

# Arrowhead Reservoir

## 2019 Fisheries Management Survey Report

PERFORMANCE REPORT

As Required by

FEDERAL AID IN SPORT FISH RESTORATION ACT

TEXAS

FEDERAL AID PROJECT F-221-M-4

INLAND FISHERIES DIVISION MONITORING AND MANAGEMENT PROGRAM

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## Survey and Management Summary

Fish populations in Arrowhead Reservoir were surveyed in 2019 using electrofishing, low-frequency electrofishing, and trap netting. Anglers (rod and reel and passive gear) targeting Blue Catfish were surveyed during a creel survey from September 2016 through February 2017. Anglers targeting all species were surveyed during a creel survey from June 2018 through May 2019. Historical data are presented with the 2018-2020 data for comparison. This report summarizes the results of the surveys and contains a management plan for the reservoir based on those findings.

**Reservoir Description:** Arrowhead Reservoir is a 14,969-acre impoundment located on the Little Wichita River in Archer and Clay Counties approximately 20 miles southeast of Wichita Falls. At time of sampling, the water elevation was near full capacity with the shoreline habitat consisting mainly of natural and rocky shoreline. The dam is located in Clay County and the reservoir is owned and operated by the City of Wichita Falls as a municipal and industrial water supply. Arrowhead has a shoreline length of 106 miles and a drainage basin of 832 square miles. Boat access is normally good with five improved public ramp sites around the reservoir. Public access includes 524-acre Lake Arrowhead State Park located on the northwest side near the dam. Bank access is adequate, but the only improved handicapped access is at the State Park. Some standing timber remains in the upper reservoir and backs of coves.

**Management History:** Important sport fish include Blue and Channel Catfish, Largemouth Bass, White Bass and White Crappie. Arrowhead is managed under statewide regulations. Fish attractors have been placed around the derricks located in the lower end of the reservoir in the past. More recent work includes placing artificial fish attractors around the state park piers and placing green lights under the fishing pier.

### Fish Community

- **Prey species:** Threadfin Shad were very abundant in the reservoir. Electrofishing catch rate of Gizzard Shad was very low, but almost all Gizzard Shad were available as prey to most sport fish. Electrofishing catch of Bluegill was also low, with no Bluegill 6-inches long or greater sampled.
- **Catfishes:** The Blue Catfish population continues to thrive providing an excellent fishery. Channel and Flathead Catfish were present in the reservoir.
- **White Bass:** White Bass were present in the reservoir but are not that popular with the anglers. Angling effort targeting this species was considered low.
- **Largemouth Bass:** Largemouth Bass were not abundant compared to historical numbers. While the percentage of tournament anglers seeking Largemouth Bass was up over the previous creel survey, the overall percentage of non-tournament anglers seeking the species was down.
- **White Crappie:** White Crappie were the most popular species in the reservoir with nearly half of the anglers targeting this species. The population abundance has been relatively constant over the last eight years.

**Management Strategies:** Request a stocking of fingerling Florida Largemouth Bass in 2020. Inform the public about the negative impacts of aquatic invasive species. Conduct additional electrofishing survey in 2020, and general monitoring surveys with trap nets, low-frequency electrofishing, and electrofishing surveys in 2023. Access and vegetation surveys will be conducted in 2023.

## Introduction

This document is a summary of fisheries data collected from Arrowhead Reservoir in 2018-2020. The purpose of the document is to provide fisheries information and make management recommendations to protect and improve the sport fishery. While information on other fishes was collected, this report deals primarily with major sport fishes and important prey species. Historical data are presented with the 2018-2020 data for comparison.

## Reservoir Description

Arrowhead Reservoir is a 14,969-acre impoundment constructed in 1966 on the Little Wichita River. It is located in Archer and Clay Counties approximately 20 miles southeast of Wichita Falls and is operated and controlled by the City of Wichita Falls. Primary uses include municipal and industrial water supply. Mean depth was 16 feet and maximum depth was 42 feet. Habitat at time of sampling consisted of natural and rocky shoreline. Some standing timber remains in the upper reservoir and backs of coves. Water level was near spillway elevation at time of habitat survey (Figure 1). The reservoir elevation rebounded in 2015 after years of drought (Figure 1) which had a positive influence on the fishery and fish populations. Other descriptive characteristics for Arrowhead are in Table 1.

