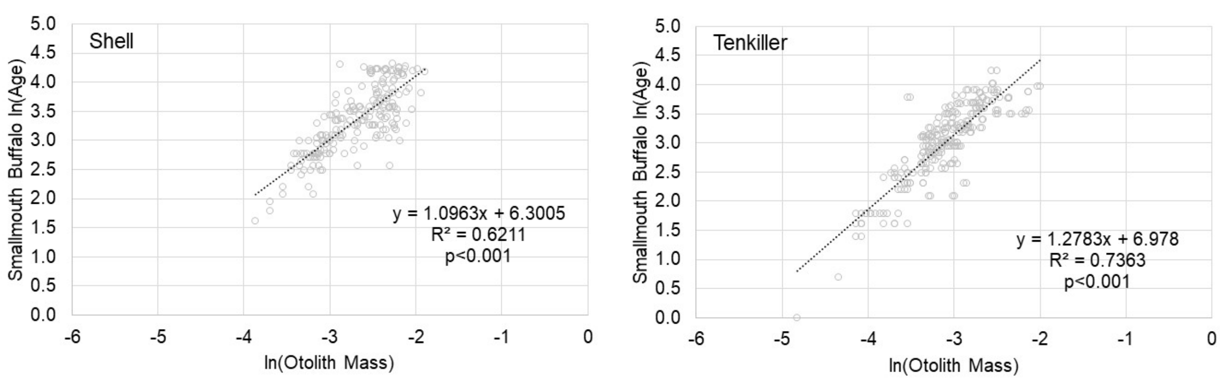
Table 9. Summary of growth parameters from Von Bertallanfy growth equations and estimates of annual mortality for Smallmouth Buffalo populations in Oklahoma Lakes. Numbers of aged individuals generally represent a subsample of collections. Annual mortality estimates are computed only for samples within the same year.

Populations	# Aged	L_∞ [95% CI]	K [95% CI]	t0 [95% CI]	A% (Collection Year)
Chimney Rock	26	-	-	-	1.8% (2021)
Ft. Gibson	146	518 [501, 537]	0.12 [0.10, 0.15]	-4.3 [-5.5, -3.3]	5.0% (2024)
Grand	233	601 [587, 617]	0.11 [0.09, 0.13]	-5.3 [-7.0, -4.1]	2.5% (2021), 6.8% (2024)
Hulah	33	-	-	-	5.9% (2023)
Keystone	197	624 [602, 654]	0.11 [0.08, 0.14]	-6.8 [-10.1, -4.4]	8.3% (2023), 1.4% (2024)
Shell Creek	212	585 [576, 597]	0.09 [0.06, 0.13]	-12.7 [-26.5, -5.7]	1.9% (2024)
Tenkiller	335	511 [498, 530]	0.08 [0.06, 0.11]	-9.7 [-14.5, -6.6]	3.6% (2024)
Texoma	107	598 [576, 630]	0.11 [0.07, 0.15]	-7.1 [-11.7, -4.3]	1.9%, (2023), 4.1% (2024)
Verdigris River	38	540 [498, 615]	0.11 [0.06, 0.20]	-5.9 [-12.8, -2.7]	3.0% (2022)

Otolith Mass as a Predictor of Age -

Otolith mass for two populations of Smallmouth Buffalo were compared to age estimates to examine the utility of this predictor of age. A total of 201 otoliths from Shell Lake and 251 otoliths from Tenkiller Lake contributed to these analyses. For both stocks, linear regressions of natural log transformations for the variables indicated strong predictive equations (Figure 5).

Figure 5. Examination of otolith mass as a predictor of age in Smallmouth Buffalo.



Morphology and Species Identification for Buffalofishes –

To date, collections of buffalofishes for our statewide morphology and genetics project have yielded 2,067 samples representing all three species (Table 8). Although our confidence in identifying Bigmouth Buffalo is high (156 fish; 7.5%), an admixture of morphological traits makes confident species ID a challenge for Smallmouth and Black buffalofishes. This low confidence in visual identification of Black Buffalo (i.e., differentiation from Smallmouth Buffalo) has resulted in relatively few fish labeled as Black Buffalo during visual inspection and measurement. However, *a posteriori* use of several morphological techniques on the remaining 1,911 fish not identified as Bigmouth Buffalo has yielded different, but inconsistent results. Through simple examination and classification of the nuchal keel, we identified 1,756 fish with pronounced keels (91.2%) and 169 fish with moderate keels (8.8%) among 1,925 fish for which this character was recorded. The D_i method, when used independently of keel, suggests that 43% of the 1,782 fish we visually identified as Smallmouth Buffalo could be Black Buffalo, elevating this cryptic species to 41% of the total buffalo catch.

Table 10. Morphology identification of Oklahoma buffalofishes. Species is indicated here by visual assignment (V) or through implementation of body depth index (D_i). Three tournament buffalofishes from uncertain origins are excluded from this table.

Stock	Bigmouth Buffalo V. Count (%)	Smallmouth Buffalo V. Count (%) D_i Count (%)	Black Buffalo V. Count (%) D_i Count (%)	Total Samples
Chimney Rock	1 (1.5)	65 (98.5) 49 (74.2)	0 (0) 16 (24.2)	66
Eufaula Lake (plus tailwater)	16 (47.1)	18 (52.9) 12 (35.3)	0 (0) 6 (17.6)	34
Ft. Gibson Lake	4 (2.0)	197 (97.0) 120 (59.1)	2 (1.0) 79 (38.9)	203
Grand Lake	10 (3.8)	250 (95.8) 112 (42.9)	1 (0.4) 139 (53.3)	261
Heyburn Lake (tailwater)	17 (100.0)	0 (0) 0 (0)	0 (0) 0 (0)	17
Hulah Lake (tailwater)	49 (59.8)	33 (40.2) 18 (22.0)	0 (0) 15 (18.3)	82
Kaw Lake	43 (26.9)	117 (73.1) 94 (58.8)	0 (0) 23 (14.4)	160
Keystone Lake	4 (1.7)	229 (97.4) 162 (68.9)	2 (0.9) 69 (29.4)	235
Shell Lake	5 (1.5)	317 (97.2) 154 (47.2)	4 (1.2) 167 (51.2)	326
Tenkiller Lake	0 (0)	418 (100.0) 126 (30.1)	0 (0) 292 (69.9)	418
Texoma Lake	2 (1.1)	173 (98.9) 139 (79.4)	0 (0) 34 (19.4)	175
Verdigris River	5 (6.5)	72 (93.5) 52 (67.5)	0 (0) 20 (26.0)	77
Totals	156 (7.6)	1,889 (92.0) 1,038 (50.5)	9 (0.4) 860 (41.9)	2,054

Addition of genetic evidence further complicates, rather than clarifies, the species differentiation of Smallmouth Buffalo, Black Buffalo, Bigmouth Buffalo, and their hybrids. Using mitochondrial barcoding, we have maternal lineage for a subsample of 308 buffalofishes from nine Oklahoma reservoirs. Though Bigmouth Buffalo are generally considered easiest to visually identify to species among the three buffalofishes, half of the Bigmouth Buffalo samples barcoded indicated maternal genetic influences from *I. bubalus* or *I. niger*, indicating some past hybridization (Table 11).

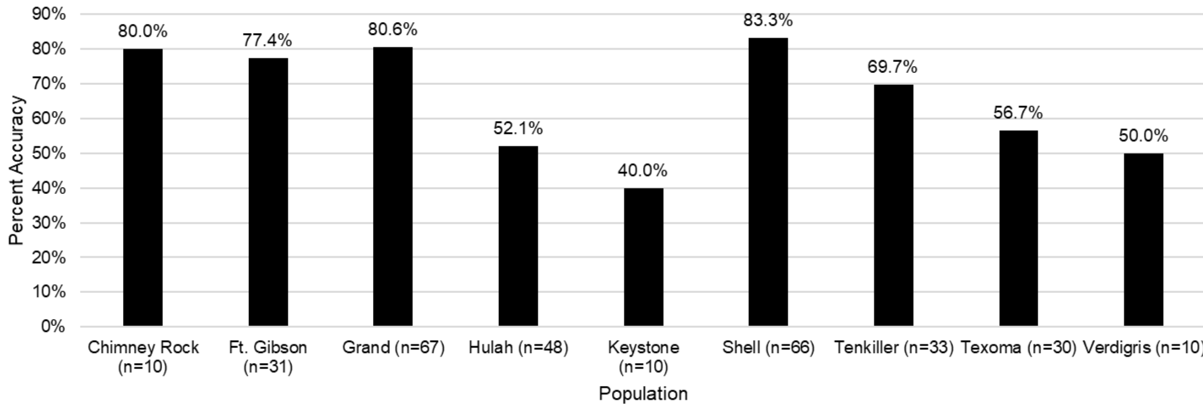
For fish visually identified as Smallmouth Buffalo across all populations sampled, 50.5% of them had body depth index characteristic of Black Buffalo (Table 10). In contrast, genetic identification indicated that smaller fractions of those fish visually resembling Smallmouth Buffalo had mitochondrial DNA indicating Black Buffalo (8%) or Bigmouth Buffalo (19%, Table 11). While it would superficially appear that D_i provides a more accurate identification of Smallmouth Buffalo than visual identification (74.4% and 73%, respectively), this does not account for the inaccurate identification of Black Buffalo. Overall, considering all three species, visual identification appeared to provide more accurate results than using Depth Index (70.8% and 50% accurate, respectively). However… it is clear that hybridization is or has been rampant in all sampled stocks of buffalofishes. No populations sampled resulted in perfect alignment between visual identification and mitochondrial DNA, though three populations exceeded 80% (Chimney Rock, Grand, and Shell). Given that mtDNA is preserved through maternal lineage, these hybridizations may represent singular events many generations ago or persistent reproductive events. Finer-scale characterization of hybrids (i.e., F1, F2) would be key to understanding the reproductive dynamics and species overlap of buffalofishes in Oklahoma reservoirs. Accuracy of visual ID was not significantly influenced by fish age, as the mean ages for accurately and inaccurately identified buffalofishes were 21.5 and 20.1 years, respectively ($t=0.7298$, $df=305$, $p=0.4661$).

Table 11. Results from buffalofish mitochondrial barcoding compared to visual species ID (above) and species ID derived from the body depth index (D_i, below).

		Confirmed via mtDNA			
Visual	Count	SMB	BKB	BMB	%Acc
SMB	278	203	21	54	73.0%
BKB	1	0	0	1	0.0%
BMB	29	5	9	15	51.7%
	308	208	30	70	70.8%

		Confirmed via mtDNA			
D_i	Count	SMB	BKB	BMB	%Acc
SMB	176	131	13	32	74.4%
BKB	103	72	8	23	7.8%
BMB	29	5	9	15	51.7%
	308	208	30	70	50.0%

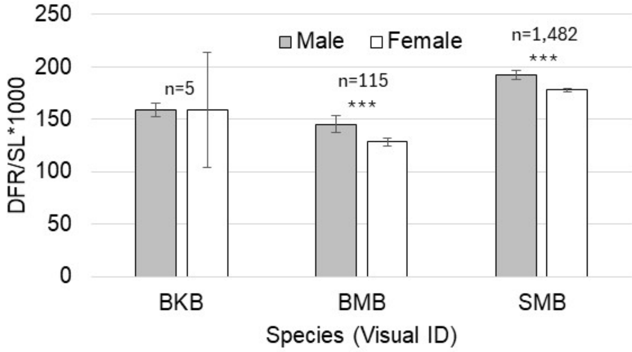
Figure 6. Accuracy of visual identification of buffalofishes (all three species combined, verified from mitochondrial barcoding) varied across populations. Data excludes three fish where population was uncertain.



The genetic data above, though small in sample size, may be useful in a determination of relative abundance among the three buffalofish species. Fundamental to this assessment, however, is an acknowledgement of the inherent complexity that mtDNA may not be a reliable definition for ***what a species is***, only that of the mother. If mtDNA defined species for Oklahoma buffalofishes, we might conclude that Smallmouth Buffalo are approximately 7-times more abundant than Black Buffalo. With this state-protected species known to be rare, whereas Smallmouth Buffalo are regarded as far more common, this may be the first dataset providing some quantification of the relative abundance for the two species.

Previous examination of anterior dorsal fin ray length in relation to standard length (DFR/SL*1000) for fish speciated based on D_i resulted in a highly significant difference (T-Test, $p<0.001$) between males and females when pooled across all collections (see 2024 annual report). Further, when males and females were pooled, this character remained significantly different for all three D_i species, when pairwise compared (T-Test, $p<0.001$). Now that mtDNA has cast some doubt on the effectiveness of D_i for species identification, a re-analysis of this character using genetic ID was warranted. Results indicate that the highly significant difference between sexes was preserved for Smallmouth Buffalo and Bigmouth Buffalo (Figure 7), but sample size in Black Buffalo was inadequate. Similarly, there is a significant difference in mean DFR/SL*1000 between Smallmouth Buffalo and Bigmouth Buffalo for pooled sexes, however, the utility of this as an identification characteristic is likely low. The ability to reasonably assign sex to Smallmouth Buffalo and Bigmouth Buffalo without physical examination of the gonads should be of value in future collections.

Figure 7. Examination of anterior dorsal fin ray length as a character for differentiating sexes in visually-identified buffalofishes was found to result in a significant difference (p<0.001; indicated by asterisks [***]) for two species when pooled across all water bodies.



