ANNUAL REPORT

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

OKLAHOMA NONGAME FISHES

RESEARCH AND MANAGEMENT

[AREA 045]

2024

ANNUAL REPORT

State: Oklahoma

Project Title: Oklahoma Nongame Fishes Research and Management

Period Covered: January 1 – December 31, 2024

Prepared by: Jason D. Schooley, Matt Pallett, and Caleb Taylor

Date Prepared: January 2025

EXECUTIVE SUMMARY

Management of Oklahoma's native nongame (NNG) fishes is a new focus for the Department with the 2023 expansion of Area 45's focus to include Paddlefish and NNG fishes. Activities throughout 2024 included a year-long collaboration with Oklahoma Fish Stickers bowfishing club to provide "fish disposal" for their tournaments. These fish collected from 10 tournaments comprised 5,073 individuals from 15 nongame species. Processing and analyses of otoliths from these fish is ongoing and will take some time to complete. 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, 1,951 buffalofishes were examined for morphology, age, sex, and genetic samples taken 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. Prior collections in 2023 were largely comprised of small sample sizes with highly variable age and size structure. However, larger sample sizes provided by tournament fish expanded our abilities to examine population dynamics of NNG fishes. We modeled population dynamics for Smallmouth Buffalo collected from Grand Lake (n=138), Keystone Lake (n=128), and Tenkiller Lake (n=138). Although these samples may still be inadequate for robust interpretation, we found the age structure of Smallmouth Buffalo to span 1-69 years, recruitment to be episodic, and some evidence to suggest that spawning interval may be non-annual (multiple years between spawns). We estimated annual mortality at 2.1-5.4% for the three reservoirs, however, a stronger understanding of fishing mortality is needed and data on exploitation are not currently available. Many other samples collected from a series of bowfishing tournaments are in progress and will inform future models. A statewide management plan for NNG fishes is in development.

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 14 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, Alligator Gar, and perhaps Hybrid Striped Bass. 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, walleye, blue catfish and channel catfish. Blue catfish and channel catfish are herein defined to mean "forked tail" catfish.

As of 2025, 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 15 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). The remaining 101 species (57%) 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).

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. 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 three studies were recently completed on bowfishing in Oklahoma (York et al. 2022; Montague et al. 2023; Zentner et al. in prep).

Figure 1. Table 2 from Rypel, et al. (2021) summarizing bag limit regulations for nongame fishes in all 50 states.

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.

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.

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. 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”.

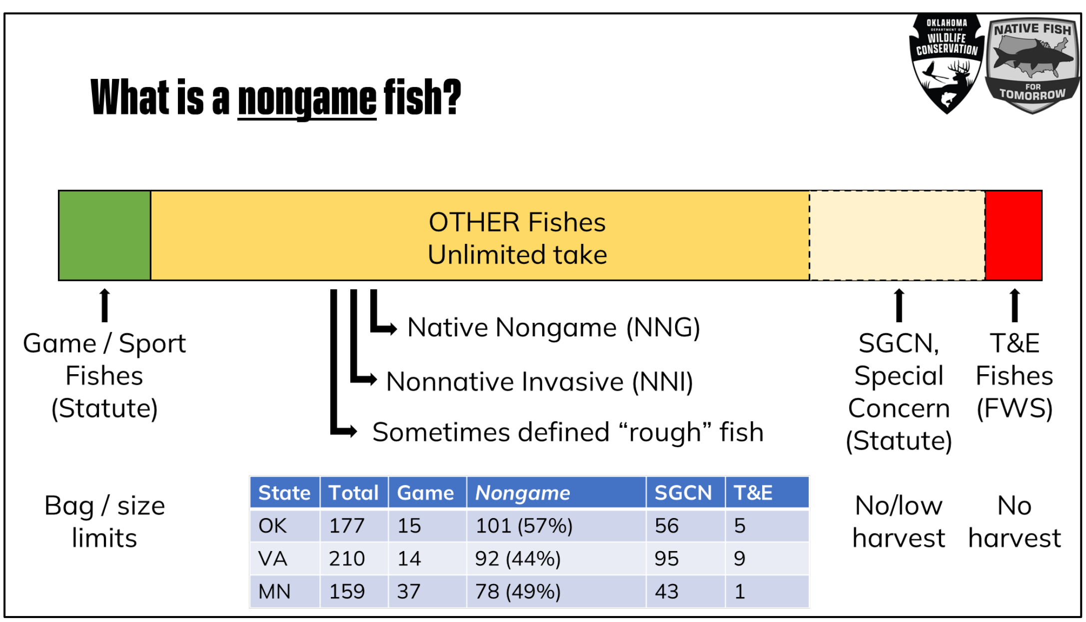


Table 2. List of 56 nongame fishes classified as Species of Greatest Conservation Need (SGCN) in Oklahoma. Excerpted from the ODWC Oklahoma Comprehensive Wildlife Conservation Strategy (ODWC 2016). Common names prefixed by an asterisk (*) are regarded as under the generalized purview of the Paddlefish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

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 (Table 4).

ODWC Fisheries Division has a standing committee focused on NNG fishes and comprised of members representing management regions and hatcheries. The Nongame Committee's focus is to provide a forum for the discussion, review, and facilitation of topics and actions relevant to Oklahoma's nongame fishes and the fisheries that target them. This includes, for example, regulatory changes and social media outreach.

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 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, 2023b) [MN]
Smallmouth Buffalo	62			(Snow et al. 2020) [OK]
Black Buffalo	56			(Lackmann et al. 2019) [MN]
	54			(Montague et al. 2023) [OK]
Alligator Gar	68*			(Daugherty et al. 2020) [TX]
	95*			A. H. Andrews, NOAA Fisheries, pers. comm. [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]
River Carpsucker	>45			(Lackmann et al. 2022b) [MN]
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]
Shorthead Redhorse	20			(Reid 2009) [ON]
Golden Redhorse	17			(Lackmann et al. 2023a) [MN]
Blue Sucker	42			(Radford et al. 2021) [IN, IL]

Table 4. Recent articles from a special issue of *Environmental Biology of Fishes* titled "Underappreciated Native Fishes of North America and their Management". Open access articles are noted with an asterisk (*).