## Angler Access

Arrowhead Reservoir has five public boat ramps and no private boat ramps. All five public ramps were available to anglers once the reservoir filled in 2015 after an extended drought. Additional boat ramp characteristics are in Table 2. Shoreline access can be found at the public boat ramp areas, bridges crossing three bays on the south side of the reservoir, one bridge on the east side of the reservoir, and in Lake Arrowhead State Park. Lake Arrowhead State Park also provides a boat dock as well as a fishing pier for anglers.

## Management History

**Previous management strategies and actions:** Management strategies and actions from the previous survey report (Mauk and Lang 2016) included:

1. Continue placing trees as fish attractors around State Park piers and explore funding sources for artificial structures.

**Action:** Found funding for artificial structures so placed Mossback, Fishiding, and Pond King artificial structures around the pier, dock, and shoreline.

2. Arrowhead is the most important reservoir in terms of angler numbers and pressure in the district so the district office must continue to provide information to the public about the reservoir.

**Action:** Utilized multiple media outlets to give the public current information about the reservoir and kept the TPWD Arrowhead web page updated.

3. Invasive species is a concern throughout Texas so we must always remind our constituents including the managing authorities, the public, and the media about the possibility of infestations and work with them to minimize the threat.

**Action:** Publicized the threat through presentations and the media. Worked with the City of Wichita Falls to sample Arrowhead Reservoirs for zebra mussel eDNA and veligers.

4. Arrowhead Reservoir has had a positive eDNA hit for zebra mussels in the past (though they have never been documented and all other water sampling has resulted in negative eDNA hits) so we must use caution in our management practices such as cleaning and drying gear, no transport of invasive species, and increasing our monitoring for their presence.

**Action:** Cleaned and dried sampling gear and let it sit unused for extended periods of time. We used Edward's protocol when transporting aquatic life to another waterbody and with the City of Wichita Falls, set up a biannual sampling of water from the reservoir.

5. Arrowhead Reservoir in the past has had a popular Largemouth Bass population with several tournaments being held at the reservoir. After the drought, the Largemouth Bass population had shown a marked decline, requiring a stocking to increase the population abundance.

**Action:** Fry and fingerling Florida strain Largemouth Bass were stocked in 2016. A 2017 fall electrofishing survey documented a more abundant population with good size structure.

6. The Blue Catfish fishery has grown in popularity but no recent information on the fishery exists, including passive gear harvest.

**Action:** Collected information about the Blue Catfish fishery by completing a Blue Catfish angler targeted creel survey, including passive gear anglers. Completed a low-frequency electrofishing survey for Blue Catfish in September of 2019.

**Harvest regulation history:** Sport fish species in Arrowhead Reservoir were managed using statewide regulations (Table 3).

**Stocking history:** Arrowhead Reservoir was last stocked with fry and fingerling Florida strain Largemouth Bass in 2016. It also received fingerlings in 2015. There had been no other recent stockings. The complete stocking history is in Table 4.

**Vegetation/habitat management history:** Problematic aquatic vegetation has not been observed in the reservoir. Fish attractors have been placed around the state park fishing pier, floating dock, and shoreline. Placement of brush piles outside the Lake Arrowhead State Park boundaries has occasionally occurred and the sites are listed on the TPWD website.

**Water transfer:** There are no inter-basin transfer of water from Arrowhead Reservoir.

## Methods

Surveys were conducted to achieve survey and sampling objectives in accordance with the objective-based sampling (OBS) plan for Arrowhead Reservoir (Mauk and Lang 2016). Primary components of the OBS plan are listed in Table 5. All survey sites were randomly selected, and all surveys were conducted according to the Fishery Assessment Procedures (TPWD, Inland Fisheries Division, unpublished manual revised 2017).

**Electrofishing** – Largemouth Bass, sunfishes, Gizzard Shad, and Threadfin Shad were collected by electrofishing (2 hours at 24, 5-min stations). Catch per unit effort (CPUE) for electrofishing was recorded as the number of fish caught per hour (fish/h) of actual electrofishing.