Overall, nongame age specimens collected to date are dominated by buffalofishes, but include 15 species (Table 12). Our program's contract for consultation with Dr. Scarnecchia at University of Idaho includes fish aging, therefore many otoliths from non-buffalofishes were sent to University of Idaho, while we retained the buffalofishes to process locally. At the time of this report, no results from University of Idaho are available.

Table 12. Summary of nongame specimens collected 2021-2025. Collection methods included gill nets, electrofishing, fish salvage, and bowfishing tournaments. Age assignment has prioritized buffalofishes. Other species are yet to be aged.

Species	Total Collected 2021-2025
Bigmouth Buffalo	152
Black Buffalo	7
Common Carp	247
Freshwater Drum	57
Gizzard Shad	24
Grass Carp	40
Longnose Gar	145
Northern Hogsucker	1
River Carpsucker	82
River Redhorse	3
Shortnose Gar	28
Skipjack	1
Smallmouth Buffalo	1,795
Spotted Gar	145
Spotted Sucker	3
	2,731

FUTURE EFFORTS AND MANAGEMENT RECOMMENDATIONS

Collections in 2026 and beyond: While opportunistic collections of buffalofishes 2021-2023 have provided much valuable information about these species, contributing to an assessment of morphology and genetics, in order to adequately assess the status, distribution, and sustainability of NNG fisheries in Oklahoma, more data were needed. Acquisition of tournament-shot fish from our collaboration with Oklahoma Fish Stickers bowfishing club in 2024 provided large volumes of specimens which have generally been adequate for assessment of age and growth, continuation/expansion of our buffalofish morphology and genetics project, and fine-tuning estimates of mortality and exploitation. Aging these specimens has proven time consuming, especially within other program priorities. We enhanced our productivity with aging buffalofishes in 2025, as we were not obligated to acquire hundreds of new specimens each month from tournaments. Overall, the collaboration with OFS was positive and we would like to maintain a communicative relationship.

Further refinement of aging buffalofishes in 2026, in addition to targeted samples to supplement gaps in data sets used above, should be priorities for management of buffalofishes.

In 2026, we hope to assist Northeast Region Management staff in collection of Shovelnose Sturgeon for potential use as broodstock in a pilot hatchery rearing program. In the absence of a commitment to bowfishing tournaments, we also hope to begin exploring capture methodologies for American Eel in the Verdigris River. For the latter, we have assembled eel traps for deployment in tailwater habitats. Consultation with members of the AFS eel committee will help guide collections.

We proposed a special project for summer 2026 to evaluate the effectiveness of bowfishing as biocontrol for Common Carp in Liberty Lake, Guthrie, Oklahoma (Appendix D). This project will likely depend on cooperation from the Guthrie City Council.

Summary of planned NNG activities in 2026

1. Continue refinement of buffalofish aging techniques
2. Complete aging of buffalofish otoliths
3. Continue monitoring NNG in Shell Lake
4. Enhance data on buffalofishes from Chimney Rock Lake
5. Attempt to collect American eels and Shovelnose Sturgeon
6. Play a larger role in Gar Week 2026
7. Continue exploring regulatory options for NNG fishes

<u>Regulatory strategies for management of nongame fishes:</u> At present, only a select number of NNG fishes in Oklahoma are afforded any sort of regulatory protection (Table 1). However, as emerging fisheries such as sport bowfishing and "carp" angling (which, in practice, targets carps, buffalofishes, and carpsuckers), plus other fisheries such as gigging, pressure these NNG stocks, we have an obligation to ensure that the fishery opportunities provided to our license holders are responsible and sustainable. Numerous challenges are realized when an expanding fishery (e.g., bowfishing) targets a group of NNG fishes with high conservation value (i.e., long lifespans, irregular recruitment) and no regulatory limitations on take. These challenges are confronted in recent, but long overdue literature on the sport, it's need for management, and the barriers to funding (Scarnecchia and Schooley 2020; Scarnecchia et al. 2021), although these concepts are not new ones (Scarnecchia 1992). Fundamentally, any hunting or fishing opportunities overseen by the Department should be managed for sustainability. However, a low social value stigma associated with many NNG fishes has been historically applied to these fish. As a result, there has been a historical reluctance to expend attention, effort, or funding on their behalf. Modern fisheries science prioritizes healthy ecosystems and aquatic communities rather than a focus on cultivating a few species (perhaps nonnative) that are favored by anglers. NNG fishes are valued for their roles in the fishery community (as predator, forage, etc.) or for the ecosystem services they provide (e.g., as hosts to freshwater mussels, see Appendix B). The conservation value of NNG fishes would conflict with their eradication or removal- whether it be willful through overfishing or negligent through lack of regulatory oversight.

A substantial regulatory proposal package was submitted in 2023 with the objective to set an example by assigning value to NNG fishes. The proposed changes would prohibit the shoot and immediate release of NNG fishes by bowfishing. This practice is currently prohibited in 42 states, but is only quasi-legal in Oklahoma through an enforcement loophole. Use of Oklahoma's native wildlife as targets with no intent to retain the usable parts (e.g., edible flesh), essentially amounts to sport wounding or killing and is in stark conflict with the fundamental tenets of the North American Model of Wildlife Conservation. Typically, state statutes prevent the wanton waste of wildlife or wildlife parts. However, Oklahoma Title 29 creates a conflict by protecting an angler's rights to return fish remains to a reservoir and there is not a clear differentiation between a filleted carcass and a perforated (wounded or dead) whole fish. Our research removed all doubt that a high fraction (87%) of fish shot with a bow and arrow die within 5 days (60% dead within 12 hours) and the sport cannot be responsibly practiced as shoot and release (Montague et al. 2023). A longer-term lab study on shoot and release mortality was performed by the Oklahoma Fisheries Research Laboratory in 2024 (Zentner et al. in press). Although many methodological details were in common with the Montague, et al. (2023) study, the OFRL study shot fish at close range in individual fish holding containers and monitored delayed mortality up to 89 days. Though overall mortality was less than the original study, was less pronounced within the first 12 hours, differed between NNG and NNI species, and was not influenced by shot location, the overall study conclusions were unified between the two studies- that release mortality from bowfishing (>60%) exceeds that of the highest documented mortality levels of hook and line catch and release.

A second major component of the regulatory proposal was comprised of an aggregate daily limit of 10 NNG fishes for all methods. This proposal was justified not as a solution to overharvest of any particular species, but as a demonstrative move by the Department to assign social value to a suite of NNG species. Fish and wildlife species with a daily bag limit are viewed as inherently more valuable. Our statewide bowfishing survey results (York et al. 2022) indicated that only a small fraction of bowfishers (13%) would be impacted by the bag limit. Additional psychological impacts of applying a bag limit to an unregulated fishery were considered (i.e., the "Limit Syndrome" as described by Evans (1971)). In the absence of a harvest limit, the benchmark of success (Fox 1975) for a bowfishing trip is individually defined. Through implementation of a harvest limit, any person harvesting over that limit would now be impacted by the limit, however someone harvesting below the limit may now be inspired to fish more because the limit is perceived as a benchmark of success. Proximity to the daily limit has been demonstrated as correlated to angler satisfaction in studies with game fishes (Cook et al. 2001). Therefore, responsible selection of a limit must consider multiple factors. A range of limits were modeled to examine the harvest impacts of inspiring enhanced effort and harvest for bowfishers typically harvesting below the new limit. The limit of 10 was ultimately selected because it impacted few bowfishers while being robust to enhanced pressure of limit-seekers. Selection of larger daily limits ran the risk of increasing harvest by moving the benchmark of success far enough to create an imbalance between harvest reduction of bowfishers above the limit and enhanced harvest of bowfishers below the limit.

Additional components to the rule change proposals related to NNG fishes and bowfishing concerned a revised definition of bowfishing equipment, an alignment of the possession limit with the daily bag limit, and some clarifications on fish carcass disposal.

Ultimately, due to pressure from bowfishing constituents in attendance at the January 2024 Wildlife Commission meeting, the Commission voted to table the proposals with the generalized directive that the Department should "collect more data" before proposing further regulatory changes on bowfishing or native nongame fishes. This decision prompted our collaboration with OFS throughout their 2024 tournament schedule.

The 2023 rule change package (tabled January 2024) was revised and submitted for 2025 (Appendix E), with justification including the public support of the 2023 package, however, the bag limit was not re-proposed. The package included a prohibition of shoot and release in addition to a definition of wanton waste as "*intentional or negligent wounding or killing and abandonment or discard of fish and wildlife in the field without making a reasonable effort to retrieve and either render it for consumption or beneficial use or lawfully dispose of the animal. This definition and context shall align with 29 O.S. 7-205 and 29 O.S. 7-403 and any exceptions provided therein."* Our program's recommendation for regulatory change was strongly supported by public opinion, ODWC research data, and accepted principles of conservation ethics. Below is the justification originally used in development of the rule change proposal in 2025 to prohibit shoot and release in bowfishing. Ultimately, these proposals were not presented to the Oklahoma Wildlife Commission.

Justification for prohibition of shoot and release bowfishing

EXECUTIVE SUMMARY

The practice of bowfishing shoot and release (S&R) in Oklahoma is legal only because it lies in a statutory loophole which challenges enforcement of established wanton waste law. The practice of S&R should be distinctly prohibited in Oklahoma, closing the loophole and officially regulating bowfishing as a consumptive practice with no viable release.

Three key areas of evidence justify prohibiting S&R:

1) Public opinion.
    a. 75% of comments during 2024 public comment period supported the closing of shoot and release
2) Research results indicate high S&R mortality.
    a. Observed cumulative mortality rates of S&R bowfishing (62-87%) exceeds that of nearly all other types of fishing in the published literature (average 18%).
3) Accepted principles of conservation ethics in Oklahoma and the United States.
    a. The North American Model of Fish and Wildlife Conservation holds as a central tenet that "wildlife may only be killed for a legitimate, non-frivolous purpose," which is at odds with wanton waste.

1) PUBLIC OPINION

As demonstrated in January 2024 when the prohibition of bowfishing S&R was originally proposed in Oklahoma, support for the continuation of this practice is low. Online public comments from 945 individuals (including 287 Oklahoma residents, 406 nonresidents, and 252 of unknown residence) overwhelmingly indicated that a proposal to prohibit S&R was appropriate and timely (75% support versus 19% oppose, n=945). Responses from Oklahoma Residents indicated generalized support (47% support versus 39% oppose) for the proposal package.

A selection of comments posted by Oklahoma residents in support of prohibiting S&R are as follows:

> *"It is abhorrent and morally wrong to allow anglers to shoot and release native fishes. Animals, unless invasive, should not be killed for sport and not utilized. This is akin to wanton waste. Please put a stop to the abuse of Oklahomas resources!"*
>
> *"This is a much needed change. The unregulated slaughter, for no reason other than thrill, of any native species should not be allowed. Especially so considering the episodic spawning and long life spans of these species"*

> *“I support these new rules because how is shooting a hole through a fish and releasing it proper stewardship of our environment? Catch and release is for maintaining the spirit and sport of fishing while helping to protect fish populations from overfishing.”*
>
> *“There is no ethical release of a fish that has been shot with an arrow. The wanton waste of native fish should most definitely be addressed with the prohibition of shoot and release.”*
>
> *“Not everyone considers these trash fish, some us would like to protect these fish for future generations. On top of that, they are essential parts of these native ecosystems, which require careful balance to continue producing quality gamefish. Wanton waste of these fish by a few bowfishermen is detrimental to all.”*
>
> *“These are welcome changes to prevent wanton waste and the wasteful killing of native fish.”*
>
> *“In what universe would killing animals with no limit and no use whatsoever beyond sport killing be legal? Imagine if people just went out and shot up native ducks or deer all day long just to throw them back and brag about how much they killed and wasted. Such sound policy! It is about time management agencies are stepping up to take their responsibility and do their job to manage bowfishing. Decades overdue, but better late than never.”*

As of 2025, S&R was prohibited in 42 states and is permitted for native nongame fishes in only four states (Alabama, North Carolina, Oklahoma, and Tennessee). The Oklahoma rule change package considered in 2024 included a more controversial measure to establish an aggregate bag limit for native, nongame fishes and this was met with vocal opposition from a minority of bowfishers with commercial interest in an unregulated sport, prompting the Oklahoma Wildlife Commission to postpone consideration of the proposals until further study was completed.