Art.	Title	Species	DOI
1*	From neglect toward enlightenment: the conservation of native fishes in the twenty-first century	Various NNG	https://doi.org/10.1007/s10641-024-01655-7
2	Don't judge a nongame fish by its cover-age: an assessment of social media posts featuring Minnesota native fishes	Various NNG	https://doi.org/10.1007/s10641-024-01653-9
3	Use of multiple climate change scenarios to predict future distributions of alligator gar (*Atractosteus spatula*) in the United States	Alligator Gar	https://doi.org/10.1007/s10641-024-01654-8
4	Minnesota's Native Fish Bill: a case study in shifting the "rough fish paradigm"	Various NNG	https://doi.org/10.1007/s10641-024-01644-w
5	Ecology of eyetail bowfin (*Amia ocellicauda*) in Green Bay, Lake Michigan	Bowfin	https://doi.org/10.1007/s10641-024-01631-1
6*	An investigation of personality in the Creek Chub, *Semotilus atromaculatus*	Creek Chub	https://doi.org/10.1007/s10641-024-01630-2
7*	Exploring the extensive movements and home range of one of North America's most mobile fish: the freshwater drum (*Aplodinotus grunniens*)	Freshwater Drum	https://doi.org/10.1007/s10641-024-01635-x
8*	Ecomorphology of Longnose Gar (*Lepisosteus osseus*): on the influence of size, sex, and river location	Longnose Gar	https://doi.org/10.1007/s10641-024-01619-x
9	For the love of suckers: scientific benefits of engaging volunteers to monitor migrations and advocate for native non-game fishes	Longnose Sucker and White Sucker	https://doi.org/10.1007/s10641-024-01616-0
10	Using environmental DNA metabarcoding to assess the spatiotemporal occurrence of the imperiled River Redhorse (*Moxostoma carinatum*) in the Escambia-Conecuh River system of Florida and Alabama, USA	River Redhorse	https://doi.org/10.1007/s10641-024-01574-7
11	Spawning migration, sex-specific home ranges, and seasonal site fidelity in a lacustrine population of Bowfin (*Amia ocellicauda*)	Bowfin	https://doi.org/10.1007/s10641-024-01585-4
12	Commercial harvest and population characteristics of freshwater drum and buffalo *Ictiobus* spp. in Ohio waters of Lake Erie	Freshwater Drum, Bigmouth Buffalo, and Smallmouth Buffalo	https://doi.org/10.1007/s10641-024-01598-z
13	Dynamic rates of Freshwater Drum near the northern extent of their range: evidence of environment-recruitment relationships	Freshwater Drum	https://doi.org/10.1007/s10641-024-01589-0
14	Species distribution models predict suitable habitat for the overlooked and understudied freshwater lampreys of Illinois	Lamprey	https://doi.org/10.1007/s10641-024-01593-4
15	Population structure and vital rates of Shortnose Gar *Lepisosteus platostomus* in a large floodplain river	Shortnose Gar	https://doi.org/10.1007/s10641-024-01583-6
16	Goldeye (*Hiodon alosoides*) population dynamics in Lake Oahe and Lake Sharpe, South Dakota	Goldeye	https://doi.org/10.1007/s10641-024-01573-8
17*	Seasonal habitat use of white sucker *Catostomus commersonii* in a small Boreal lake	White Sucker	https://doi.org/10.1007/s10641-024-01581-8
18*	Smallmouth buffalo (*Ictiobus bubalus* Rafinesque) population trends and demographics in the Upper Mississippi River System	Smallmouth Buffalo	https://doi.org/10.1007/s10641-024-01554-x
19	Otolith analysis reveals long-lived population demographics of quillback *Carpiodes cyprinus* and river carpsucker *C. carpio* in Colorado	Quillback and River Carpsucker	https://doi.org/10.1007/s10641-024-01557-8
20	Examination of freshwater drum populations at the center of their latitudinal range: implications for development of diverse recreational angling opportunities	Freshwater Drum	https://doi.org/10.1007/s10641-024-01545-y
21*	Diversity of movement patterns of Longnose Gar tracked in coastal waters of western Lake Ontario	Longnose Gar	https://doi.org/10.1007/s10641-023-01491-1
22	Scale-dependent tradeoffs between habitat and time in explaining Alligator Gar (*Atractosteus spatula*) movement	Alligator Gar	https://doi.org/10.1007/s10641-023-01473-3
23*	Habitat niche dynamics of the sicklefin redhorse: a southern Appalachian Mountain habitat specialist	Sicklefin Redhorse	https://doi.org/10.1007/s10641-023-01465-3
24	Harvest trends, growth and longevity, and population dynamics reveal traditional assumptions for redhorse (*Moxostoma* spp.) management in Minnesota are not supported	Redhorse spp.	https://doi.org/10.1007/s10641-023-01460-8

RESEARCH AND MANAGEMENT ACTIVITIES / METHODS

Oklahoma Fish Stickers Bowfishing Tournaments - Throughout 2024, our nongame program was aligned with a local bowfishing club Oklahoma Fish Stickers (OFS) to provide "fish disposal" for all their tournaments spanning January to September 2024. For these events, ODWC personnel attended the weigh-in with individually numbered 32-gallon refuse barrels to transport shot fish offsite for later processing. Data recorded at the tournament was superficial, including the location (waters fished), tournament format[1], number of teams participating, and when possible, the weigh-in results, as provided by the tournament organizer. The total take for each team was kept separate using the numbered barrels and they were transported to cold storage (when possible) at the ODWC Miami Office for later processing. For two tournaments, segregation by team was either not possible (TNT tournament) or not warranted (Youth Worlds Tournament).

Shell Lake Experimental Bowfishing Tournament – In August 2024, our program held a simulated bowfishing tournament on Shell Lake in Osage County. Prior to the event, we captured and PIT tagged 333 buffalofishes (all three species) and 216 Spotted Gar to generate population abundance estimates for use in estimating tournament exploitation. These activities will be included in a separate report detailing the tagging methodologies, population estimation, tournament development, and analyses of take.

Other Collections – In January and February 2024, 112 buffalofishes were acquired from gillnet collections on Lake Texoma. Additionally, in June 2024, 18 presumptive age-1 Smallmouth Buffalo were collected from Ft. Gibson Lake with electrofishing. These fish are included in general summary tables or figures with other fish from those reservoirs.

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

---

[1] Bowfishing tournament formats generally determine the winner based on weight or count. For weight tournaments, it can be the total aggregate weight of all shot fish (total weight), or the total aggregate weight of a discrete number of fish (e.g., Big 5, 10, 20). An alternative format (often in fall) prioritizes minimum weight of small fish (e.g., Little 20). Tournament formats awarding for total count of fish shot are referred to as "numbers" tournaments. In some cases, multiple formats may be combined (e.g., a numbers tournament with a separate prize for Big 20) and tournaments typically also have a separate prize for the individual shooter who weighs in the heaviest fish. The Youth Worlds Tournament has a unique format in that there are no teams and each youth participant can weigh in up to 4 fish, one each of any gar, buffalofish, carp, and Freshwater Drum.

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-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	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. 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).

<u>Disposal of specimens –</u> Responsible disposal of shot fish post-processing was a priority for our collaboration with the OFS tournaments. Fish carcasses were segregated into two lots: gars and non-gars. Carcasses of non-gars were taken to Darling International pet food rendering plant in Billings, Missouri. Due to the toxicity of gar roe, we could not salvage the gar carcasses into pet food and they were buried per the guidelines of Oklahoma statutes.

<u>Other Native Nongame Projects -</u> 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)
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
Skipjack Herring	ODWC Southeast Regional Management (Porter Office)	Arkansas River, R.S. Kerr Reservoir	Develop baseline life history information for the species (age and growth) in consideration for informing a managed fishery.
Blue Sucker	ODWC Durant Hatchery, US Fish and Wildlife Service	Lower Kiamichi River, Red River	Investigate rearing and captive propagation requirements for this and other SGCN fishes.
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.
Goldeye	OFRL (Norman Office) and South-Central Region Management (Durant Office)	Texoma Lake	Determine otolith aging precision for refinement of life history for the species.
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)
Misc. (gars, buffalofishes, carps)	ODWC Human Dimensions	Statewide	Examine and determine baseline social perceptions of native nongame fishes as we try to better communicate about these species (Figure 3).