**Trap netting** – Crappie were collected using trap nets (15 net nights at 15 stations). CPUE for trap netting was recorded as the number of fish caught per net night (fish/nn).

**Low-frequency electrofishing** – Blue Catfish were collected by low-frequency electrofishing at 15 stations. The minimum duration of electrofishing at each station was 3 minutes. CPUE for electrofishing was recorded as the number of fish caught per hour (fish/h) of actual electrofishing.

**Statistics** – Sampling statistics (CPUE for various length categories), structural indices [Proportional Size Distribution (PSD), terminology modified by Guy et al. 2007], and condition indices [relative weight ( $W_r$ )] were calculated for target fishes according to Anderson and Neumann (1996). Index of Vulnerability (IOV) was calculated for Gizzard Shad (DiCenzo et al. 1996). Standard error (SE) was calculated for structural indices and IOV. Relative standard error ( $RSE = 100 \times SE$  of the estimate/estimate) was calculated for all CPUE and creel statistics.

**Creel survey** – A year-long roving creel survey was conducted from 2018 into 2019. The creel period was June through May. Angler interviews were conducted on 5 weekend days and 4 weekdays per quarter to assess angler use and fish catch/harvest statistics in accordance with the Fishery Assessment Procedures (TPWD, Inland Fisheries Division, unpublished manual revised 2017). In addition to the year-long creel survey, a six-month creel survey of rod and reel and passive gear anglers targeting Blue Catfish was conducted in 2016 and 2017. The creel period was September through February with angler interviews conducted on 5 weekend days and 4 weekdays per quarter.

**Habitat** – A structural habitat survey was conducted in 2015. Vegetation surveys have been conducted every four years to monitor aquatic vegetation. Habitat was assessed with the digital shapefile method (TPWD, Inland Fisheries Division, unpublished manual revised 2017).

**Water level** – Source for water level data was the United States Geological Survey (USGS 2020).

## Results and Discussion

**Habitat:** A habitat survey was last conducted in 2015 (Mauk and Lang 2016) and habitat has remained unchanged since then (Table 6). A vegetation survey was conducted with native emergent vegetation (cattails and bulrush) being the only type documented covering about 3% of the reservoir, the most ever documented (Table 7).

**Creel:** Directed fishing effort by anglers was highest for White Crappie (47.5%), followed by anglers fishing for catfish (25.3%; Table 8). Total fishing effort for all species decreased 15,000h since the previous creel survey in 2007/2008 but direct expenditures at Arrowhead Reservoir increased \$74,000 when comparing the two creel survey periods (Table 9). Anglers are willing to travel to fish Arrowhead Reservoir with as many traveling from 250 miles as those who report traveling 50 miles. Local anglers traveling 25 miles or less is the highest category though (Appendix D).

**Prey species:** Electrofishing catch rates of Gizzard Shad and Bluegill were 37.0/h and 12.5/h, respectively. Index of Vulnerability (IOV) for Gizzard Shad was excellent, indicating that 97% of Gizzard Shad were available to existing predators; this was higher than IOV estimate in 2017 and similar to that in 2015 (Figure 2). Total CPUE of Gizzard Shad was considerably lower than either of the previous two surveys (Figure 2). Total CPUE of Bluegill in 2019 was lower than the previous two surveys completed in

2015 and 2017, and size structure continued to be dominated by small individuals (Figure 3). Threadfin Shad had a catch rate of 1,895.5/h, much higher than in 2017 when the catch rate was 32.0/h and 2015 when no Threadfin Shad were sampled. It is unclear why Gizzard Shad abundance has dropped significantly while at the same time Threadfin Shad abundance has exploded. The Gizzard Shad population crash warrants additional monitoring efforts to determine if this is a one-time occurrence or if this a potential problem. This is especially important considering the tendency of Threadfin Shad to exhibit mass die-offs when the water temperature dips below 50° F. Monitoring predators mean relative weight is another measurement that can indicate how serious the lack of Gizzard Shad abundance is and whether additional management strategies such as stocking should be considered. Currently, Largemouth Bass mean relative weight is considered good and Blue Catfish are considered fair.