Given that the rules package presented in 2024 included a bag limit, the Department received public comments from bowfishers that vehemently opposed the bag limit while still supporting the prohibition of S&R. Here are a few examples from Oklahoma bowfishers (with supportive statements <u>underlined</u>):

> *“The person or persons who came up with this [bag limit] probably most likely supported by some animal rights groups!!! <u>I do agree that the rough fish shot should not be returned to the water but kept</u>.”*
>
> *“<u>And in regards to shoot and release, I feel a few morons have made it bad for the rest of us</u>. I would propose bowfishers keep their catch until finished and then dump their harvest in the deep waters of the lake where turtles and birds can consume them.”*
>
> *“Against, the aggregate limit, <u>for the shoot and release [prohibition]</u>.”*
>
> *“They should not have a limit on none [sic] game But they <u>should not release any after they have been shot</u>”*
>
> *“I do not believe there should be a size limit or bag limit on nongame fishes <u>however it should be illegal to release a fish after being shot regardless of the fish</u>”*

In addition to the public support for the prohibition of shoot and release in bowfishing, numerous Tribal Nations and conservation organizations voiced support for ending the practice in Oklahoma: Choctaw Nation, Izaak Walton League of America – Minnesota Division, Kansas Chapter of the American Fisheries Society, Muskogee Creek Nation, Native Fish Coalition, Native Fish for Tomorrow (NF4T), North American Native Fishes Association (NANFA), Oklahoma Chapter of American Fisheries Society (select members), Oklahoma Conservation Coalition, The Nature Conservancy (TNC), and Trout Unlimited (TU). Below are a few highlights from the support voiced by these organizations:

> *“ODWC’s efforts to ... prohibit catch and release of native nongame fish for bow fishermen are directly aligned with NANFA’s mission of increasing appreciation and conservation of native nongame fishes and we commend Oklahoma’s efforts to manage and delegate value to these important native species. Please consider this letter as an official comment of support for the proposed rule changes and Oklahoma’s efforts to increase appreciation, awareness, and management of its nongame native fishes.”*
>
> - Fritz Rohde, NANFA President

> *“...closing the loophole on shoot and release bowfishing, is essential to maintain consistency with the North American Model of Fish and Wildlife Conservation. Wildlife should only be killed for legitimate purposes and Oklahoma’s Wanton Waste laws follow that axiom. Given the high mortality rate in shoot and release bowfishing, this practice is nothing more than legalized wanton waste. Closing this loophole is a non-controversial and essential protection, not only for fish populations but for the sport of bowfishing. This also brings Oklahoma into alignment with the overwhelming majority of other states on this issue.”*
>
> - Andrew Geving, NF4T President

> *“The protection of healthy aquatic communities and sustainable fisheries benefits all Oklahomans. We believe the ... rule changes are supported by sound science and otherwise align with the North American Model of Wildlife Conservation. The Nature Conservancy values the capabilities and expertise of the Oklahoma Department of Wildlife Conservation, and appreciates the agency’s efforts to manage our public wildlife resources.”*
>
> - Katie Gillies, TNC OK Director of Conservation

> *“We believe that nongame, native fish play a very important role in the ecological balance of our watersheds. And while the nongame title might indicate that these species don’t yet serve a recreational economic impact (that’s clearly studied), we believe that their contributions as natives carry an inherent value. We also believe, as anglers, that the wanton waste and destruction of native fish is ethically and morally opposed to the model of conservation that has preserved North American wildlife for many years. It’s absolutely within the scope, and is the very foundation of the ethos of ODWC, to regulate the sport-killing and waste of these species.”*
>
> - Jake Miller, TU Dave Whitlock Chapter

2) RESEARCH RESULTS
In 2023, the Department published an award-winning research study on the short-term mortality impacts of S&R in bowfishing (Montague, et al. 2023). At the direction of the Wildlife Commission, a second study was performed by the Department under more controlled, laboratory conditions to assess both short-term and long-term mortality (to 89 days; Zentner, et al., in press). Though the mortality rates from the second project varied slightly from the first project, the fundamental conclusions of high short-term and long-term mortality for fish perforated by an arrow persisted. Further, the observed cumulative mortality rates of S&R bowfishing (62-87%) exceed that of nearly all other types of fishing in the published literature (average 18%; reviewed by Bartholomew and Bohnsack 2005). Further, shot/wound location had a high influence on mortality, with fish shot in critical areas (i.e., head, spine, or internal organs) experiencing a 96% short-term mortality (Montague, et al. 2023). The authors of both studies in Oklahoma concluded that responsibly managed bowfisheries for native, nongame fishes should be considered a 100% consumptive (kill) pursuit, with no viable release. Fortunately, only a small minority of bowfishers surveyed in Oklahoma (20%) reported that they return their shot fish to the water, however, a distinction was not clear between practicing S&R and disposal of carcasses (York, et al. 2022).

3) CONSERVATION ETHICS
In principle, shoot and release bowfishing (effectively sport killing/wounding and immediate discard of fish) is wanton waste of natural resources according to Oklahoma Fish and Game laws (29 O.S. 7-205). A conflict exists for enforcement of this statute in that disposal of “fish remains” into reservoirs is permitted (29 O.S. 7-403). A shot and immediately discarded fish does not legally fit the definition of “fish remains” unless filleted or eviscerated (see supporting document on ODWC law enforcement policy interpretation of these relevant laws). Shoot and release

> bowfishing therefore exists as somewhat of a loophole among distinct laws regulating wanton waste and disposal. Peer-reviewed science, public opinion, conservation organizations, and the North American Model of Fish and Wildlife Conservation (NAM) agree that the practice of S&R does not align with ethical, sustainable, or responsible fisheries management. The NAM holds as a central tenet that "wildlife may only be killed for a legitimate, non-frivolous purpose," which is at odds with wanton waste. https://www.fishwildlife.org/landing/north-american-model-wildlife-conservation
>
> A passionate subset of bowfishers will undoubtedly continue to provide vocal opposition to any and all regulations related to the sport. However, when assigning weight to such opposition, we must consider whether this passionate minority is motivated by commercial interests (e.g., guides or tournament directors/promoters) and whether this private financial interest is more important than the Department's commitment to conservation ethics. In apparent support of the latter, 86% of bowfishers surveyed reported that they trust the Department to appropriately manage native, nongame fishes (York, et al. 2022), and this is chiefly done through regulation. Closing this loophole is the right thing to do for Oklahoma.

Although ODWC failed to implement rule these changes for the benefit of native nongame conservation or management in 2025, the Muscogee (Creek) Nation approved a suite of regulatory measures in August 2025 (https://www.muscogeenation.com/wp-content/uploads/2025/11/Final-25-26-Conservation-Regulations.pdf). Specifically, the Creek Nation identified a classification of fishes as "native nongame", including buffalofishes and gars, established a 10-fish aggregate limit for NNG, and prohibited shoot and release bowfishing (Figure 8). Due to political uncertainties surrounding Tribal sovereignty and unclear inter-jurisdictional rights / responsibilities for enforcement of fish and game laws, the effectiveness and applicability of these Tribal rules to non-Tribal citizens deserves clarification. However, it is a positive sign to see that the Creek Nation followed our lead on implementation of these rules. While the aggregate limit and prohibition of shoot and release bowfishing are direct applications of our rule change proposals, the Nation went a step further by creating a distinct classification for native nongame fishes, setting them apart in value and management from nonnative invasive fishes (a key management objective articulated by Scarnecchia and Schooley (2020)). While other states have attempted to assign value to NNG fishes with different naming and classification techniques (e.g., Minnesota assignment of "native rough fishes"), no perfect solution has yet emerged. Native fish advocates have voiced opposition to the continued usage of the pejorative "rough" moniker, as it maintains the etymological implication that the group of fishes are of lesser value or status. At this time, based on Oklahoma's statutory nuances, we advise the continued promotion and use of the NNG descriptor. As relations between ODWC and the Tribes continue to politically evolve, we hope to build upon a mutual respect for Oklahoma's native fishes to manage this resource responsibly and in perpetuity. Further, we thank the Muscogee Creek Nation for taking these regulatory steps toward a vision of conservation for native nongame fishes.

Figure 8. Excerpts from Muscogee Creek Nation Wildlife Code assigning native nongame status to buffalofishes and gars, a native nongame aggregate bag limit of ten fish, and prohibiting shoot and release.

Muscogee Creek Nation

Title 23 – Wildlife Code
Conservation Regulations

[Revised August 30, 2025]

CHAPTER 3 FISHING REGULATIONS

Subchapter 1 <u>General Fishing Regulations</u>

Section 3–11 Game Fish Defined

A. The following shall be considered Game Fish:

1. Largemouth;
2. Spotted bass;
3. Black and white crappie;
4. Channel catfish, blue catfish, and flathead catfish.

B. Species not listed in Subsection A are Non-Game fish.

Section 3–12 Native Non-Game Fish

A. The following shall be considered Native Non-Game Fish:

1. Gars (including Alligator longnose, short-nose, and spotted);
2. Buffalo (including Smallmouth buffalo);

B. Aggregate daily bag limit (all native, nongame species combined) of ten (10) fish per person. The aggregate limit does not supersede any individual species limit.

Section 3–13 Non-Native Invasive Non-Game Fish

A. The following shall be considered Nonnative, invasive fish species:

1. Common carp;
2. Grass carp;
3. Bighead carp;
4. Silver carp; and
5. Black carp.

B. Non-Native Invasive non-game fish are excluded from the aggregate limit and may be taken without limit unless otherwise specified by the MCN Wildlife Regulations

Section 3–23 Methods of Taking Non-Game Fish

A. These methods are legal for taking nongame fish according to the following provisions unless restricted under special regulations.

B. Bow and Arrow (Bowfishing):

1. Bowfishing may be used to take nongame fish only, throughout the year in all waters unless restricted

2. Fish taken by bow and arrow shall not be released, shall count towards the daily bag limit, and any carcasses or remains shall be properly disposed of.

3. Persons taking fish by bow and arrow (bowfishing) shall be subject to an aggregate daily bag limit (all native, nongame species combined) of ten (10) fish per person.

4. The possession limit, in the field, for persons taking fish with bow and arrow (bowfishing) may not exceed the daily aggregate limit, regardless of the start and end times of the bowfishing activity.

a) Nonnative, invasive fish species (including common carp, grass carp, bighead carp, silver carp and black carp are excluded from the aggregate limit and may be taken without limit unless otherwise specified by the MCN Wildlife Regulations

5. Legal bowfishing is restricted to:

a) Any bow (including a crossbow);

b) Devices that permit a bow to be held mechanically at full or partial draw are permitted.

<u>Outreach, social media, and human dimensions:</u> ODWC continues to be a leader among agencies advocating for the appreciation of NNG fishes. November 2025 saw another successful installment of the popular #GarWeek on social media platforms (historically including "X" [formerly Twitter], Facebook, Instagram, TikTok, and BlueSky). As in previous years, the objective was to feature the nexus between gars and other NNG fishes that have low social value, but high conservation value. While statewide angler surveys have typically reflected low rankings for NNG fishes among the more popular game fishes and NNG fishes have been held in relatively low social regard among anglers (York et al. 2022), social media campaigns have been shown to be effective at fostering goodwill on behalf of our quirky native nongame fishes such as the gars when the messaging is delivered by the Department- a passionate and authoritative source.

Gar Week 2025 took place Nov. 3-9. ODWC worked closely with our partners at Gar Lab (https://solomondavid.net/) and other agencies to bring new content anchored by gars but including native nongame fish conservation and nonnative/invasive species awareness. ODWC alone had more than 1.3 million impressions across three social media platforms.

Gar Week merchandise included a new gar sticker, a limited release of the 2025 Gar Week sticker and four gar trading cards. When matched with federal funds, sales #GarWeek merchandise generated $4,188.

Social media platform-specific numbers:

<u>X/Twitter</u>	<u>TikTok</u>	<u>Instagram</u>
Impressions 788.6k	Views: 279k	Views: 238k
Engagements 34.6k	Engagements: 36,691	Reach: 63.2k
Replies 449	New Followers: 722	Engagements: 8.8k
Likes 19.9k		New Follows: 330

These efforts for Gar Week were entirely led and facilitated by ODWC Communication and Education Division. Closer integration and consultation with our Native Nongame program would be beneficial for all parties. Our participation on some level throughout 2026, either by collecting content on gars and NNG fishes, providing video testimonials, or simply advising behind the scenes would benefit our program's goals while perhaps enhancing the accuracy, relevance, and reach.

Management plan for nongame fishes: Our program and the Department would benefit from the development of a plan for the statewide management of these fishes. It is likely that there is significant overlap with the fundamental hypotheses and objectives featured in the Oklahoma Paddlefish Management Plan (Scarnecchia et al. 2013). Using the Paddlefish plan as a blueprint (simply substituting "native nongame fishes"), we reveal a meaningful outline for a future NNG management plan-

A Comprehensive Plan for the Management of Native Nongame Fishes in Oklahoma
Oklahoma Department of Wildlife Conservation (modified from Scarnecchia, et al. 2013)

Philosophy and fundamental hypotheses

1. Oklahoma's NNG fishes are irreplaceable species of historical, recreational, commercial, and aesthetic significance.
2. Maintaining natural habitat conditions and numbers of wild fish adequate to sustain natural reproduction, growth and survival are critical to the long-term survival of the species.
3. Benefits from NNG resources should accrue to the entire public, rather than to just a few individuals or groups.
4. Sustainable recreational harvest and non-harvest fishing opportunities are desirable at the level appropriate within the productive capacity of the stocks.
5. The management plan for harvest and habitat should lead to sustainability of the resource and be matched to the life history of the species.
6. High-quality data is critical to stock assessment and sustainable management; fish harvest should be a key source of necessary data.
7. Goals, objectives, and actions, including management regulations and monitoring, should be as uniform as practicable among the stocks but remain sensitive to stock-specific and location-specific fisheries constraints and conditions.
8. A thorough knowledge of the stock-recruitment relationship and factors affecting year class strength should be high priorities for stock assessment.
9. The plan for Oklahoma NNG stocks and harvest management units need not be consistent with, but should not be detrimental to, broader (regional or national) NNG conservation and management goals and activities. The plan should strive for consistency with other in-state and regional fisheries management plans.
10. Evaluation, regulation, enforcement, information, and education are keys to the success of the plan and should be assessed annually for effectiveness.