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 your 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 other anglers you know 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

Bowfishing Tournament Collaboration with OFS – Representatives from ODWC attended weigh-in for a total of eight bowfishing tournaments in 2024 (Table 7a). We were requested to participate in one non-OFS tournament (Youth Worlds Bowfishing Tournament). These tournaments occurred on Grand Lake, Tenkiller, Ft. Gibson Lake (three tournaments), Kaw Lake, and Keystone Lake. Two tournaments (Iceman and TNT) were not restricted to a single reservoir, but were eligible for take on legal waters statewide. For the Iceman tournament, we asked teams where they shot fish, which added Lake Eufaula (including the tailwater), Arkansas River, and Oologah Lake as origins for shot fish in 2024. The origins of fish shot in the TNT tournament were unknown. In addition, ODWC hosted a tenth, experimental tournament on Shell Lake. As this tournament will be described in depth in a separate report, it is largely omitted here, though retained in some tables for comparison to OFS tournaments.

Tournament participation and take varied (Table 7a,b), with weather and lake conditions cited by participants as a key factor in low catches (e.g., Iceman, Ft. Gibson Lake 1). Team participation ranged 7-16 teams, with individual participants ranging 34-56, when known. The Youth Worlds tournament was reported to have 247 participants, but the hybrid format of that tournament, which includes target shooting and unique weigh-in rules (i.e., up to one fish each from four taxonomic groups: buffalofishes, gars, carps, and Freshwater Drum), makes it difficult to compare to other tournaments with adult participants. Seven tournaments were held at nighttime, with the remaining three during the daytime. Catch rates (average fish shot per team) for nighttime tournaments (32.2) were generally double that of daytime tournaments (15.9), when the Youth Tournament and massive TNT tournament were excluded.

Ft. Gibson Lake was the most popular location for tournaments (3), however no teams from the statewide Iceman tournament reported shooting fish from Ft. Gibson Lake, perhaps due to the weigh in being in Coweta or due to winter conditions on the lake at that time.

Contemporaneous notes were taken by Department participants at several of the tournaments. These provide some context to participation and take from these tournaments, therefore several are summarized here:

> Iceman – Ten teams entered, though only 8 weighed-in fish. Lakes in the region were partially frozen and weather was cold. Teams were asked to not cull fish, but compliance could not be validated. Three teams only weighed five fish while other teams returned with smaller fish that might have otherwise been culled.
>
> Grand Lake – Eleven teams entered, though only 10 teams weighed-in fish. One redhorse spp. (Golden or River) was retained by a bowfisher for use as a potential state record fish for Bowfishing Association of America. (This fish would not have qualified as an Oklahoma State Record for either species if certified by the Department.) The tournament hosts were tallying fish counts within four vague taxonomic groups (gars, buffalofishes, carps, and “quillbacks”). No Quillbacks were actually taken, though the take did include 15 River Carpsuckers. Participants reported foggy conditions, low water clarity, and difficult shooting.
>
> Keystone Lake – Participants noted ease in targeting / scouting fish during the days preceding the daytime tournament. However, they reported poor success on the day of the tournament and the weather was hot.
>
> Kaw Lake – Conditions were rainy during this nighttime shoot. An additional hour of shooting was added prior to weigh in, but the weigh in was ultimately held only 30 min late.
>
> Ft. Gibson Lake 3 (Little 20 format) – Participants reported ease in finding and shooting fish, that they “could have shot over 500 fish each team if they had wanted”. However, the 16 teams and 53 shooters only weighed-in 718 fish total (44.9 fish/team). This testimony implies that the participants were being choosy or exercising restraint in pursuit of small fish.

Although 5,073 nongame fish were collected from bowfishing tournaments in 2024, not all fish were processed for several reasons. Fish from the August 2024 Ft. Gibson Lake 3 tournament were unable to be put into cold storage due to an inclement weather power outage lasting several days. Therefore, these 718 fish were counted by species (within team barrels) and a subsample of 100 buffalofishes (biased mostly towards smaller Smallmouth Buffalo to supplement length groups for population modeling) were fully processed in their rancid state of decay >48 hours after the weigh-in.

The TNT statewide tournament (Table 8) yielded 2,534 fish totaling 10,160 lbs. Due to inadequate cold storage space, limited staff availability, and other factors, the anticipated take from this large tournament necessitated an abbreviated effort to maintain our commitment to participation in OFS tournaments as agreed. Therefore, a 14' dump trailer was used for the fish collection from weigh-in and this was deposited on site and picked up later. Though an aggregated weight of the tournament take was taken when the fish were dumped at Darling International, fish were not processed and species composition was not known. Abbreviated weigh-in data were provided by OFS (Table 8), including the total number of fish shot per team. The count of fish taken from this single, large tournament matched the combined take from the nine other tournaments observed in 2024.

Table 7a. Summary of participation for bowfishing tournaments observed by ODWC in 2024.

Date	Name & Location	Format (Day/Night)	Teams (shooters)	Avg fish shot/team
1/27/24	Iceman, Statewide	Big 5 (N)	10 (34)	11.6
3/9/24	Grand Lake	Big 20 (N)	11	23.4
4/6/24	Ft. Gibson Lake (1)	Numbers (D)	8	14.0
5/18/24	Keystone Lake	Big 10 (D)	10 (36)	17.7
6/8/24	Tenkiller Lake	Numbers (N)	11 (36)	48.4
6/22/24	Youth Worlds Tournament, Ft. Gibson Lake (2)	1 ea. gar, buffalo, carp, drum (D)	- (247)	-
7/20/24	Kaw Lake	Big 20 (N)	7	32.4
8/9/24	ODWC Experimental, Shell Lake	Total Weight (N)	10 (35)	32.5
8/17/24	Ft. Gibson Lake (3)	Little 20 (N)	16 (53)	44.9
9/7/24	TNT, Statewide	Numbers & Big 20 (N)	11	230.4

Table 7b. Summary of take statistics for bowfishing tournaments observed by ODWC in 2024.

Tournament	Tot. Fish Shot	Tot. NNG	Total lbs.	NNG lbs.	Big Fish (lbs.)	% Buffs	% Gars	% Carps	% NNG
Iceman	93	82	700.65	554.57	GRC (25.97)	64.5	0.0	11.8	88.2
Grand Lake	234	178	1,687.40	1,172.24	GRC (28.57)	45.3	10.3	23.9	76.1
Ft. Gibson Lake (1)	98	25	479.11	144.12	SMB (17.06)	19.4	6.1	74.5	25.5
Keystone Lake	177	122	1,494.87	1,009.12	LNG (22.97)	32.2	36.7	321.1	68.9
Tenkiller Lake	532	526	1,540.94	1,518.87	LNG (17.94)	75.8	10.5	1.1	98.9
Ft. Gibson Lake (2)	135	120	658.43	570.58	GRC (19.53)	48.9	37.0	11.1	88.9
Kaw Lake	227	181	1,503.40	1,018.98	BMB (31.53)	52.9	22.9	20.3	79.8
ODWC, Shell Lake	325	300	1,689.27	1,591.27	BKB (18.70)	68.6	20.0	7.7	92.3
Ft. Gibson Lake (3)	718	683	-	-	-	66.4	22.0	4.9	95.1
TNT	2,534	-	10,160.00	-	GRC (44.0)	-	-	-	-
Totals	5,073		19,914.07	7,579.75					

Table 8. Weigh-in summary from TNT statewide bowfishing tournament September 2024. The tournament was a dual-format with prizes for numbers and big 20. Additional side pots were available for the biggest fish weighed in (lbs) for each of four taxonomic groups.