**Blue Catfish:** A low-frequency electrofishing survey was completed for Blue Catfish since creel data indicates that Blue Catfish is the catfish species that anglers target and the fishery supports several guides. The catch rate was 201.3/h with a stock length catch rate of 58.7/h indicating lots of legal-length fish were available to anglers (Figure 4). While CPUE-S RSE was > 25, CPUE-Total had an RSE <25 so no additional sampling was deemed necessary. Mean relative weight ranged from 80-105 with most inch groups falling in the 85-90 range. Comparing this to the 2016 gill net data when  $W_r$ 's ranged from 88-99 is hard since fish were collected at different times of the years. Gill nets collected pre-spawn catfish in spring and low-frequency electrofishing collected post spawn catfish in the fall. Another factor in the decline of  $W_r$  could be explained by the apparent decline of the Gizzard Shad population, though there is not enough data at this time to know for certain that there is a decline in  $W_r$  or is it explained by seasonal sampling differences discussed above. Directed fishing effort, catch per hour, and total harvest for Blue Catfish showed a significant increase over the previous 2007/2008 creel survey indicating the species has become very important to the anglers at Arrowhead Reservoir (Tables 8 and 10). Anglers targeting Blue Catfish increased from 1.8% of all anglers to 9.2% with another 14.5% identifying themselves as targeting catfish in general. Blue Catfish were generally harvested with only 12.4% of legal-length Blue Catfish released (Table 10). Observed harvest showed good angler compliance, and harvested fish ranged in length from 16 to 36 inches (Figure 5). A six-month creel of rod and reel and passive gear anglers targeting Blue Catfish was conducted from September 2016 to March 2017 (Figure 6; Table 11). Passive gear accounted for 39.1% of the total harvest of Blue Catfish for the period. Passive gear parties comprised 15.4% of contacted angling parties and 21.2% of rod and reel anglers reported using passive gear in the past for Blue Catfish.

**Channel Catfish:** Directed fishing effort remained nearly identical between the two creel surveys with the percent of anglers targeting Channel Catfish being 1.5% during the 2007/2008 creel survey and 1.6% during the 2018/2019 (Table 8). Angler directed effort is low for this species, so it is considered a negligible species with no further population survey work called for in the objective based sampling plan. The results from the recent creel survey found catch per hour and total harvest for Channel Catfish had decreased indicating the Channel Catfish were a minimal fishery at Arrowhead Reservoir (Table 12). Channel Catfish made up a harvest-oriented fishery as only 7.1% of the legal-length fish were released. Observed harvest in 2018/2019 showed good angler compliance, and harvested fish ranged in length from 12 to 22 inches (Figure 7).

**White Bass:** Directed fishing effort decreased by nearly half from 8,675.9 h in the 2007/2008 creel survey to 4,116.4 h in the 2018/2019 survey (Table 13). Anglers targeting White Bass dropped from 5.4% in 2007/2008 to 2.9% in 2018/2019. This species is considered a negligible species in the objective based sampling plan because of low targeted effort by anglers for this species, so no further population survey work was planned. Catch per hour doubled over the two creel survey periods, but total harvest for White Bass decreased from 23,121.2 fish, to 14,382.6 fish between the two surveys (Table 13). Approximately 30% of legal-length White Bass were released in the 2018/2019 creel survey, a decrease from the 2007/2008 survey where 43% of legal-length fish were released. Observed harvest in 2018/2019 showed good angler compliance, and harvested fish ranged in length from 10 to 16 inches (Figure 8).

**Largemouth Bass:** The sampling objective of CPUE with an RSE of  $\leq 25$  was met. The electrofishing catch rate of Largemouth Bass was 13.5/h in 2019, a decrease from 2017 when the catch rate was 41.0/h but a slight increase from 2015 when the catch rate was 9.5/h (Figure 9). Mean relative weight ranged