Goals for NNG management in Oklahoma

1. Provide a basis for cooperative, coordinated management of Oklahoma NNG fishes in consultation with the appropriate federal agencies and Native American Tribes.
2. Provide for an orderly, equitable, and sustainable recreational fishery for NNG fishes and a harvest consistent with the productive capacity of the stocks. This goal should include similar regulations between in-state harvest areas and between states, to the extent possible.
3. Develop and maintain a standardized database for stock assessment and yield forecasting.
4. Maintain and enhance existing NNG fish habitat and obtain additional information to better define and provide for NNG habitat requirements.
5. Conduct research necessary for successful long-term management.

6. Integrate and define the role of artificial propagation and stocking in the successful long-term management.
7. Increase public awareness of NNG fishes and their habitat requirements.
8. Incorporate public acceptance and compliance with the regulatory framework established for long-term management.

LITERATURE CITED

Andrews, A. H., D. J. Daugherty, M. Wertnik, C. Welte, N. G. Smith, D. L. Buckmeier, and D. Riecke. 2024. Alligator gar as a centenarian species: extending lifespan estimates using bomb radiocarbon and laser ablation–accelerator mass spectrometry. Marine and Freshwater Research 75(8):MF24024.

Belpaire, C., P. Hodson, F. Pierron, and M. Freese. 2019. Impact of chemical pollution on Atlantic eels: Facts, research needs, and implications for management. Current Opinion in Environmental Science & Health 11:26–36.

von Bertalanffy, L. 1938. A Quantitative Theory of Organic Growth (Inquiries on Growth Laws. II). Human Biology 10(2):181–213.

Bohen, R. 2025. Bigmouth and Smallmouth Buffalo in Wisconsin: Population Characteristics and Contributions to Bowfishing Harvest. University of Wisconsin, Stevens Point, Wisconsin.

Bryant, D. 2024. Age, Growth, and Reproductive Biology of Buffalofishes (Ictiobus spp.) in the lower Red River catchment. Auburn University, Auburn, Alabama.

Buckmeier, D. L., N. G. Smith, and D. J. Daugherty. 2013. Alligator Gar Movement and Macrohabitat Use in the Lower Trinity River, Texas. Transactions of the American Fisheries Society 142(4):1025–1035.

Carlson, T. 2022. Population Dynamics and Seasonal Movements of Blue Suckers (Cycleptus elongatus) in the James River, South Dakota. University of South Dakota, Vermillion, South Dakota.

Cook, M. F., T. J. Goeman, P. J. Radomski, J. A. Younk, and P. C. Jacobson. 2001. Creel Limits in Minnesota: A Proposal for Change. Fisheries 26(5):19–26.

Côté, C. L., P. Gagnaire, V. Bourret, G. Verreault, M. Castonguay, and L. Bernatchez. 2013. Population genetics of the American eel (Anguilla rostrata): FST = 0 and North Atlantic Oscillation effects on demographic fluctuations of a panmictic species. Molecular Ecology 22(7):1763–1776.

Daugherty, D. J., A. H. Andrews, and N. G. Smith. 2020. Otolith-Based Age Estimates of Alligator Gar Assessed Using Bomb Radiocarbon Dating to Greater than 60 Years. North American Journal of Fisheries Management 40(3):613–621.

Davis-Foust, S. L., R. M. Bruch, S. E. Campana, R. P. Olynyk, and J. Janssen. 2009. Age Validation of Freshwater Drum using Bomb Radiocarbon. Transactions of the American Fisheries Society 138(2):385–396.

DiBenedetto, K. C. 2009. Life history characteristics of Alligator Gar, Atractosteus spatula, in the Bayou Dularge area of southcentral Louisiana. Louisiana State University.

Eddy, S., and J. C. Underhill. 1978. How to Know the Freshwater Fishes, 3rd edition. WCB/McGraw-Hill, Boston, Massachusetts.

Evans, G. B. 1971. The upland shooting life1st ed. Knopf, New York.

Flowers, H. J., H. Drouineau, and R. Leaf. 2023. American Eel Benchmark Stock Assessment and Peer Review Report. Page 341. Atlantic States Marine Fisheries Commission.

Fox, A. C. 1975. Effects of traditional harvest regulations on bass populations and fishing. Pages 393–398 *in* R. H. Stroud and H. Clepper, editors. Black Bass biology and management. Sport Fishing Institute, Washington, D.C.

Fries, L. T., D. J. Williams, and S. K. Johnson. 1996. Notes: Occurrence of *Anguillicola crassus* , an Exotic Parasitic Swim Bladder Nematode of Eels, in the Southeastern United States. Transactions of the American Fisheries Society 125(5):794–797.

Hubbs, C., R. J. Edwards, and G. P. Garrett. 2008. An Annotated Checklist of the Freshwater Fishes of Texas, with Keys to Identification of Species, 2nd edition. Texas Academy of Science.

ICES and WGAMEEL. 2023. Working Group on American Eel (WGAMEEL; outputs from 2022 meeting). Page 3165773 Bytes. ICES Scientific Reports.

Jelks, H. L., S. J. Walsh, N. M. Burkhead, S. Contreras-Balderas, E. Diaz-Pardo, D. A. Hendrickson, J. Lyons, N. E. Mandrak, F. McCormick, J. S. Nelson, S. P. Platania, B. A. Porter, C. B. Renaud, J. J. Schmitter-Soto, E. B. Taylor, and M. L. Warren. 2008. Conservation Status of Imperiled North American Freshwater and Diadromous Fishes. Fisheries 33(8):372–407.

Knights, B. 2003. A review of the possible impacts of long-term oceanic and climate changes and fishing mortality on recruitment of anguillid eels of the Northern Hemisphere. Science of The Total Environment 310(1–3):237–244.

Lackmann, A. R., A. H. Andrews, M. G. Butler, E. S. Bielak-Lackmann, and M. E. Clark. 2019. Bigmouth Buffalo Ictiobus cyprinellus sets freshwater teleost record as improved age analysis reveals centenarian longevity. Communications Biology 2(1):197.

Lackmann, A. R., E. S. Bielak-Lackmann, M. G. Butler, and M. E. Clark. 2022a. Otoliths suggest lifespans more than 30 years for free-living bowfin *Amia calva*: Implications for fisheries management in the bowfishing era. Journal of Fish Biology 101(5):1301–1311.

Lackmann, A. R., E. S. Bielak-Lackmann, R. I. Jacobson, A. H. Andrews, M. G. Butler, and M. E. Clark. 2023a. Harvest trends, growth and longevity, and population dynamics reveal traditional assumptions for redhorse (*Moxostoma* spp.) management in Minnesota are not supported. Environmental Biology of Fishes.

Lackmann, A. R., E. S. Bielak-Lackmann, R. I. Jacobson, M. G. Butler, and M. E. Clark. 2022b. Otolith allometry informs age and growth of long-lived Quillback Carpiodes cyprinus. Environmental Biology of Fishes 105(8):1051–1064.

Lackmann, A. R., S. A. Black, E. S. Bielak-Lackmann, and J. A. Lackmann. 2023b. Centenarian lifespans of three freshwater fish species in Arizona reveal the exceptional longevity of the buffalofishes (Ictiobus). Scientific Reports 13(1):17401.

Lackmann, A. R., S. A. Black, E. S. Bielak-Lackmann, and J. A. Lackmann. 2023c. Centenarian lifespans of three freshwater fish species in Arizona reveal the exceptional longevity of the buffalofishes (Ictiobus). Scientific Reports 13(1):17401.

Lackmann, A. R., J. Lyons, K. A. Kuber, T. P. Parks, D. L. Walchak, E. S. Bielak-Lackmann, C. R. Vaughan, S. D. Robertson, J. D. Woodling, and M. E. Clark. 2025. Otolith Age Analysis Reveals Lifespans Greater Than 50 Years for the Three Species of Carpsucker (*Carpiodes* spp.) in Wisconsin. Aquaculture, Fish and Fisheries 5(6):e70136.

Lackmann, A. R., J. Sereda, M. Pollock, R. Bryshun, M. Chupik, K. McCallum, J. Villeneuve, E. S. Bielak-Lackmann, and M. E. Clark. 2023d. Bet-hedging bigmouth buffalo (*Ictiobus cyprinellus*) recruit episodically over a 127-year timeframe in Saskatchewan. Canadian Journal of Fisheries and Aquatic Sciences 80(2):313–329.

Long, J. M., R. A. Snow, D. E. Shoup, and J. B. Bartnicki. 2023. Validation and Comparison of Age Estimates for Smallmouth Buffalo in Oklahoma Based on Otoliths, Pectoral Fin Rays, and Opercula. North American Journal of Fisheries Management 43(3):618–627.

Maxson, K. A., L. E. Solomon, T. A. Bookout, S. A. DeLain, A. D. Bartels, M. C. Bowler, E. J. Gittinger, E. N. Ratcliff, J. L. West, S. A. Love, J. A. DeBoer, A. L. Whitten-Harris, M. J. Spear, B. S. Ickes, A. F. Casper, and J. T. Lamer. 2024. Smallmouth buffalo (Ictiobus bubalus Rafinesque) population trends and demographics in the Upper Mississippi River System. Environmental Biology of Fishes 107(12):1625–1649.

Maxwell, R., and S. Kinney. 2021. Final Report Louisiana State Wildlife Grant (F18AF00021) Collection and Analysis of American Eels (Anguilla rostrata) in Louisiana. Page 17. Louisiana Department of Wildlife and Fisheries, Baton Rouge.

McGrath, P. E., E. J. Hilton, and J. A. Musick. 2016. Population Demographics of Longnose Gar, *Lepisosteus osseus,* from the Tidal Rivers of Virginia. Copeia 104(3):738–745.

Mensinger, G. C. 1971. Oklahoma Commercial Fisheries Harvest Summary 1961-1969. Proceedings of the Oklahoma Academy of Sciences 51:23–28.

Miller, M. J., E. Feunteun, and K. Tsukamoto. 2016. Did a “perfect storm” of oceanic changes and continental anthropogenic impacts cause northern hemisphere anguillid recruitment reductions? ICES Journal of Marine Science 73(1):43–56.

Miranda, L. E., and P. W. Bettoli. 2007. Mortality. Pages 229–277 *in* C. S. Guy and M. L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda, Maryland.

Montague, G. F., J. D. Schooley, D. L. Scarnecchia, and R. A. Snow. 2023. Bowfishing shoot and release: High short-term mortality of nongame fishes and its management implications. North American Journal of Fisheries Management 43(4):962–983.

Montague, G. F., D. L. Zentner, R. A. Snow, J. B. Bartnicki, D. E. Shoup, and B. A. Schmidt. 2024. Commercial harvest and population characteristics of freshwater drum and buffalo Ictiobus spp. in Ohio waters of Lake Erie. Environmental Biology of Fishes 107(12):1653–1673.

ODWC. 2016. Oklahoma Comprehensive Wildlife Conservation Strategy: A Strategic Conservation Plan for Oklahoma's Rare and Declining Wildlife. Page 422. Oklahoma Department of Wildlife Conservation, Oklahoma City.

Patton, T., and C. Lyday. 2008. Ecological Succession and Fragmentation in a Reservoir: Effects of Sedimentation on Habitats and Fish Communities. Pages 147–167 *in* M. S. Allen, S. Sammons, and M. J. Maceina, editors. Balancing Fisheries Management and Water Uses for Impounded River Systems. American Fisheries Society, Symposium 62, Bethesda, Maryland.

Phillips, G. L., and J. C. Underhill. 1971. Distribution and Variation of the Catostomidae of Minnesota. Occasional Papers of the Bell Museum of Natural History 10:1–45.

Pike, C., J. Casselman, V. Crook, M. B. DeLucia, D. Jacoby, and M. Gollock. 2020, November 8. Anguilla rostrata. The IUCN Red List of Threatened Species 2023: e.T191108A129638652.

Pratt, T. C., L. M. O'Connor, J. A. Stacey, D. R. Stanley, A. Mathers, L. E. Johnson, S. M. Reid, G. Verreault, and J. Pearce. 2019. Pattern of Anguillicoloides crassus infestation in the St. Lawrence River watershed. Journal of Great Lakes Research 45(5):991–997.

Radford, D. S., A. R. Lackmann, C. J. Moody-Carpenter, and R. E. Colombo. 2021. Comparison of Four Hard Structures Including Otoliths for Estimating Age in Blue Suckers. Transactions of the American Fisheries Society 150(4):514–527.

Reid, S. M. 2009. Age, growth and mortality of black redhorse (*Moxostoma duquesnei*) and shorthead redhorse (*M. macrolepidotum*) in the Grand River, Ontario. Journal of Applied Ichthyology 25(2):178–183.

Rypel, A. L., P. Saffarinia, C. C. Vaughn, L. Nesper, K. O'Reilly, C. A. Parisek, M. L. Miller, P. B. Moyle, N. A. Fangue, M. Bell-Tilcock, D. Ayers, and S. R. David. 2021. Goodbye to "Rough Fish": Paradigm Shift in the Conservation of Native Fishes. Fisheries 46(12):605–616.

Scarnecchia, D. L. 1992. A Reappraisal of Gars and Bowfins in Fishery Management. Fisheries 17(5):6–12.

Scarnecchia, D. L., B. D. Gordon, J. D. Schooley, and A. A. Nealis. 2013. A Comprehensive Plan for the Management of Paddlefish in Oklahoma. Oklahoma Department of Wildlife Conservation, Oklahoma City.

Scarnecchia, D. L., and J. D. Schooley. 2020. Bowfishing in the United States: History, Status, Ecological Impact, and a Need for Management. Transactions of the Kansas Academy of Science 123(3–4).