Team	#Fish Shot (rank)	Big 20 Total lbs (rank)	Big Common Carp	Big Gar	Big Grass Carp	Big Buffalo
Hendricks	69 (7)	243.4 (7)		20.8		15.6
2Gen	98 (6)	221.2 (9)		20.8	22.8	10.8
Plug Uglies	344 (4)	306.4 (3)		22.0	30.0	
Scale Breakers	32 (10)	476.0 (1)			44.0	
Line Em Up	21 (11)	259.0 (5)	7.0			12.4
TNT	356 (3)	230.0 (8)		19.8		
Caddo Killers	36 (9)	208.0 (10)				
Haulin A$$	133 (5)	253.6 (6)	4.2		36.2	
Bro Time	979 (1)	369.4 (2)		24.8		
Just Send It	422 (2)	268.2 (4)	5.8			
Slut Bus Boyz	44 (8)	143.4 (11)				
	2,534	2,978.6				

To date, collections of buffalofishes for our statewide morphology and genetics project have yielded 1,954 samples representing all three species (Table 7). Although our confidence in identifying Bigmouth Buffalo is high (152 fish; 7.8%), 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 1,799 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 1,792 fish we visually identified as Smallmouth Buffalo could be Black Buffalo, elevating this cryptic species to 41% of the total buffalo catch.

Table 9. Updated results of opportunistic collections and bowfishing tournament collections of Oklahoma buffalofishes for genetics and morphology. 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	1 (0.4)	220 (98.7) 132 (59.2)	2 (0.9) 90 (40.4)	223
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	152 (7.8)	1,792 (91.9) 1,016 (52.1)	7 (0.4) 783 (40.1)	1,951

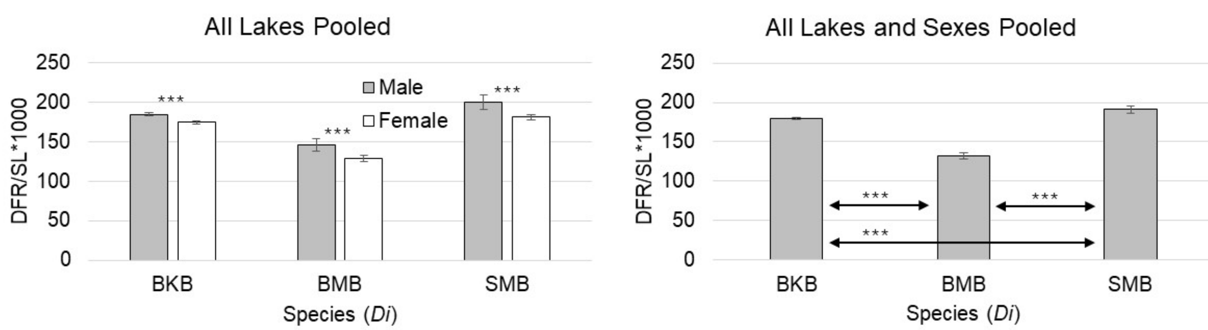
Addition of preliminary genetics evidence further complicates, rather than clarifies, the species differentiation of Smallmouth Buffalo and Black Buffalo. Using mitochondrial barcoding, we have maternal lineage for a subsample of 72 buffalofishes from a variety of Oklahoma reservoirs. Though Bigmouth Buffalo are generally considered easy to identify to species among the three buffalofishes, approximately one third of the samples barcoded indicated maternal genetic influences from *I. bubalus* at approximately half the frequency of *I. cyprinellus*, indicating some past hybridization. For fish visually identified as Smallmouth Buffalo, approximately half of them had body depth index characteristic of Black Buffalo, however, mitochondrial barcoding did not identify *I. niger*, only *I. bubalus* and *I. cyprinellus*. Regardless of *Di*, for fish visually identified as "not Bigmouth Buffalo", *I. bubalus* mitochondrial DNA appeared to be represented at a frequency of 2-3:1 when compared to *I. cyprinellus*. These results are somewhat confounding, and we hope that increased sample size may clarify the results and establish clearer patterns between genetic species ID and morphology.

Table 10. Preliminary results from buffalofish mitochondrial barcoding compared to visual species ID and species ID derived from the body depth index (*Di*).

Species - Visual ID	Species - *Di*	Species - Mitochondrial Barcoding
Bigmouth Buffalo (16)	Bigmouth Buffalo (16)	*bubalus* (5)
		cyprinellus (11)
Smallmouth Buffalo (56)	Black Buffalo (29)	*bubalus* (22)
		cyprinellus (7)
	Smallmouth Buffalo (27)	*bubalus* (19)
		cyprinellus (8)

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 (Figure 4). Further, when males and females were pooled, this character remained significantly different for all three D_i species, when pairwise compared (T-Test, $p<0.001$). A re-analysis of this character will be warranted when genetic results confirm species ID.

Figure 4. Examination of anterior dorsal fin ray length as a character for differentiating sexes in buffalofishes was found to result in a significant difference ($p<0.001$; indicated by asterisks [***]) for each species when pooled across all water bodies. When sexes were further pooled (n=1,647), species remained significantly distinct. This character may serve as a reasonable differentiator for the three species, presuming that *Di* is an accurate differentiator. Or, perhaps, there is simply a correlation between body depth and dorsal fin ray length.



As no morphological examination has otherwise yet been tested and verified to confidently differentiate Smallmouth from Black buffalofishes, we hereafter consider any fish not identified as a Bigmouth Buffalo to represent an admixture and we refer to them as Smallmouth/Black Buffalo except when describing species in terms of D_i. Full genetic identification to species (or hybrid) is forthcoming but not currently available.