from 89-102 with most fish around 95. This compares to 2017 when it ranged from 93-126 with bass greater than 15 inches exhibiting excellent  $W_r$ 's. It is not apparent that low abundance of Gizzard Shad is having an influence on the Largemouth Bass population except on possibly the bigger fish. The 2015 survey was after the drought of record broke so the low abundance was understandable and with stockings occurring in 2016, it is understandable that the 2017 catch rate would be improved but the low abundance in 2019 was unexpected. The length frequency indicates poor recruitment with few sub-stock bass present. The reservoir has remained near capacity since 2015 and habitat would not be expected to be limiting as evidenced by the increase in emergent vegetation. The low abundance of Largemouth Bass probably affected the creel survey results, since the percentage of non-tournament anglers targeting Largemouth Bass dropped from 15.2% in 2007/2008 to 5.3% during 2018/2019 (Table 14). Tournament anglers increased slightly from 4.9% to 6.4% during the same two creel periods (Table 14), but tournament catch decreased (Table 14). Directed fishing effort, catch per hour, and total harvest for Largemouth Bass all declined from the previous 2007/2008 creel survey (Table 14). Less than half (43%) of the bass caught by non-tournament anglers were released though sample size is small (Table 14). Regulation adherence appears to have improved since no sub-legal length were documented during the 2018/2019 creel survey (Figure 10).

**White Crappie:** The survey objective of stock CPUE  $\leq 25$  was met. The trap net catch rate of White Crappie was 14.6/nn in 2019, similar to the 2015 and 2011 surveys when the catch rates were 22.5/nn and 14.1/nn respectively (Figure 11). Mean relative weight was excellent with most inch groups being over 100 but declined for larger fish. This excellent relative weight for most crappie is possibly due to the high abundance of Threadfin Shad. Threadfin Shad may have provided forage for most crappie but the larger individuals may need slightly bigger prey to maintain their weight. It is possible that they utilize the larger Gizzard Shad whose abundance was quite low in 2019. White Crappie was the most popular targeted species in Lake Arrowhead with 47.5% of directed fishing effort in the 2018/2019 creel survey, an increase over the 42.2% targeting them in 2007/2008 (Table 8). There was little difference in directed effort for White Crappie between the 2007/2008 and 2018/2019 creel surveys with an estimated 68,559 hours for the recent creel survey (Table 15). Estimated total harvest increased from 96,818 to 104,433 fish per year (Table 15). Size of harvested White Crappie in 2018/2019 ranged from 9 to 15 inches in total length (Figure 12).



# Fisheries Management Plan for Arrowhead Reservoir, Texas

Prepared – July 2020

**ISSUE 1:** Largemouth Bass have been an important part of the fishery at Arrowhead Reservoir with many tournaments being held targeting this species. The 2019 electrofishing survey resulted in few sub-stock bass being found indicating poor recruitment. The 2018-2019 creel also found reduced catch and harvest rates as well as effort for anglers targeting this species.

## MANAGEMENT STRATEGIES

1. Request a stocking of fingerling Florida Largemouth Bass at 1,000 fish/km in 2020.
2. Complete an additional electrofishing survey in 2020 including a category 2 age and growth analysis, as well as a genetic analysis of the population. A standard survey in 2023 to monitor the species will be completed.

**ISSUE 2:** Gizzard Shad and Bluegill abundance was down, two important prey species that are needed for healthy predator populations. Threadfin Shad are quite abundant but with Threadfin Shad being prone to die offs during periods of cold-water temperatures, monitoring these species is warranted.

## MANAGEMENT STRATEGY

1. Complete an additional electrofishing survey in 2020, as well as the standard survey in 2023 to monitor the species.
2. Examine Largemouth Bass mean relative weight to determine if prey species are adequate for the Largemouth Bass population.
3. Stocking of Gizzard Shad would be considered if abundance continues to be of concern and predator relative weights are poor.

**ISSUE 3:** Arrowhead Reservoir has had a positive eDNA hit for zebra mussels in the past (though they have never been documented and all other water sampling has resulted in negative eDNA hits) so we must use caution in our management practices such as cleaning and drying gear, no transport of invasive species, and increasing our monitoring for their presence.

## MANAGEMENT STRATEGIES

1. Plan gear usage so as not to possibly spread zebra mussels but clean and dry gear after usage.
2. Continue partnership began in 2019 of collecting water samples for the City of Wichita Falls, who run tests for eDNA and presence/absence of veligers. In the case of a positive test, have Texas Parks and Wildlife rerun sample for quality assurance.

**ISSUE 4:** White Bass estimated catch and harvest rates determined by the creel survey indicates a good White Bass population exists but is underutilized regarding anglers targeting the species.