Scarnecchia, D. L., and J. D. Schooley. 2022. Trophies, Technology, and Timescape in Fisheries Management, as Exemplified through Oklahoma's World Record Paddlefish *Polyodon spathula*. Fisheries 47(9):381–394.

Scarnecchia, D. L., J. D. Schooley, K. M. Backes, A. Slominski, S. Dalbey, and Y. Lim. 2019. Paddlefish Life History: Advances and Applications in Design of Harvest Management Regulations. Pages 1–27 *in* J. D. Schooley and D. L. Scarnecchia, editors. Paddlefish: Ecological, Aquacultural, and Regulatory Challenges of Managing a Global Resource. American Fisheries Society, Bethesda, Maryland.

Scarnecchia, D. L., J. D. Schooley, A. R. Lackmann, S. J. Rider, D. K. Riecke, J. McMullen, J. E. Ganus, K. D. Steffensen, N. W. Kramer, and Z. R. Shattuck. 2021. The Sport Fish Restoration Program as a Funding Source to Manage and Monitor Bowfishing and Monitor Inland Commercial Fisheries. Fisheries 46(12):595–604.

Shepard, S. L. 2015. American Eel Biological Species Report. Page xii+121. US Fish and Wildlife Service, Region 5, Hadley, Massachusetts.

Smith, N. G., D. L. Buckmeier, D. J. Daugherty, D. L. Bennett, P. C. Sakaris, and C. R. Robertson. 2020. Hydrologic Correlates of Reproductive Success in the Alligator Gar. North American Journal of Fisheries Management 40(3):595–606.

Snow, R. A., M. J. Porta, and D. M. Bogner. 2020. Examination of the Current Oklahoma State Record Smallmouth Buffalo. Proc. Okla. Acad. Sci. 100:16–21.

Stuart, M., N. Kludt, M. A. Pegg, F. Montesanto, C. Lyon, and C. J. Chance-Ossowski. 2024. Dynamic rates of Freshwater Drum near the northern extent of their range: evidence of environment-recruitment relationships. Environmental Biology of Fishes 107(12):1691–1708.

Turner, S. M., B. C. Chase, and M. S. Bednarski. 2018. Evaluating the Effect of Dam Removals on Yellow-Phase American Eel Abundance in a Northeastern U.S. Watershed. North American Journal of Fisheries Management 38(2):424–431.

Ulmo-Diaz, G., A. Engman, W. O. McLarney, C. A. Lasso Alcalá, D. Hendrickson, E. Bezault, E. Feunteun, F. L. Prats-Léon, J. Wiener, R. Maxwell, R. S. Mohammed, T. J. Kwak, J. Benchetrit, B. Bougas, C. Babin, E. Normandeau, H. H. V. Djambazian, S. Chen, S. J. Reiling, J. Ragoussis, and L. Bernatchez. 2023. Panmixia in the American eel extends to its tropical range of distribution: Biological implications and policymaking challenges. Evolutionary Applications 16(12):1872–1888.

Warren, M. L., B. M. Burr, S. J. Walsh, H. L. Bart, R. C. Cashner, D. A. Etnier, B. J. Freeman, B. R. Kuhajda, R. L. Mayden, H. W. Robison, S. T. Ross, and W. C. Starnes. 2000. Diversity, Distribution, and Conservation Status of the Native Freshwater Fishes of the Southern United States. Fisheries 25(10):7–31.

Wellman, T., E. Martin, and A. L. Benson. 2022. Species of Greatest Conservation Need National Database 2005-2022. U.S. Geological Survey.

Woodling, J. D., A. Treble, M. M. Brandt, and A. R. Lackmann. 2024. Otolith analysis reveals long-lived population demographics of quillback Carpiodes cyprinus and river carpsucker C. carpio in Colorado. Environmental Biology of Fishes 107(12):1609–1623.

York, B., J. D. Schooley, and D. L. Scarnecchia. 2022. Oklahoma Bowfishing Values and Perspectives toward Nongame Fishes and Their Management. North American Journal of Fisheries Management 42(4):1020–1040.

Zentner, D. L., J. D. Schooley, R. A. Snow, and TBD. in press. Lab based estimates of long-term bowfishing shoot-and-release mortality with comparisons to prior work and considerations for future bowfishing research and management.

Zentner, D., D. Shoup, and S. K. Brewer. 2023. Effects of sucker gigging on fish populations in Oklahoma scenic rivers. U.S. Fish and Wildlife Service, Cooperator Science Series.

Appendix A. Regulatory Summary for Select Nongame Fishes

Daily bag limits for select nongame fishes in select states.

Species of Greatest Conservation Need (SGCN) are shaded in orange. Aggregate bag limits are shaded in green. The designation *NA* is used when a species is not found in a state (according to the species distribution map) and any uncertainties are noted with a question mark (?).

Native Nongame Species	OK	TX	MO	AR	NM	NE	CO	LA	AL	MS	IA	IL	TN	OH	WI	MN	VA	KS	Dist. MAP
Alligator Gar	1	1	20	1	NA	NA	NA	unlim	1	2	NA	1	0	0	NA	NA	NA	?	LINK
Longnose Gar	unlim	unlim	20	unlim	unlim	unlim	NA	unlim	unlim	unlim	unlim	unlim	unlim	?	unlim	10	1 or 5	unlim	LINK
Shortnose Gar	unlim	unlim	20	unlim	unlim	unlim	NA	unlim	unlim	unlim	unlim	unlim	unlim	0	unlim	10	?	unlim	LINK
Spotted Gar	unlim	unlim	20	unlim	unlim	unlim	NA	unlim	unlim	unlim	unlim	unlim	unlim	0	unlim	10	?	unlim	LINK
Bigmouth Buffalo	unlim	unlim	20	unlim	unlim	unlim	NA	25	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	exotic	unlim	LINK
Smallmouth Buffalo	unlim	unlim	20	unlim	unlim	unlim	NA	25	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	exotic	unlim	LINK
Black Buffalo	1	unlim	20	unlim	unlim	unlim	NA	25	unlim	unlim	unlim	unlim	unlim	unlim	0	unlim	exotic	unlim	LINK
River Carpsucker	unlim	unlim	20	unlim	unlim	unlim	NA	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	20	unlim	LINK
Quillback	unlim	unlim	20	unlim	unlim	unlim	NA	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	20	unlim	LINK
Highfin Carpsucker	unlim	unlim	20	unlim	unlim	unlim	NA	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	20	unlim	LINK
Freshwater Drum	unlim	unlim	20	unlim	unlim	unlim	NA	25	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	20	unlim	LINK
Paddlefish	1	0	2	2	NA	2	NA	2	0	2	2	2	2		0	0	NA	2	LINK
Bowfin	unlim	unlim	20	unlim	unlim	0	NA	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	unlim	1 or 5	?	LINK
Links to Regs:	LINK	LINK	LINK	LINK		LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	

Appendix B. Ecosystem services of Oklahoma's Nongame Fishes – Mussel Hosts

Oklahoma's native nongame fishes are host to many freshwater mussels, some of which are imperiled (red shading indicates endangered and yellow shading indicates threatened). The right three columns contain mussel species hosted by taxonomic grouping of similar species (gars, buffalofishes, and carpsuckers).

Data are summarized from the Illinois Natural History Mussel database
https://fms19.naturalhistorysurvey.org/fmi/webd/Freshwater%20Mussel%20Host%20Database
Imperiled status of mussels is derived from US Fish and Wildlife species status listings https://ecos.fws.gov/ecp/report/species-listings-by-tax-group?statusCategory=Listed&groupName=Clams&total=120

Mussel Common Name	Longnose Gar	Shortnose Gar	Spotted Gar	Alligator Gar	Florida Gar	Bigmouth Buffalo	Smallmouth Buffalo	Black Buffalo	Freshwater Drum	Bowfin	River Carpsucker	Quillback	Highfin Carpsucker	Shorthead Redhorse	Robust Redhorse	Silver Redhorse	Jumprock	Golden Redhorse	River Redhorse	White Sucker	Spotted Sucker	Gars	Buffalofishes	Carpsuckers
Alewife Floater																				1		0	0	0
Altamaha Arcmussel															1		1				1	0	0	0
Altamaha Lance															1							0	0	0
Altamaha Spinymussel																					1	0	0	0
Arkansas Brokenray																				1		0	0	0
Arkansas Fatmucket									1													0	0	0
Atlantic Pigtoe																	1					0	0	0
Black Sandshell									1													0	0	0
Bleufer									1													0	0	0
Butterfly									1													0	0	0
California Floater																				1		0	0	0
Clubshell																		1				0	0	0
Creek Heelsplitter		1				1				1										1		1	1	0
Cylindrical Papershell																				1		0	0	0
Deertoe									1													0	0	0
Eastern Floater																				1		0	0	0
Ebonyshell									1													0	0	0
Elktoe							1				1	1		1		1		1		1		0	1	2
Fat Pocketbook									1													0	0	0
Fatmucket					1													1		1		1	0	0
Fawnsfoot									1													0	0	0
Florida Sandshell					1																	1	0	0
Florida Spike					1																	1	0	0
Flutedshell	1					1			1	1		1		1		1			1	1		1	1	1
Fragile Papershell									1													0	0	0
Giant Floater	1								1		1									1		1	0	1
Higgins Eye									1													0	0	0
Inflated Heelsplitter									1													0	0	0
Neosho Mucket									1													0	0	0
Northern Riffleshell										1		1										0	0	1
Ohio Pigtoe																				1		0	0	0
Pink Heelsplitter									1													0	0	0
Pink Mucket									1													0	0	0
Pink Papershell									1													0	0	0
Plain Pocketbook									1													0	0	0
Pondmussel						1				1												0	1	0
Purple Bankclimber															1						1	0	0	0
Rabbitsfoot																		1				0	0	0
Rock Pocketbook							1		1			1		1						1		0	1	1
Round Pearlshell			1																			1	0	0
Round Pigtoe									1													0	0	0
Rough Fatmucket																						0	0	0
Scaleshell									1													0	0	0
Slippershell																						0	0	0
Southern Creekmussel																						0	0	0
Southern Kidneyshell																					1	0	0	0
Southern Pocketbook																						0	0	0
Southern Rainbow																						0	0	0
Spectaclecase														1								0	0	0
Threehorn Wartyback									1													0	0	0
Threeridge		1							1									1				1	0	0
Wabash Pigtoe																1						0	0	0
Washboard	1								1	1			1									1	0	1
Western Pearlshell																				1		0	0	0
White Heelsplitter	1																		1	1		1	0	0
Yellow Sandshell	1	1		1																		3	0	0
Totals	5	3	1	1	3	3	2	0	24	5	2	4	1	4	3	3	2	5	2	14	4	13	5	7

Appendix C. Memorandum from PNNG Program on American Eel SGCN Status

March 5, 2025
Justification for extending SGCN status for American Eel *Anguilla rostrata* in Oklahoma
Prepared by J.D. Schooley, Senior Fisheries Biologist, on behalf of the ODWC Paddlefish and Native Nongame Program

Background: in response to a March 3, 2025, email from the ODWC Wildlife Diversity Program seeking feedback on status updates for Species of Greatest Conservation Need (SGCN) in Oklahoma's State Wildlife Action Plan, our program began compiling current status information on American Eel to determine whether the proposed removal of the species from SGCN status in Oklahoma was warranted. This memo highlights our findings.

As of 2016, American Eel was classified as a Species of Greatest Conservation Need (SGCN) in the Oklahoma Comprehensive Wildlife Conservation Strategy (ODWC 2016) with the following justification:

Ranking Criterion #	Description	Points Awarded
1	National Heritage Global Rank	2 (species has a Global Heritage Rank of G4, "apparently secure" natureserve.org)
2	Availability of other Federal Assistance Funding Sources	1 (Species is eligible for management funding as a sport fish)
3	Percent of population size or geographic range within Oklahoma	1 (Oklahoma encompasses <5% of the species range or population)
4	Trend in population size or geographic range over the past 50 years	3 (Species has experienced a well-documented and substantial population and/or range decline)
5	Length of annual residency in Oklahoma	2 (Species is an annual resident that does not breed in Oklahoma, but individuals may be present in the state for four months or more out of the year; or the species' continued existence in the state is uncertain and has not been well-documented during the past 50 years)
	Total Points	9
	Tier	III (6-10 total pts)
	SGCN Selection Criteria	4 (Species that have been identified as conservation priorities through a national, peer-reviewed status assessment, or assessment of a large taxonomic division. Examples of these include: assessments of freshwater fish, freshwater mussels and crayfish prepared by the American Fisheries Society...)

Further, the Comprehensive Strategy (ODWC 2016) notes that in Oklahoma, American Eel is "rare and occurs at low density in the Red and Arkansas rivers; spawns in the Atlantic Ocean but juveniles migrate to inland rivers to develop into adults; upstream movement limited by navigation system dams" with a trend in population size as "unknown" (p. 41).