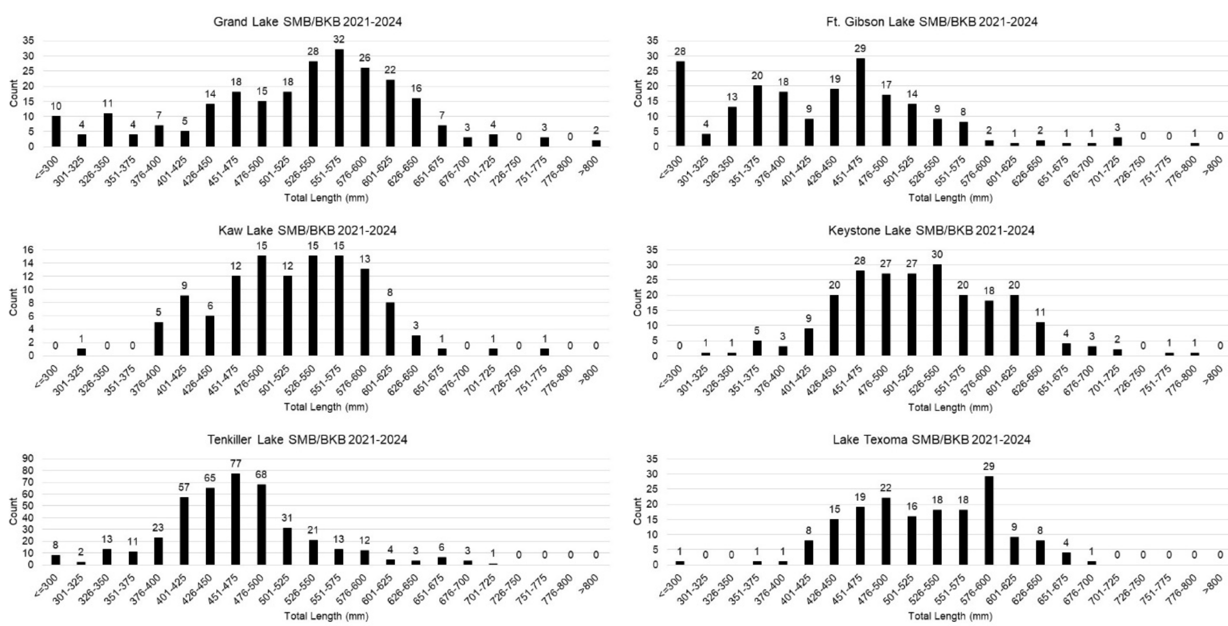
Overall, nongame specimens collected in 2024 totaled to 2,051 fish across 15 species (Table 11). Though processing the kill from bowfishing tournament was generally completed within a few days of the weigh-in, it was not possible to keep up with the rapid accumulation of otoliths and age analyses is lagging far behind. Our program's contract for consultation with Dr. Scarnecchia at University of Idaho includes fish aging, therefore we shipped a large batch of otoliths from non-buffalofishes while we retained the buffalofishes to process locally. At the time of this report, no results from University of Idaho were available. Much of the aging efforts in 2024 focused on completing select samples from 2023 in addition to some new samples from 2024, based on prioritization (e.g., Shell Lake samples collected in August 2024 were moved to the top of the priority list).

Table 11. Summary of nongame specimens collected prior to and during 2024 with status of age assignment. Collection methods included gill nets, electrofishing, fish salvage, and bowfishing tournaments.

Species	2021-2023 Total	Aged	%	2024 Total	Aged	%	Spp. Total (% aged)
Bigmouth Buffalo	125	47	37.6%	27	0	0.0%	152 (30.9%)
Black Buffalo				7	1	14.3%	7 (14.3%)
Common Carp				247	0	0.0%	247 (0%)
Freshwater Drum				57	0	0.0%	57 (0%)
Gizzard Shad				24	0	0.0%	24 (0%)
Grass Carp				40	0	0.0%	40 (0%)
Longnose Gar				145	0	0.0%	145 (0%)
Northern Hogsucker				1	0	0.0%	1 (0%)
River Carpsucker	9	2	22.2%	73	0	0.0%	82 (2.4%)
River Redhorse				3	0	0.0%	3 (0%)
Shortnose Gar				28	0	0.0%	28 (0%)
Skipjack				1	0	0.0%	1 (0%)
Smallmouth Buffalo	545	297	54.5%	1,250	225	18.0%	1,795 (29.1%)
Spotted Gar				145	0	0.0%	145 (0%)
Spotted Sucker				3	0	0.0%	3 (0%)
	679	346	51.0%	2,051	226	11.0%	2,730 (21.0%)

Fish collections from bowfishing tournaments in 2024 have yielded highly variable sample sizes and size structure, which somewhat limits our interpretation of the catches. However, pooling tournament data with opportunistic data from 2021-2023 provides acceptable samples for several lakes (Figure 5).

Figure 5. Size structure of select Smallmouth/Black buffalofish collections from Oklahoma reservoirs, updated for 2024.



Many samples remain incomplete regarding age assignment, with only 51% of samples collected in 2021-2023 completed and 11% of samples from 2024 completed at the time of this report. Therefore, only three populations (Grand Lake n= 134, Keystone Lake n=128, and Tenkiller n=138) are reported in depth here due to larger sample sizes and current availability of ages. The frequency of OFS tournaments held on Ft. Gibson (3 of 8) indicates that this is a priority reservoir for understanding bufflofish population dynamics. Therefore, completion of Ft. Gibson age assignment for buffalofishes (n=203) is a key priority for 2025 and will be reported in depth in the 2025 annual report. Age data for Shell Lake will be reported in depth in the report describing the Shell Lake Experimental Bowfishing Tournament.

Grand Lake Smallmouth/Black Buffalo Population Dynamics – When Grand Lake 2021-2023 data are supplemented by data collected from tournaments in 2024, a total of 251 Smallmouth/Black buffalofishes were used for further analysis on population dynamics. Total lengths ranged 230-849 mm, and ages ranged 1-40 years old (n=134, Figure 6). In the Grand Lake system, we see a wide range of lengths and ages collected which will necessitate a large sample to confidently evaluate this population.

The age frequency distribution of Smallmouth Buffalo in Grand Lake is entirely derived from specimens collected from electrofishing in 2021. Bowfishing tournament specimens from 2024 have not yet been aged, but will greatly contribute to future analyses. Targeted collections of young fish (Figure 6) have contributed to the knowledge of early growth for the species to help fill gaps in age data for other reservoirs. The age frequency distribution otherwise appears to be bimodal with peaks at around age-9 and age-22. It is unknown if this is a sample size artifact or if it represents the true age structure of the stock. Once age analyses are completed for fish taken from the bowfishing tournament in 2024, a more thorough understanding of the population dynamics will be possible. Fish above age-35 appear to be rare to nonexistent, which might promote the assumption of size or age truncation in the stock due to harvest pressure. However, the size structure (Figure 5) does not corroborate this. More data are needed to strengthen analyses and inform age-based models. The poor fit of the Grand Lake Von Bertalanffy growth curve model is hindered by fish aged 14-18 years that do not appear to fit the curve (Figure 7). Utility of this model appears suspect, and there is no discernible asymptote in the plot.

Figure 6. Observed age structure for Smallmouth Buffalo (n=134) collected using electrofishing in 2021 from Grand Lake.