## MANAGEMENT STRATEGY

1. Promote the fishery to the public when making presentations, talking to individuals, and through social media.

**ISSUE 5:** Many invasive species threaten aquatic habitats and organisms in Texas and can adversely affect the state ecologically, environmentally, and economically. For example, zebra mussels (*Dreissena polymorpha*) can multiply rapidly and attach themselves to any available hard structure, restricting water flow in pipes, fouling swimming beaches, and plugging engine cooling systems. Giant salvinia (*Salvinia molesta*) and other invasive vegetation species can form dense mats, interfering with recreational activities like fishing, boating, skiing, and swimming. The financial costs of controlling and/or eradicating these types of invasive species are significant. Additionally, the potential for invasive species to spread to other river drainages and reservoirs via watercraft and other means is a serious threat to all public waters of the state.

#### MANAGEMENT STRATEGIES

1. Cooperate with the controlling authority to maintain appropriate signage at access points around the reservoir.
2. Educate the public about invasive species through the use of media and the internet.
3. Make a speaking point about invasive species when presenting to constituent and user groups.
4. Keep track of (i.e., map) future inter-basin water transfers to facilitate potential invasive species responses.

## Objective-Based Sampling Plan and Schedule (2020-2024)

#### Sport fish, forage fish, and other important fishes

Sport fishes in Arrowhead Reservoir have historically included Blue, Channel and Flathead Catfish, White Bass, Largemouth Bass, and White Crappie. The primary forage species has been Bluegill and Gizzard Shad. Threadfin Shad were an important prey species in the 2019 electrofishing survey.

#### Negligible fisheries

The most recent creel survey completed in 2018/2019 found low percentages of anglers targeting Channel Catfish and White Bass so survey work on these two species is not deemed needed. In addition, Channel Catfish have historically been present but in low abundance in gill net surveys.

#### Survey objectives, fisheries metrics, and sampling objectives

**Largemouth Bass:** Abundance was considered low in the electrofishing survey completed in 2019. A stocking request was made for fingerling Florida Largemouth Bass stocking in 2020. This fishery is popular with both tournament and non-tournament anglers and needs management attention. An additional electrofishing survey will be completed in 2020 as well as the report year scheduled in 2023. The objective of both surveys will be general monitoring of this recovering fishery, sampling 24 random sites to collect meaningful CPUE data with a CPUE-S with a RSE  $\leq 25$  with no additional sampling if RSE is not achieved. This amount of sampling was sufficient in 2019 to achieve sampling objective. Collection of 50 stock-length bass will be collected to examine size structure. All stock-length bass will be measured and weighed for relative weight analysis. In 2023, a mean length at age category 2 analysis will be completed collecting 13 Largemouth Bass between the lengths of 13.0 to 14.9 inches in length. Thirty bass for genetic analysis will also be collected since it was last completed in 2011 and the reservoir was greatly impacted by the drought that ended in 2015.

**Bluegill, Gizzard and Threadfin Shad:** These species will be collected while electrofishing for Largemouth Bass and the objective is general monitoring. Gizzard Shad CPUE with  $RSE \leq 25$  is the objective and has been met in the previous electrofishing surveys presented in this report. It is anticipated that the number of Gizzard Shad collected will be sufficient for IOV calculation. No objectives will be set for data collection for Bluegill since past surveys have shown are near impossible to meet, so no additional sampling will occur except for that expended for Largemouth Bass.

**White Crappie:** White Crappie will be surveyed using 15 random trap net sites in 2023. This effort in the past has been adequate to attain the stated objectives that follow. General monitoring will suffice with a sampling objective of a meaningful CPUE with  $CPUE-S RSE \leq 25$ . Collection of 50 stock-length crappie will occur examine size structure. All stock-length crappie will be measured and weighed for relative weight analysis.

**Blue Catfish:** Low-frequency electrofishing will be utilized to sample the important Blue Catfish fishery in 2023. Twenty 3-minute random stations will be completed, with a general monitoring sampling objective of achieving  $CPUE-S RSE \leq 25$ . Collection of 50 stock-length catfish for size structure will be an objective as well. All stock-length and greater will be measured and weighed for relative weight reporting. Fifteen stations did not prove adequate for a meaningful CPUE with  $CPUE-S RSE \leq 25$  so increasing the effort to 20 which should prove adequate to achieve the stated objective goals. No additional sampling will be completed if objectives are not met.