Proposed removal of American Eel from SGCN status in 2025 is based on the species not being listed in the most recent, authoritative list of freshwater and diadromous fishes in need of conservation, as published by the American Fisheries Society Endangered Species Committee (Jelks et al. 2008). An earlier effort by The Southeastern Fishes Council Technical Advisory Committee listed American Eel as "Currently Stable" and present in all 51 southeastern watersheds considered in the literature, including portions of the Arkansas and Red rivers in Oklahoma (Warren et al. 2000). The US Fish and Wildlife Service reviewed the status of American Eel in 2007 and again in 2015, finding that, "...available scientific and commercial information indicates that despite a population reduction over the past century, American eels are widely distributed throughout a large part of their historical range” (p. 93), adding that the species-wide status is stable (Shepard 2015). Based on these limited and quasi-authoritative lists of which species are or are not imperiled in the United States, plus the Shepard (2015) report, it would seem justified that American Eel is a lower conservation priority. However, more recent findings and a general scientific consensus among eel experts would indicate that the conservation status of American Eel is more dire, and the species is worthy of SGCN status in Oklahoma and regionally.

Why should American Eel remain on the Oklahoma SGCN list?

1. Species status, though stable, is at historic lows and considered depleted or imperiled by multiple sources. Data from fisheries for American Eels are aggregated and summarized by the Atlantic States Marine Fishery Commission (https://asmfc.org/species/american-eel/), who lists the species’ population abundance as depleted, per their 2023 stock assessment (Flowers et al. 2023). The assessment further describes recruitment to have decreased with potential recruitment overfishing. The species status has been impacted by “combination of historical overfishing, habitat loss due to damming mainstems and tributaries of rivers, mortality from passing through hydroelectric turbines, pollution, possibly parasites and disease, climate change, and other unexplained factors at sea” (p. 17). Other research suggests that the combination and simultaneous timing of a suite of anthropogenic and biotic factors may be responsible for large declines in species abundance and/or recruitment due to food web shifts in the ocean environment (Knights 2003; Miller et al. 2016). American Eel is listed as “Endangered A2bd” with a population trend of stable based on an assessment in 2020 for the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List (Pike et al. 2020). A recent report from the International Council for the Exploration of the Sea (ICES) Working Group on American Eel (WGAMEEL) which reviewed the published literature on the species in the US and Canada concluded that the evidence indicated a decline in abundance but also noted data inadequacies in Gulf Slope drainages (ICES and WGAMEEL 2023). However, the report highlights extensive work on American Eels in Oklahoma’s neighboring states of Arkansas, Louisiana, and Texas. Lastly, the Convention on International Trade of Endangered Species (CITES) is currently reviewing the state of American Eel status and international trade for consideration as listing them among other regulated species.
2. Genetic characterization of American Eels reflects a single, large, panmictic stock, although the effective population size is small. A recent genetic study including American Eel specimens from Louisiana and Texas indicated that although there is no spatially-distinct population genetic structure of the panmictic stock, this does not altogether mitigate concerns for depletion at the fringe of the species range where a presumptive resupply of eels spawned elsewhere will migrate upstream (Ulmo-Diaz et al. 2023). There is some evidence that phenotype, life history, and behavior of the species vary over a gradient of both latitude and habitats, however the mechanisms for how the species adapts to local conditions and whether or not these adaptations are heritable is poorly understood. Though coastal harvests of glass eels is on the scale of millions of individuals, genetic evidence indicates that the presumed large, panmictic stock has an effective population size several orders of magnitude smaller. Côté, et al. (2013) estimated that the American Eel population had an effective population size (Ne) of 10,532 (95% CI 9,312-11,752), which is diminutively tiny considering the massive scale of their native range across freshwater, coastal, and marine habitats.
3. Recent evidence indicates that American Eels may be long-lived and experience episodic recruitment. Longevity information for American Eel is inconsistent across studies, with some reporting maximum age of 40 years (https://www.fws.gov/species/american-eel-anguilla-rostrata) with reproductive maturity reached at approximately 25, while others report a shorter lifespan and earlier maturity. A Canadian website summary on the species noted an individual captive eel that lived to 88 years, but there is no attribution for this detail (https://www.dfo-mpo.gc.ca/species-especes/publications/sara-lep/eel-anguille/index-eng.html). Maxwell and Kinney (2021) found a maximum age of 16 among 301 fish examined in Louisiana. In a genetic sample of >2,000 eels from 32 locations, Côté, et al. (2013) found there to be only 12 cohorts represented, each with parental contributions (effective breeding population, Nb) ranging 473-10,999. These findings,

taken with other knowledge of eel life history, seem to indicate that only a small fraction of the extant adults of the species are potentially reproducing each year.

4. Populations are vulnerable to both freshwater and marine stressors such as pollution, dams, and climate change. Given the distances traveled and the myriad of habitats encountered in the migratory life history of American Eel, an accumulation of potential stressors exist, each accruing potential impacts on movement, foraging, growth, development, and other factors. As benthic predators in freshwater ecosystems, American Eels are prone to accumulate or biomagnify organic pollutants, but the impacts on their life history or reproduction are not understood (Belpaire et al. 2019). The negative impacts of high dams on migratory fishes has been well-documented for decades, with a general consensus that dams block migrations and fragment populations. A study on dam removal in the Northeastern United States indicated that catch rates of American Eels increased as a result of dam removals, which improved passage for the species (Turner et al. 2018). A study in Florida on glass eel catch rates indicated a temporal shift in recruitment (i.e., 15 days earlier) over the 21-year study period, presumably due to the impacts of rising global ocean temperatures (E. Johnson, Florida Fish and Wildlife Conservation Commission, unpublished data).
5. American Eels are afflicted by a harmful invasive nematode parasite in their air bladder; the consequences of which are not fully understood. In 1995, *Anguillicola crassus*, a parasitic swim bladder nematode from Asia was found in captive-reared American Eels in Texas and in a wild American Eel in South Carolina in 1996 (Fries et al. 1996), though the parasite has now been commonly detected throughout the range in United States freshwater habitats. A recent study in Louisiana found the parasite in 33% of 315 eels examined and infection rates varied across sampling locations (Maxwell and Kinney 2021). A similar infection rate (~30%) was observed in the St. Lawrence River in Canada (Pratt et al. 2019). The consequences of air bladder infection by this parasite are not fully understood, but are presumed to be negative for the individual infected. Degradation of the air bladder results in impaired buoyancy regulation, which can reduce foraging and swimming efficiency. The latter would be particularly troublesome when the infected individual out-migrates from shallow freshwater into the deeper ocean enroute to spawn. Population impacts would likely be realized if infected individuals experienced higher mortality prior to reproduction.
6. Regional / inter-jurisdictional coordination of conservation efforts will be harmed through declassification in Oklahoma. In Oklahoma's neighboring states of Arkansas, Kansas, Louisiana, Missouri, and Texas, American Eel maintains SGCN status (Wellman et al. 2022) and is known as a Regional Species of Greatest Conservation Need (https://www.nwf.org/Our-Work/Wildlife-Conservation/southeast-regional-priority-species). Migratory fishes benefit from the coordinated conservation status and consistent management frameworks along their migratory pathways. Though no official interjurisdictional coordination group exists for American Eels in the Gulf Slope drainage, this model is effectively demonstrated by the presence and influence of the Mississippi Interstate Cooperative Resource Association (MICRA, micrarivers.org), which includes a collaborative network of state agencies for the management of Paddlefish, sturgeons, invasive carps, and other fishes within the Mississippi River watershed. Removing American Eel from SGCN status by Oklahoma would set us apart from neighboring states, effectively providing a conflict in conservation of the species across jurisdictional boundaries.
7. There are many known unknowns, yet SGCN status offers opportunities. Though there have been large advances in knowledge on American Eel biology, population genetics, stock abundance, etc. since the USFWS determined the species was not imperiled (Shepard 2015), there remains a high level of uncertainty about the species and its future. Though many states are decommissioning dams due to the barriers they create for migratory fishes, Oklahoma does not appear to be trending towards such ecological enlightenment. Recent renovation of the Zink Dam on the Arkansas River in Tulsa paired with the potential for one or more low head dams nearby has increased concerns for the impacts of these structures on an already diminished stretch of prairie river which comprises the native range of numerous migratory fishes. Future relicensing of hydroelectric dams by the Federal Energy Regulatory Commission (FERC) and the potential applicability or development of fish passage structures in Oklahoma should consider impacts to all migratory species. In addition, the ever-growing thirst of urban sprawl for municipal water remains a consistent threat to rivers and streams across Oklahoma. Construction of new

reservoirs or dams will only serve to further truncate the accessible habitat for migratory fishes in the Arkansas and Red river basins. Removing SGCN status from one or more species which may be impacted by such habitat losses would seem to be foolish, given the high level of uncertainty, especially weighed against the nonexistent gains from downgrading the protected status.

Literature Cited

Andrews, A. H., D. J. Daugherty, M. Wertnik, C. Welte, N. G. Smith, D. L. Buckmeier, and D. Riecke. 2024. Alligator gar as a centenarian species: extending lifespan estimates using bomb radiocarbon and laser ablation–accelerator mass spectrometry. Marine and Freshwater Research 75(8):MF24024.

Belpaire, C., P. Hodson, F. Pierron, and M. Freese. 2019. Impact of chemical pollution on Atlantic eels: Facts, research needs, and implications for management. Current Opinion in Environmental Science & Health 11:26–36.

von Bertalanffy, L. 1938. A Quantitative Theory of Organic Growth (Inquiries on Growth Laws. II). Human Biology 10(2):181–213.

Bohen, R. 2025. Bigmouth and Smallmouth Buffalo in Wisconsin: Population Characteristics and Contributions to Bowfishing Harvest. University of Wisconsin, Stevens Point, Wisconsin.

Bryant, D. 2024. Age, Growth, and Reproductive Biology of Buffalofishes (Ictiobus spp.) in the lower Red River catchment. Auburn University, Auburn, Alabama.

Buckmeier, D. L., N. G. Smith, and D. J. Daugherty. 2013. Alligator Gar Movement and Macrohabitat Use in the Lower Trinity River, Texas. Transactions of the American Fisheries Society 142(4):1025–1035.

Carlson, T. 2022. Population Dynamics and Seasonal Movements of Blue Suckers (Cycleptus elongatus) in the James River, South Dakota. University of South Dakota, Vermillion, South Dakota.

Cook, M. F., T. J. Goeman, P. J. Radomski, J. A. Younk, and P. C. Jacobson. 2001. Creel Limits in Minnesota: A Proposal for Change. Fisheries 26(5):19–26.

Côté, C. L., P. Gagnaire, V. Bourret, G. Verreault, M. Castonguay, and L. Bernatchez. 2013. Population genetics of the American eel (Anguilla rostrata): FST = 0 and North Atlantic Oscillation effects on demographic fluctuations of a panmictic species. Molecular Ecology 22(7):1763–1776.

Daugherty, D. J., A. H. Andrews, and N. G. Smith. 2020. Otolith-Based Age Estimates of Alligator Gar Assessed Using Bomb Radiocarbon Dating to Greater than 60 Years. North American Journal of Fisheries Management 40(3):613–621.

Davis-Foust, S. L., R. M. Bruch, S. E. Campana, R. P. Olynyk, and J. Janssen. 2009. Age Validation of Freshwater Drum using Bomb Radiocarbon. Transactions of the American Fisheries Society 138(2):385–396.

DiBenedetto, K. C. 2009. Life history characteristics of Alligator Gar, Atractosteus spatula, in the Bayou Dularge area of southcentral Louisiana. Louisiana State University.

Eddy, S., and J. C. Underhill. 1978. How to Know the Freshwater Fishes, 3rd edition. WCB/McGraw-Hill, Boston, Massachusetts.

Evans, G. B. 1971. The upland shooting life1st ed. Knopf, New York.

Flowers, H. J., H. Drouineau, and R. Leaf. 2023. American Eel Benchmark Stock Assessment and Peer Review Report. Page 341. Atlantic States Marine Fisheries Commission.

Fox, A. C. 1975. Effects of traditional harvest regulations on bass populations and fishing. Pages 393–398 *in* R. H. Stroud and H. Clepper, editors. Black Bass biology and management. Sport Fishing Institute, Washington, D.C.

Fries, L. T., D. J. Williams, and S. K. Johnson. 1996. Notes: Occurrence of *Anguillicola crassus* , an Exotic Parasitic Swim Bladder Nematode of Eels, in the Southeastern United States. Transactions of the American Fisheries Society 125(5):794–797.

Hubbs, C., R. J. Edwards, and G. P. Garrett. 2008. An Annotated Checklist of the Freshwater Fishes of Texas, with Keys to Identification of Species, 2nd edition. Texas Academy of Science.

ICES and WGAMEEL. 2023. Working Group on American Eel (WGAMEEL; outputs from 2022 meeting). Page 3165773 Bytes. ICES Scientific Reports.

Jelks, H. L., S. J. Walsh, N. M. Burkhead, S. Contreras-Balderas, E. Diaz-Pardo, D. A. Hendrickson, J. Lyons, N. E. Mandrak, F. McCormick, J. S. Nelson, S. P. Platania, B. A. Porter, C. B. Renaud, J. J. Schmitter-Soto, E. B. Taylor, and M. L. Warren. 2008. Conservation Status of Imperiled North American Freshwater and Diadromous Fishes. Fisheries 33(8):372–407.

Knights, B. 2003. A review of the possible impacts of long-term oceanic and climate changes and fishing mortality on recruitment of anguillid eels of the Northern Hemisphere. Science of The Total Environment 310(1–3):237–244.

Lackmann, A. R., A. H. Andrews, M. G. Butler, E. S. Bielak-Lackmann, and M. E. Clark. 2019. Bigmouth Buffalo Ictiobus cyprinellus sets freshwater teleost record as improved age analysis reveals centenarian longevity. Communications Biology 2(1):197.