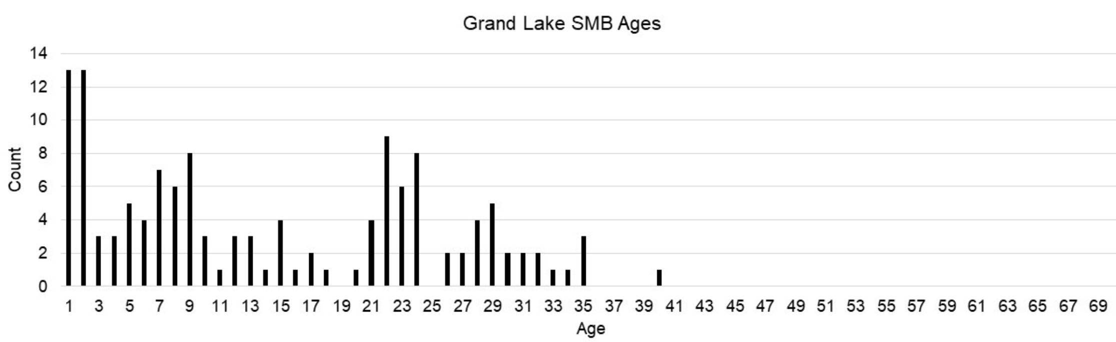
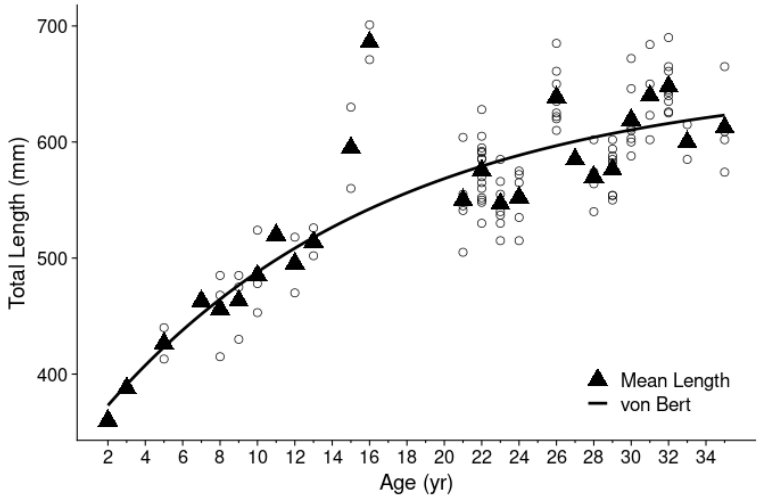


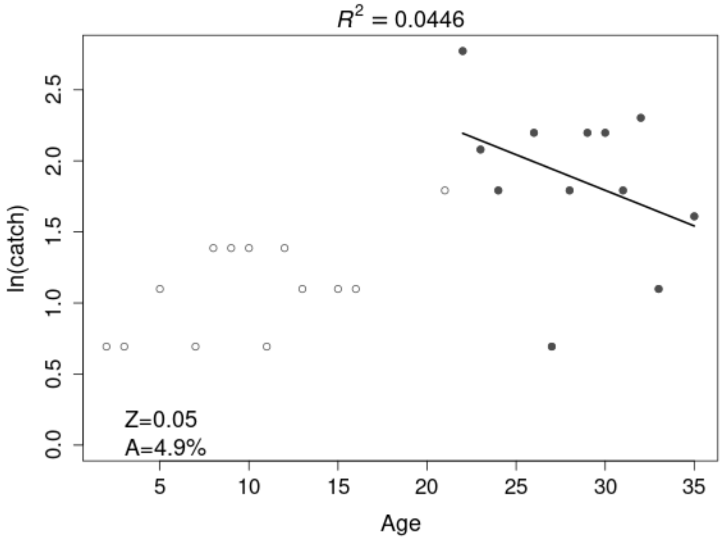
Figure 7. Von Bertalanffy growth curve for Smallmouth Buffalo from Grand Lake.



We observed that female Grand Lake Smallmouth Buffalo were gravid at 520 mm or greater (generally classified as stage 3 – maturing or stage 4 – mature). However, a large portion of the females collected of this size or greater were nongravid during the time of collection. This may be a strong indication that these fish may not be spawning annually. Gonadal recrudescence (or renewal) for buffalofishes is not well-studied, however in studies of Paddlefish, the rate of recrudescence may vary across latitudes, across stocks within the same species, or even within the lifespan of an individual fish (with shorter inter-spawning intervals [i.e., more rapid recrudescence] observed in older fish at prime reproductive potential) (Scarnecchia et al. 2007, 2019). Additional data on fecundity and gonadal recrudescence will be essential in determining accurate estimations of buffalofishes' resilience to exploitation. However, the little evidence we have from the Grand Lake Smallmouth Buffalo stock indicates that we would be prudent to consider modeling various multi-year spawning intervals when examining the potential population impacts of exploitation on Oklahoma's buffalofishes.

Total annual mortality of Smallmouth Buffalo in Grand Lake was estimated at 4.9% (Figure 8). Instantaneous rates of mortality are low in this population- including both natural and fishing mortality, however there still appears to be much uncertainty in this poorly-fitting model (R^2 = 0.0446). A stronger understanding of mortality is needed to set harvest limits based on maximum sustainable yield. Completion of age analyses on the 250 Grand Lake Smallmouth Buffalo specimens we have on hand will greatly improve our analytical abilities.

Figure 8. Catch Curve for Smallmouth/Black buffalofishes from Grand Lake.



Keystone Lake Smallmouth/Black Buffalo Population Dynamics – When age data from a 2023 Keystone Lake bowfishing tournament were added to tournament in 2024, a total of 229 Smallmouth Buffalo were available for further analysis on population dynamics. In the 2023 (n=174) and 2024 (n=55) samples, total lengths ranged 320-795 mm and 428-692 mm, respectively. Within the aged subsample from 2023, ages ranged 2-49 years old (n=128, Figure 9). In the Keystone Lake system, we see a wide range of lengths and ages collected which will necessitate a large sample to confidently evaluate this population.

The age frequency distribution for Smallmouth Buffalo collected by bowfishing from Keystone Lake is right-skewed, with most fish younger than age-20. No individuals collected were age-1. Failed detection of young cohorts is not necessarily evidence of lack of recruitment, as these individuals may be present in the population but not vulnerable to bowfishing (or the timing of collections). If early life history data are needed, alternative sampling methods may need to be evaluated. The age frequency distribution also indicates that few old fish may be in the population, given the longevity of the species, however the size structure (Figure 5) does not indicate an absence of larger fish. Some subtle cues of episodic recruitment may be observed in the age structure, but a larger sample size is likely needed before more robust analyses are possible. Inclusion of age data collected in 2024 will nearly double the sample size of specimens aged and provide better data for modeling population dynamics. Abiotic and biotic factors that may be driving potential strong and weak year classes are unknown but can be evaluated in the future. Von Bertalanffy growth curve indicates fish in this stock are reaching asymptotic length around age-15 (Figure 10). At this age, the growth curve begins to flatten or asymptote, indicating most fish are reaching sexual maturity. Mean lengths at age are quite variable, indicating that perhaps more age data are needed to refine the model before additional interpretation.

Figure 9. Observed age structure for Smallmouth Buffalo (n=128) from an August 2003 bowfishing tournament on Keystone Lake.