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## Tables and Figures

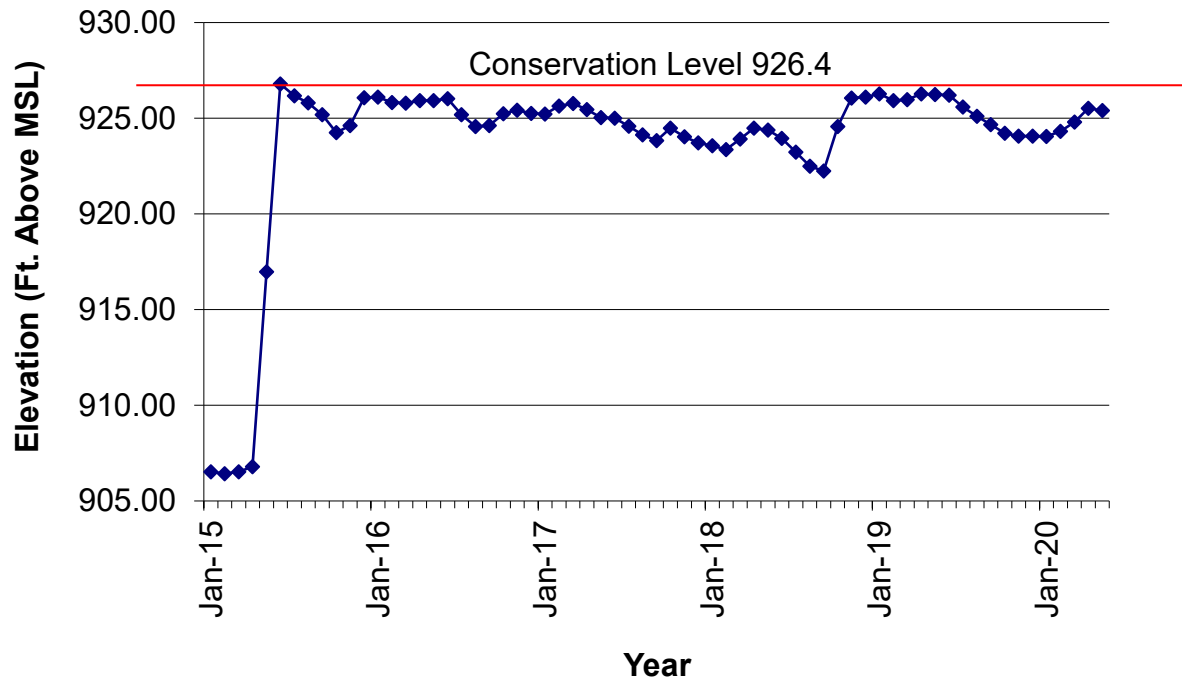


Figure 1. Monthly water level elevations in feet above mean sea level (MSL) recorded for Arrowhead Reservoir, Texas.

Table 1. Characteristics of Arrowhead Reservoir, Texas.

Characteristic	Description
Year constructed	1966
Controlling authority	City of Wichita Falls
Counties	Archer and Clay
Reservoir type	Mainstem
Shoreline Development Index	6.4
Conductivity	373 $\mu$ S/cm

Table 2. Boat ramp characteristics for Arrowhead Reservoir, Texas, August, 2019. Reservoir elevation at time of survey was 925.1 feet above mean sea level.

Boat ramp	Latitude Longitude (dd)	Public	Parking capacity (N)	Elevation at end of boat ramp (ft)	Condition
State Park	33.75475 -98.38766	Y	115	916	Good
Westside Ramp	33.74502 -98.36544	Y	25	906	Good
Pawnee Point	33.74158 -98.33917	Y	10	917	Good
Henrietta Bridge	33.72989 -98.31939	Y	50	917	Good
Dam	33.66894 -98.37933	Y	7	920	Good

Table 3. Harvest regulations for Arrowhead Reservoir, Texas.