Lackmann, A. R., E. S. Bielak-Lackmann, M. G. Butler, and M. E. Clark. 2022a. Otoliths suggest lifespans more than 30 years for free-living bowfin *Amia calva*: Implications for fisheries management in the bowfishing era. Journal of Fish Biology 101(5):1301–1311.

Lackmann, A. R., E. S. Bielak-Lackmann, R. I. Jacobson, A. H. Andrews, M. G. Butler, and M. E. Clark. 2023a. Harvest trends, growth and longevity, and population dynamics reveal traditional assumptions for redhorse (*Moxostoma* spp.) management in Minnesota are not supported. Environmental Biology of Fishes.

Lackmann, A. R., E. S. Bielak-Lackmann, R. I. Jacobson, M. G. Butler, and M. E. Clark. 2022b. Otolith allometry informs age and growth of long-lived Quillback Carpiodes cyprinus. Environmental Biology of Fishes 105(8):1051–1064.

Lackmann, A. R., S. A. Black, E. S. Bielak-Lackmann, and J. A. Lackmann. 2023b. Centenarian lifespans of three freshwater fish species in Arizona reveal the exceptional longevity of the buffalofishes (Ictiobus). Scientific Reports 13(1):17401.

Lackmann, A. R., S. A. Black, E. S. Bielak-Lackmann, and J. A. Lackmann. 2023c. Centenarian lifespans of three freshwater fish species in Arizona reveal the exceptional longevity of the buffalofishes (Ictiobus). Scientific Reports 13(1):17401.

Lackmann, A. R., J. Lyons, K. A. Kuber, T. P. Parks, D. L. Walchak, E. S. Bielak-Lackmann, C. R. Vaughan, S. D. Robertson, J. D. Woodling, and M. E. Clark. 2025. Otolith Age Analysis Reveals Lifespans Greater Than 50 Years for the Three Species of Carpsucker (*Carpiodes* spp.) in Wisconsin. Aquaculture, Fish and Fisheries 5(6):e70136.

Lackmann, A. R., J. Sereda, M. Pollock, R. Bryshun, M. Chupik, K. McCallum, J. Villeneuve, E. S. Bielak-Lackmann, and M. E. Clark. 2023d. Bet-hedging bigmouth buffalo (*Ictiobus cyprinellus*) recruit episodically over a 127-year timeframe in Saskatchewan. Canadian Journal of Fisheries and Aquatic Sciences 80(2):313–329.

Long, J. M., R. A. Snow, D. E. Shoup, and J. B. Bartnicki. 2023. Validation and Comparison of Age Estimates for Smallmouth Buffalo in Oklahoma Based on Otoliths, Pectoral Fin Rays, and Opercula. North American Journal of Fisheries Management 43(3):618–627.

Maxson, K. A., L. E. Solomon, T. A. Bookout, S. A. DeLain, A. D. Bartels, M. C. Bowler, E. J. Gittinger, E. N. Ratcliff, J. L. West, S. A. Love, J. A. DeBoer, A. L. Whitten-Harris, M. J. Spear, B. S. Ickes, A. F. Casper, and J. T. Lamer. 2024. Smallmouth buffalo (Ictiobus bubalus Rafinesque) population trends and demographics in the Upper Mississippi River System. Environmental Biology of Fishes 107(12):1625–1649.

Maxwell, R., and S. Kinney. 2021. Final Report Louisiana State Wildlife Grant (F18AF00021) Collection and Analysis of American Eels (Anguilla rostrata) in Louisiana. Page 17. Louisiana Department of Wildlife and Fisheries, Baton Rouge.

McGrath, P. E., E. J. Hilton, and J. A. Musick. 2016. Population Demographics of Longnose Gar, *Lepisosteus osseus,* from the Tidal Rivers of Virginia. Copeia 104(3):738–745.

Mensinger, G. C. 1971. Oklahoma Commercial Fisheries Harvest Summary 1961-1969. Proceedings of the Oklahoma Academy of Sciences 51:23–28.

Miller, M. J., E. Feunteun, and K. Tsukamoto. 2016. Did a “perfect storm” of oceanic changes and continental anthropogenic impacts cause northern hemisphere anguillid recruitment reductions? ICES Journal of Marine Science 73(1):43–56.

Miranda, L. E., and P. W. Bettoli. 2007. Mortality. Pages 229–277 *in* C. S. Guy and M. L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda, Maryland.

Montague, G. F., J. D. Schooley, D. L. Scarnecchia, and R. A. Snow. 2023. Bowfishing shoot and release: High short-term mortality of nongame fishes and its management implications. North American Journal of Fisheries Management 43(4):962–983.

Montague, G. F., D. L. Zentner, R. A. Snow, J. B. Bartnicki, D. E. Shoup, and B. A. Schmidt. 2024. Commercial harvest and population characteristics of freshwater drum and buffalo Ictiobus spp. in Ohio waters of Lake Erie. Environmental Biology of Fishes 107(12):1653–1673.

ODWC. 2016. Oklahoma Comprehensive Wildlife Conservation Strategy: A Strategic Conservation Plan for Oklahoma's Rare and Declining Wildlife. Page 422. Oklahoma Department of Wildlife Conservation, Oklahoma City.

Patton, T., and C. Lyday. 2008. Ecological Succession and Fragmentation in a Reservoir: Effects of Sedimentation on Habitats and Fish Communities. Pages 147–167 *in* M. S. Allen, S. Sammons, and M. J. Maceina, editors. Balancing Fisheries Management and Water Uses for Impounded River Systems. American Fisheries Society, Symposium 62, Bethesda, Maryland.

Phillips, G. L., and J. C. Underhill. 1971. Distribution and Variation of the Catostomidae of Minnesota. Occasional Papers of the Bell Museum of Natural History 10:1–45.

Pike, C., J. Casselman, V. Crook, M. B. DeLucia, D. Jacoby, and M. Gollock. 2020, November 8. Anguilla rostrata. The IUCN Red List of Threatened Species 2023: e.T191108A129638652.

Pratt, T. C., L. M. O'Connor, J. A. Stacey, D. R. Stanley, A. Mathers, L. E. Johnson, S. M. Reid, G. Verreault, and J. Pearce. 2019. Pattern of Anguillicoloides crassus infestation in the St. Lawrence River watershed. Journal of Great Lakes Research 45(5):991–997.

Radford, D. S., A. R. Lackmann, C. J. Moody-Carpenter, and R. E. Colombo. 2021. Comparison of Four Hard Structures Including Otoliths for Estimating Age in Blue Suckers. Transactions of the American Fisheries Society 150(4):514–527.

Reid, S. M. 2009. Age, growth and mortality of black redhorse (*Moxostoma duquesnei*) and shorthead redhorse (*M. macrolepidotum*) in the Grand River, Ontario. Journal of Applied Ichthyology 25(2):178–183.

Rypel, A. L., P. Saffarinia, C. C. Vaughn, L. Nesper, K. O'Reilly, C. A. Parisek, M. L. Miller, P. B. Moyle, N. A. Fangue, M. Bell-Tilcock, D. Ayers, and S. R. David. 2021. Goodbye to "Rough Fish": Paradigm Shift in the Conservation of Native Fishes. Fisheries 46(12):605–616.

Scarnecchia, D. L. 1992. A Reappraisal of Gars and Bowfins in Fishery Management. Fisheries 17(5):6–12.

Scarnecchia, D. L., B. D. Gordon, J. D. Schooley, and A. A. Nealis. 2013. A Comprehensive Plan for the Management of Paddlefish in Oklahoma. Oklahoma Department of Wildlife Conservation, Oklahoma City.

Scarnecchia, D. L., and J. D. Schooley. 2020. Bowfishing in the United States: History, Status, Ecological Impact, and a Need for Management. Transactions of the Kansas Academy of Science 123(3–4).

Scarnecchia, D. L., and J. D. Schooley. 2022. Trophies, Technology, and Timescape in Fisheries Management, as Exemplified through Oklahoma's World Record Paddlefish *Polyodon spathula*. Fisheries 47(9):381–394.

Scarnecchia, D. L., J. D. Schooley, K. M. Backes, A. Slominski, S. Dalbey, and Y. Lim. 2019. Paddlefish Life History: Advances and Applications in Design of Harvest Management Regulations. Pages 1–27 *in* J. D. Schooley and D. L. Scarnecchia, editors. Paddlefish: Ecological, Aquacultural, and Regulatory Challenges of Managing a Global Resource. American Fisheries Society, Bethesda, Maryland.

Scarnecchia, D. L., J. D. Schooley, A. R. Lackmann, S. J. Rider, D. K. Riecke, J. McMullen, J. E. Ganus, K. D. Steffensen, N. W. Kramer, and Z. R. Shattuck. 2021. The Sport Fish Restoration Program as a Funding Source to Manage and Monitor Bowfishing and Monitor Inland Commercial Fisheries. Fisheries 46(12):595–604.

Shepard, S. L. 2015. American Eel Biological Species Report. Page xii+121. US Fish and Wildlife Service, Region 5, Hadley, Massachusetts.

Smith, N. G., D. L. Buckmeier, D. J. Daugherty, D. L. Bennett, P. C. Sakaris, and C. R. Robertson. 2020. Hydrologic Correlates of Reproductive Success in the Alligator Gar. North American Journal of Fisheries Management 40(3):595–606.

Snow, R. A., M. J. Porta, and D. M. Bogner. 2020. Examination of the Current Oklahoma State Record Smallmouth Buffalo. Proc. Okla. Acad. Sci. 100:16–21.

Stuart, M., N. Kludt, M. A. Pegg, F. Montesanto, C. Lyon, and C. J. Chance-Ossowski. 2024. Dynamic rates of Freshwater Drum near the northern extent of their range: evidence of environment-recruitment relationships. Environmental Biology of Fishes 107(12):1691–1708.

Turner, S. M., B. C. Chase, and M. S. Bednarski. 2018. Evaluating the Effect of Dam Removals on Yellow-Phase American Eel Abundance in a Northeastern U.S. Watershed. North American Journal of Fisheries Management 38(2):424–431.

Ulmo-Diaz, G., A. Engman, W. O. McLarney, C. A. Lasso Alcalá, D. Hendrickson, E. Bezault, E. Feunteun, F. L. Prats-Léon, J. Wiener, R. Maxwell, R. S. Mohammed, T. J. Kwak, J. Benchetrit, B. Bougas, C. Babin, E. Normandeau, H. H. V. Djambazian, S. Chen, S. J. Reiling, J. Ragoussis, and L. Bernatchez. 2023. Panmixia in the American eel extends to its tropical range of distribution: Biological implications and policymaking challenges. Evolutionary Applications 16(12):1872–1888.

Warren, M. L., B. M. Burr, S. J. Walsh, H. L. Bart, R. C. Cashner, D. A. Etnier, B. J. Freeman, B. R. Kuhajda, R. L. Mayden, H. W. Robison, S. T. Ross, and W. C. Starnes. 2000. Diversity, Distribution, and Conservation Status of the Native Freshwater Fishes of the Southern United States. Fisheries 25(10):7–31.

Wellman, T., E. Martin, and A. L. Benson. 2022. Species of Greatest Conservation Need National Database 2005-2022. U.S. Geological Survey.

Woodling, J. D., A. Treble, M. M. Brandt, and A. R. Lackmann. 2024. Otolith analysis reveals long-lived population demographics of quillback Carpiodes cyprinus and river carpsucker C. carpio in Colorado. Environmental Biology of Fishes 107(12):1609–1623.

York, B., J. D. Schooley, and D. L. Scarnecchia. 2022. Oklahoma Bowfishing Values and Perspectives toward Nongame Fishes and Their Management. North American Journal of Fisheries Management 42(4):1020–1040.

Zentner, D. L., J. D. Schooley, R. A. Snow, and TBD. in press. Lab based estimates of long-term bowfishing shoot-and-release mortality with comparisons to prior work and considerations for future bowfishing research and management.

Zentner, D., D. Shoup, and S. K. Brewer. 2023. Effects of sucker gigging on fish populations in Oklahoma scenic rivers. U.S. Fish and Wildlife Service, Cooperator Science Series.

Appendix D. NNG Special Project Proposal for 2026

Special Project Proposal
Paddlefish and Native Nongame Program
October 17, 2025

Title: Effectiveness of Recreational Bowfishing as Biocontrol for Common Carp in a Small Oklahoma Reservoir

Duration: May-June 2026 (fieldwork), July 2026 (analyses)

Estimated Budget Request: $2,900 for Lowrance sonar equipment, $4,900 for BioBase EcoSound Habitat+ with EcoFish add-on analytical services one-year subscription. Both costs will be shared by other program projects in 2025-26.

Control of nonnative, invasive species is often cited as a potential benefit of active take fishing methodologies such as bowfishing. No studies have demonstrated the effectiveness of bowfishing take as biocontrol. This requires stock assessment of the target species, namely knowledge on density or abundance in addition to size/age structure. Although traditional fisheries methodologies (e.g., catch / mark / recapture, sacrificing fish for age and growth, basic population dynamics modeling) are adequate to perform stock assessments before and after a period of biocontrol removal using bowfishing, additional techniques may prove useful as a future surrogate for assessment of biomass reduction in applied control efforts.

Sonar-based systems for the identification and enumeration of aquatic organisms as well as habitat classification (e.g., substrate hardness, vegetative cover) are available using consumer-grade equipment and automated cloud analyses. A new technology from BioBase, EcoFish™, allows the locating, counting, and relative size classification of fish (in addition to bottom hardness, bathymetry, and vegetative cover) using down-scan sonar logs processed via BioBase's automated cloud algorithms.