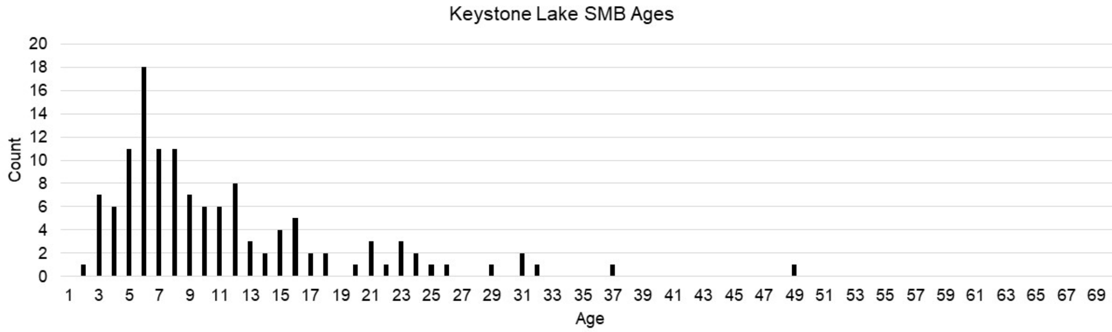
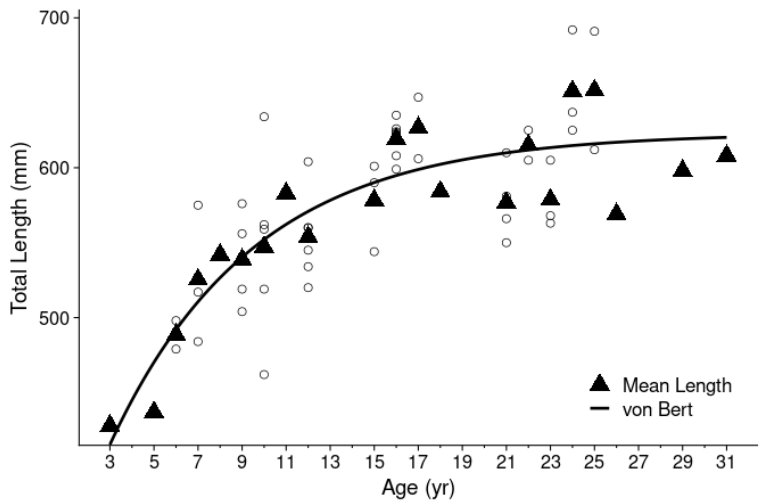
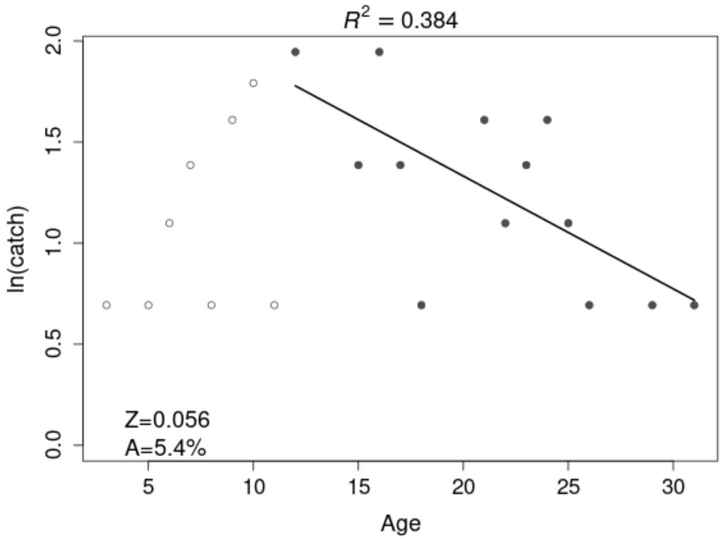


Figure 10. Von Bertalanffy growth curve for Smallmouth Buffalo from Keystone Lake.



Total annual mortality of Smallmouth Buffalo in Keystone Lake was estimated at 5.4% (Figure 11). Instantaneous rates of mortality are low in this population- including both natural and fishing mortality, however there still appears to be much uncertainty in the model (R^2 = 0.384). Further evaluation discerning natural and fishing mortality are needed to better understand the fishery. A stronger understanding of mortality is needed to set harvest limits based on maximum sustainable yield. These results will hopefully be achieved when all of the 2024 specimens have been aged, yielding an age sample of >200 Smallmouth Buffalo.

Figure 11. Catch Curve for Smallmouth Buffalo from Keystone Lake.



Tenkiller Lake Smallmouth/Black Buffalo Population Dynamics –Tenkiller Lake data were derived from two tournaments in 2024 for a total of 418 Smallmouth Buffalo used for further analysis on population dynamics. Total lengths ranged 233-720 mm for the full sample, and a subsample of aged fish ranged 1-69 years old (n=138, Figure 12). In the Tenkiller Lake system, we see a wide range of lengths and ages collected which will necessitate a large sample to confidently evaluate this population.

The age frequencies distribution indicates a wide distribution of ages for this species taken by bowfishing. Three individuals collected were age-1 or age-2, indicating at least some recent recruitment. A larger sample size may be required to validate this, but the age distribution appears to have a subtle pattern indicating episodic recruitment at regular intervals. For example, peaks are observed at approximately 6-7 year intervals: ages 6, 13, 19, 26, 33, 40, 44, and 50. The age frequency distribution also shows several missing year classes (7 and 32). This may be due to sample size, recruitment failure, or errors in age assignment. Abiotic and biotic factors that may be driving these strong and weak year classes are unknown but can be evaluated in the future. Age structure, when examined in context of size structure (Figure 5) suggests that growth is slower in Tenkiller than in Keystone or Grand lakes. Von Bertalanffy growth curve indicates fish are reaching asymptotic length at around age-20 (Figure 13) and growth appears to be slower than in Grand or Keystone.

Figure 12. Observed age structure for Smallmouth Buffalo (n=138) from Tenkiller Lake.

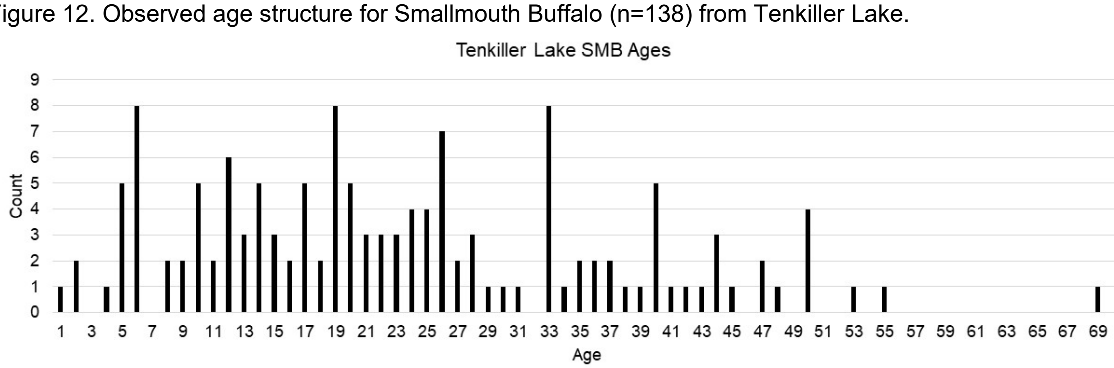
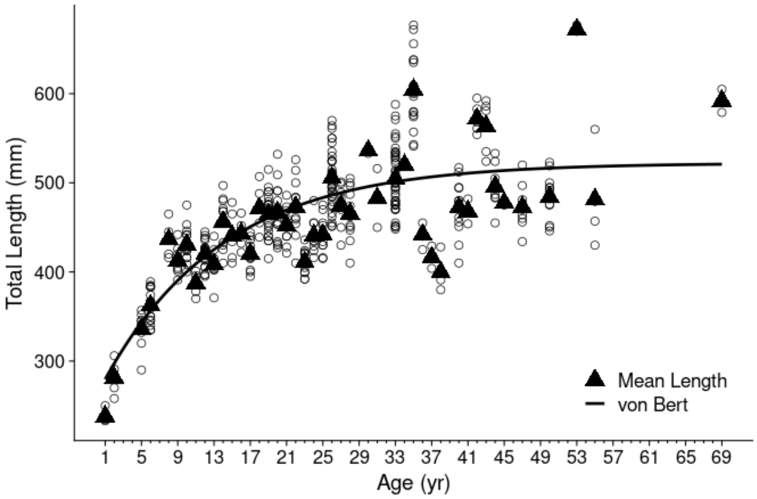
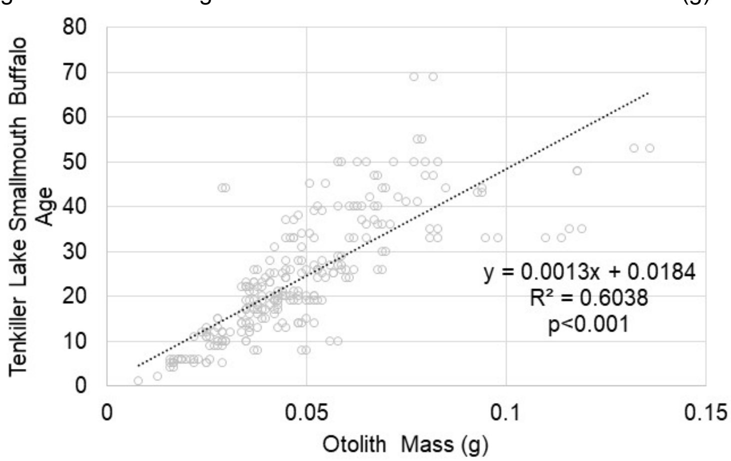


Figure 13. Von Bertalanffy growth curve for Smallmouth Buffalo from Tenkiller Lake.



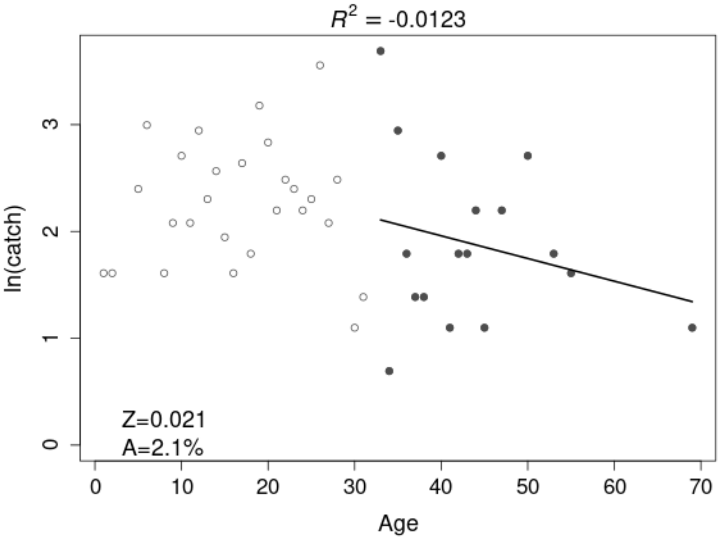
For a total of 137 Tenkiller Lake Smallmouth Buffalo, otolith mass was recorded to investigate the relationship to age. For most fish, both otoliths were weighed (n=114), but for the remainder (n=23) only one was weighed. Each individual weight was paired with the age assigned to that fish (both otoliths were not sectioned), resulting in a total of 252 data pairs used for linear regression. Otolith mass was positively correlated to estimated age for Smallmouth Buffalo in Tenkiller Lake (R^2= 0.6038, p<0.001, Figure 14), although variability was observed beyond approximately age 30 (likely linked to variability in age estimation). Future aging efforts will include otolith mass as an additional validation tool for the aging process.

Figure 14. Linear Regression for Smallmouth Buffalo otolith mass (g) and estimated age.



Total annual mortality of Smallmouth Buffalo in Tenkiller Lake was estimated at 2.1% (Figure 15). Instantaneous rates of mortality are low in this population- including both natural and fishing mortality, however there still appears to be much uncertainty in the model (R^2 = 0.0123). Further evaluation discerning natural and fishing mortality are needed to better understand the fishery. A stronger understanding of mortality is needed to set harvest limits based on maximum sustainable yield. These results will hopefully be achieved when all of the 2024 specimens have been aged, yielding an age sample of >400 Smallmouth Buffalo.

Figure 15. Catch Curve for Smallmouth Buffalo from Tenkiller Lake.



FUTURE EFFORTS AND MANAGEMENT RECOMMENDATIONS

Collections in 2025 and beyond: While opportunistic collections of buffalofishes 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 provided large volumes of specimens which will likely be adequate for assessment of age and growth, continuation/expansion of our buffalofish morphology and genetics project, and better fine tune our estimates of mortality and exploitation. Aging these specimens has proven time consuming, especially within other program priorities. We hope to enhance our productivity with aging buffalofishes in 2025, as we will not be obligated to acquire hundreds of new specimens each month from tournaments and intend to be more selective on which tournaments from which we might solicit additional samples. Overall, the collaboration with OFS was positive and we would like to maintain a communicative relationship.

In February 2025, we plan to scout locations for 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.

Regulatory strategies for management of nongame fishes: 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 prep). 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.

<u>Outreach, social media, and human dimensions:</u> ODWC, with the assistance of the Nongame Fishes Committee and our program, continues to be a leader among agencies advocating for the appreciation of NNG fishes. November 2024 saw another successful installment of the popular #GarWeek on social media platforms (i.e., “X” [Formerly Twitter], Facebook, Instagram, 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.

<u>Management plan for nongame fishes:</u> 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

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

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.

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.

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.

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.

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.

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., J. Sereda, M. Pollock, R. Bryshun, M. Chupik, K. McCallum, J. Villeneuve, E. S. Bielak-Lackmann, and M. E. Clark. 2023b. 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.

McAllister, C. T., E. M. Leis, D. G. Cloutman, and H. W. Robison. 2023. New Geographic Distribution Record for Quillback, *Carpiodes cyprinus* (Cypriniformes: Catostomidae) in the Verdigris River (Arkansas River drainage) of Northern Oklahoma.

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.

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.

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.

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., L. F. Ryckman, Y. Lim, G. J. Power, B. J. Schmitz, and J. A. Firehammer. 2007. Life History and the Costs of Reproduction in Northern Great Plains Paddlefish (*Polyodon spathula*) as a Potential Framework for Other Acipenseriform Fishes. Reviews in Fisheries Science 15(3):211–263.

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.

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.

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 prep. 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