Following previous conversations with the Guthrie City Council about potential ODWC removal of Common Carp in Liberty Lake (169 acres), we propose to perform a stock assessment on Common Carp in the reservoir, consisting of several days of electrofishing collections to establish estimates of relative catch rate (density) and size structure. All fish will be batch-marked using a fin punch for use in Schnabel series estimation of abundance prior to release. During this initial assessment, sonar logs of the entire lake will be recorded and fish density/abundance and size structure will be examined.

Following the initial stock assessment, a period of repeated removal efforts using bowfishing for Common Carp only will be performed, and shot fish will be retained, checked for marks, measured and weighed, and otoliths retained for age estimation.
After bowfishing efforts have completed, the lake will be sonar mapped a second time to evaluate any change in abundance, biomass, or size structure.

To determine the population level impacts of removal efforts, a second electrofishing stock assessment collection will occur, though all fish will be retained to simulate a mechanical removal using electrofishing.

Finally, a third sonar mapping effort will culminate the project, providing three perspectives of data provided by the sonar: 1) initial, 2) post-bowfishing removal, and 3) post-electrofishing removal. Not only will we examine the effectiveness of known bowfishing removal efforts and their impacts on a standing stock of Common Carp, we will also be able to compare the effectiveness of bowfishing to electrofishing removal.

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION
FISHERIES DIVISION RULE CHANGE PROPOSAL

Use this form when submitting proposals for fishing rule changes in Title 800. Deadline is June 1 for all rule change proposals (due to Fisheries Division Admin). Proposals received after the deadline cannot be considered until the following year.

Submitted by: Jason D. Schooley Division/Section: Fisheries
Date submitted: May 12, 2025 Date received (OKC): ____________________

1. Specific Title 800 Section to be changed (i.e.: 800:25-7-51 Deer-archery):
800:10-1-4. Size and bag limits on fish

2. General description of proposed rule change:
The chief purpose of this rule change is to prohibit the practice of shoot and release (S&R) in bowfishing.

3. Purpose/Justification/Explanation:
The practice of bowfishing shoot and release (S&R) in Oklahoma is legal only because it lies in a statutory loophole which challenges enforcement of established wanton waste law. The practice of S&R should be distinctly prohibited in Oklahoma, closing the loophole and officially regulating bowfishing as a consumptive practice with no viable release.
   - Department research results indicate high S&R mortality. Observed cumulative mortality rates of S&R bowfishing (62-87%) exceeds that of nearly all other types of fishing in the published literature (average 18%).

   In 2023, the Department published an award-winning[1] research study on the short-term mortality impacts of S&R in bowfishing (Montague, et al. 2023). At the direction of the Wildlife Commission, a second study was performed by the Department under more controlled, laboratory conditions to assess both short-term and long-term mortality (to 89 days; Zentner, et al., *in press*). Though the mortality rates from the second project varied slightly from the first project (Figure 1), the fundamental conclusions of high short-term and long-term (Figure 2) mortality for fish perforated by an arrow persisted. Further, the observed cumulative mortality rates of S&R bowfishing (62-87%) exceed that of nearly all other types of fishing in the published literature (average 18%; reviewed by Bartholomew and Bohnsack 2005). Shot/wound location had a high influence on mortality, with fish shot in critical areas (i.e., head, spine, or internal organs) experiencing a 96% short-term mortality (Montague, et al. 2023). The authors of both studies in Oklahoma concluded that responsibly managed bowfisheries for native, nongame fishes should be considered a 100% consumptive (kill) pursuit, with no viable release. Fortunately, only a small minority of bowfishers surveyed in Oklahoma (20%) reported that they return their shot fish to the water, however, a distinction was not clear between practicing S&R and disposal of carcasses (York, et al. 2022).

4. Exact wording of proposed rule (as it would appear in rule/regulations). Copy original text directly from Title 800; use ~~strikethrough~~ for language to be removed and underline for language to be inserted):
800:10-1-4. Size and bag limits on fish
There are no length or bag (harvest) limit restrictions on any game or nongame fish taken from waters of this state, except as follows:

[1] Montague, et al. (2023) received the prestigious *Mercer Patriarche Best Paper in the North American Journal of Fisheries Management* award of merit from the American Fisheries Society in September 2024.

(1) General provisions for size limits and bag limits- All fish not kept must be returned to the water unharmed immediately.

(A) Size limits (measured as total length, unless specified) are minimum limits unless specified.

(B) Release of striped bass, striped bass hybrids, trout, paddlefish, or alligator gar caught and placed on a stringer, in a live well or otherwise held in possession is prohibited statewide (no culling).

(C) Persons fishing trotlines or throwlines must release all fish on their lines except those held in possession for their daily limit, before leaving the trotline or throwline.

(D) Fish taken by bow and arrow, gig, spear, or speargun shall not be released, shall count towards the daily bag limit, and any carcasses or remains shall be properly disposed of (OAC 800:10-5-6p and 29 O.S. 7-205, 7-403).

...

5. Rule Impact Statement: (required by Administrative Procedures Act)

a. Purpose of proposed rule:
Given that research performed in Oklahoma by Oklahoma Department of Wildlife Conservation has demonstrated that release mortality of fish shot with a bow and arrow is excessive and higher than all other fishing methods, prohibiting shoot and release of nongame fish is aligned with the responsible management of bowfishing as a 100% take activity with no viable release.

b. Persons who will affected by proposed rule:
Current and future bowfishers, in addition to licensed guides participating in bowfishing, will be impacted by these rule changes. Participants in sport bowfishing will be responsible for maintaining possession of the fish they shoot rather than discarding dead or dying fish.

c. Persons who will benefit:
Hunters, anglers, and the general public who value the aquatic biodiversity of Oklahoma and who prioritize the ethical and sustainable use of our aquatic natural resources will benefit from the reduced discard of shot fish and the unsightly dumping of whole fish in and around access points or in Oklahoma public waters, improving the outdoor experience for all users.

d. Probable economic impact of proposed rule upon affected classes of persons, including a listing of all fee changes and, whenever possible, a separate justification for each fee change:
These rule changes are not accompanied by any fees or undue burdens for compliance. This rule provides guidance for the retention, use, and disposal of remains for fish shot in sport bowfishing.

e. Probable costs to ODWC and to any other agency of the implementation and enforcement of the proposed rule, the source of revenue to be used for implementation and enforcement of the proposed rule, and any anticipated effect on state revenues, including a projected net loss or gain in such revenues if it can be projected by the agency:
The proposed rule change for bowfishing is developed to assist in the streamlining or simplification of law enforcement. In sport bowfishing, without any limits on take and with inconsistent interpretation of statutes on legal and ethical take, retention, use, and possession of nongame fishes, enforcement of existing and future laws is hindered. This rule proposal will make rules more enforceable.

f. Probable economic impact or cooperation needed from any political subdivision:
None anticipated.

g. Determination of whether implementation of rule may have an adverse economic effect on small business:
Licensed fishing guides that participate in bowfishing may serve as a small business affected by these bowfishing rule changes. The changes do not cause an undue burden on the fishing guides, as these are fundamental aspects of ethical and regulated hunting or fishing. Any perceived or actual increases in operating costs to fishing guides could be offset through their pricing for guide services in a competitive market. Bowfishing tournament promoters are an adjacent small business or industry that may be affected by the rule changes. However, tournament participants should retain the ability to participate fully, as retention of shot fish is fundamental to tournament participation.

h. An explanation of the measures ODWC has taken to minimize compliance costs and a determination of whether there are less costly or less intrusive methods for achieving the purpose of the proposed rule:
Unlimited take and lack of clarity on retention, possession, use, and disposal of shot fish has hindered the management of sport bowfishing as an ethical and sustainable alternative to hook and line fishing. The proposed rule changes are no more intrusive than standard limitations placed on the harvest of any other type of fish and game managed by Oklahoma Department of Wildlife Conservation.

i. Determination of the effect of the proposed rule on the public health, safety and environment and, if the proposed rule is designed to reduce significant risks to the public health, safety and environment, an explanation of the nature of the risk to what extent the proposed rule will reduce the risk:
Aside from the potentially net positive effects of these rule changes on the abundance and biodiversity of native, nongame fishes in Oklahoma waters that are bowfished (through reduction in take of these species), there are no direct links between these proposed rule changes and public health, safety, and the environment. If implemented, this rule aims to reduce the dumping and waste of whole, shot fish near access points of public waters. While these rotting piles of fish are a pungent eyesore, their impacts on the environment are not fully known. Reduction in the dumping of fish would be a net positive environmental benefit to human users of these access points.

j. Determination of any detrimental effect on the public health, safety and environment if the proposed rule is not implemented:
Unregulated take and discard of shot fish at access points of public waters likely has a negative impact on the human users of those access points. Any ecological impacts from the dumping of fish carcasses in waters of this state are not fully understood, however, the dumping of dead or dying fish in or near spawning habitats may hinder or interrupt spawning behavior.

6. Supporting data, public input, statute references, etc. Attach additional/supporting documents.:

Figure 1. Estimated short-term release mortality (figure excerpted from Zentner, et al. *in press*) for nongame fish shot with a bow and arrow. Points represent average mortality for all fish at each timestep with 95% confidence intervals represented by error bars. Montague, et al. (2023) is represented in grey and Zentner, et al. (*in press*) is represented in black.

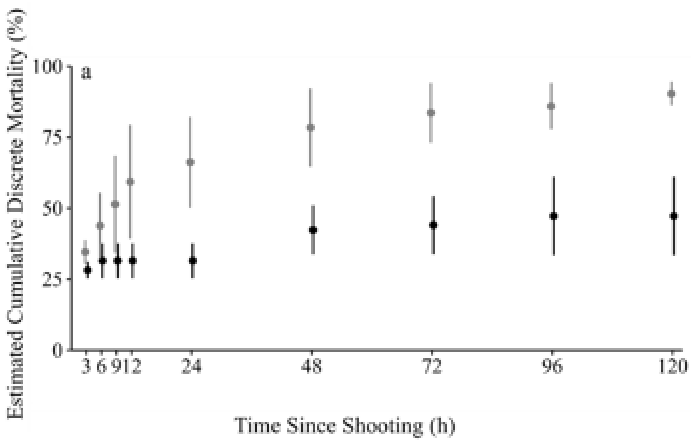
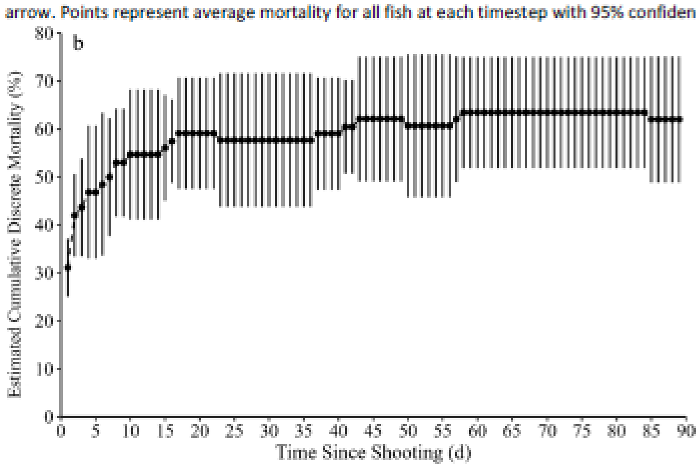


Figure 2. Estimated long-term release mortality (figure excerpted from Zentner, et al. *in press*) for nongame fish shot with a bow and arrow. Points represent average mortality for all fish at each timestep with 95% confidence intervals represented by error bars.



Additional supporting documents are appended to this proposal:

1) Montague et al. 2023 paper on high S&R mortality
2) Zentner et al. 2025 paper on high S&R mortality
3) ODWC Law Enforcement bowfishing policy clarification memo March 31, 2021

7. Statutory Authority from Title 29 allowing ODWC to make the proposed change: Title 29 O.S., Section 3-103, 5-401; Article XXVI, Section 1 and 3 of the Constitution of Oklahoma; Department of Wildlife Conservation Commission.

8. Approvals (through supervisory chain-of-command):

   a. Immediate Supervisor: ______________________________ Date: ________________
   b. Asst Chief/Dist. Chief: ______________________________ Date: ________________
   c. Division Chief/Section Head: ________________________ Date: ________________
   d. Assistant Director: _________________________________ Date: ________________

Literature Cited

Bartholomew, A., and J.A. Bohnsack. 2005. A review of catch-and-release angling mortality with implications for no-take reserves. Reviews in Fish Biology and Fisheries 15:129–154. https://doi.org/10.1007/s11160-005-2175-1

Montague, G.F., J.D. Schooley, D.L. Scarnecchia, and R.A. Snow. 2023. Bowfishing shoot-and-release: high short-term mortality of nongame fishes and its management implications. North American Journal of Fisheries Management 43(4):962-983. https://doi.org/10.1002/nafm.10904

York, B., J.D. Schooley, and D.L. Scarnecchia. 2022. Oklahoma bowfishing values and perspectives toward nongame fishes and their management. North American Journal of Fisheries Management 42:1020–1040. https://doi.org/10.1002/nafm.10795

Zentner, D.L., J.D. Schooley, R.A. Snow, and C. Gainer. *In press*. Lab based estimates of long-term bowfishing shoot-and-release mortality with comparisons to prior work and considerations for future bowfishing research and management.