Species	Bag limit	Length limit
Catfish: Channel and Blue Catfish, their hybrids and subspecies	25 (in any combination)	12-inch minimum
Catfish, Flathead	5	18-inch minimum
Bass, White	25	10-inch minimum
Bass, Largemouth	5	14-inch minimum
Crappie: White and Black Crappie, their hybrids and subspecies	25 (in any combination)	10-inch minimum

Table 4. Stocking history for Arrowhead, Texas. FGL = fingerling; AFGL = advanced fingerling; ADL = adult; and UNK = unknown.

<b>Species</b>	<b>Year</b>	<b>Number</b>	<b>Life Stage</b>	<b>Mean TL (in)</b>
Blue Catfish	1987	24,100	FGL	2.0
	1988	16	ADL	15.8
	1995	333,436	FGL	2.0
	Total	357,552		
Channel Catfish	1967	60,000	AFGL	7.9
	1969	10,000	AFGL	7.9
	1970	121,600	AFGL	7.9
	1972	155,000	AFGL	7.9
	Total	346,600		
Florida Largemouth Bass	1990	405,682	FRY	0.6
	1995	408,934	FGL	1.3
	2001	397,726	FGL	1.5
	2005	136,905	FGL	1.9
	2006	360,109	FGL	1.6
	2010	376,777	FGL	1.6
	2015	116,638	FGL	1.8
	2016	180,811	FGL	1.8
	2016	604,125	FRY	0.3
	2020	102,246	FGL	1.8
	Total	3,089,953		
Largemouth Bass	1967	468,000	FRY	0.7
	1970	50,000	UNK	0.0
	1971	105,000	UNK	0.0
	Total	623,000		
Striped Bass	1982	25,351	UNK	0.0
	1983	126,805	UNK	0.0
	Total	152,156		

Table 5. Objective-based sampling plan components for Arrowhead Reservoir, Texas 2016–2019.

Gear/target species	Survey objective	Metrics	Sampling objective
<i>Electrofishing</i>			
Largemouth Bass	Abundance	CPUE–Stock	RSE-Stock $\leq$ 25
<i>Low-frequency electrofishing</i>			
Blue Catfish	Abundance	CPUE–stock	RSE-Stock $\leq$ 25
<i>Trap netting</i>			
Crappie	Abundance	CPUE–stock	RSE-Stock $\leq$ 25

Table 6. Survey of structural habitat types, Arrowhead Reservoir, Texas, 2015. Shoreline habitat type units are in miles and standing timber and boat docks are in acres.

Habitat type	Estimate	% of total
Bulkhead	<0.1 miles	<0.1
Natural	121.0 miles	94.3
Rocky	6.6 miles	5.1
Rocky bluff	0.7 miles	0.5
Boat docks	9.7 acres	<0.1
Standing timber	1,384.6 acres	11.9

Table 7. Survey of aquatic vegetation, Arrowhead Reservoir, Texas, 2003–2019. Surface area (acres) is listed with percent of total reservoir surface area in parentheses.

Vegetation	2003	2007	2011	2015	2019
Native submersed	0.3 (<0.1)	29.3 (<0.1)			
Native floating-leaved		47.2 (0.3)	3.5 (<0.1)	2.4 (<0.1)	
Native emergent		45.2 (0.3)			439.8 (3.1)



Table 8. Percent directed angler effort by species for Arrowhead Reservoir, Texas, 2007–2008 and 2018–2019. Survey periods were from 1 June through 31 May.

Species	2007/2008	2018/2019
Blue Catfish	1.8	9.2
Channel Catfish	1.5	1.6
White Bass	5.4	2.9
Largemouth Bass	15.2	5.3
White Crappie	42.2	47.5
Anything	21.2	11.8
Sunfish	0.6	
Crappie spp.		0.9
Catfish spp.	7.1	14.5
Bass Tournament	4.9	6.4

Table 9. Total fishing effort (h) for all species and total directed expenditures at Arrowhead Reservoir, Texas, 2007/2008 and 2018/2019. Survey periods were from 1 June through 31 May. Relative standard error is in parentheses.

Creel statistic	2007/2008	2018/2019
Total fishing effort	159,542 (15)	144,215 (16)
Total directed expenditures	\$681,022 (19)	\$765,930 (20)

## Gizzard Shad

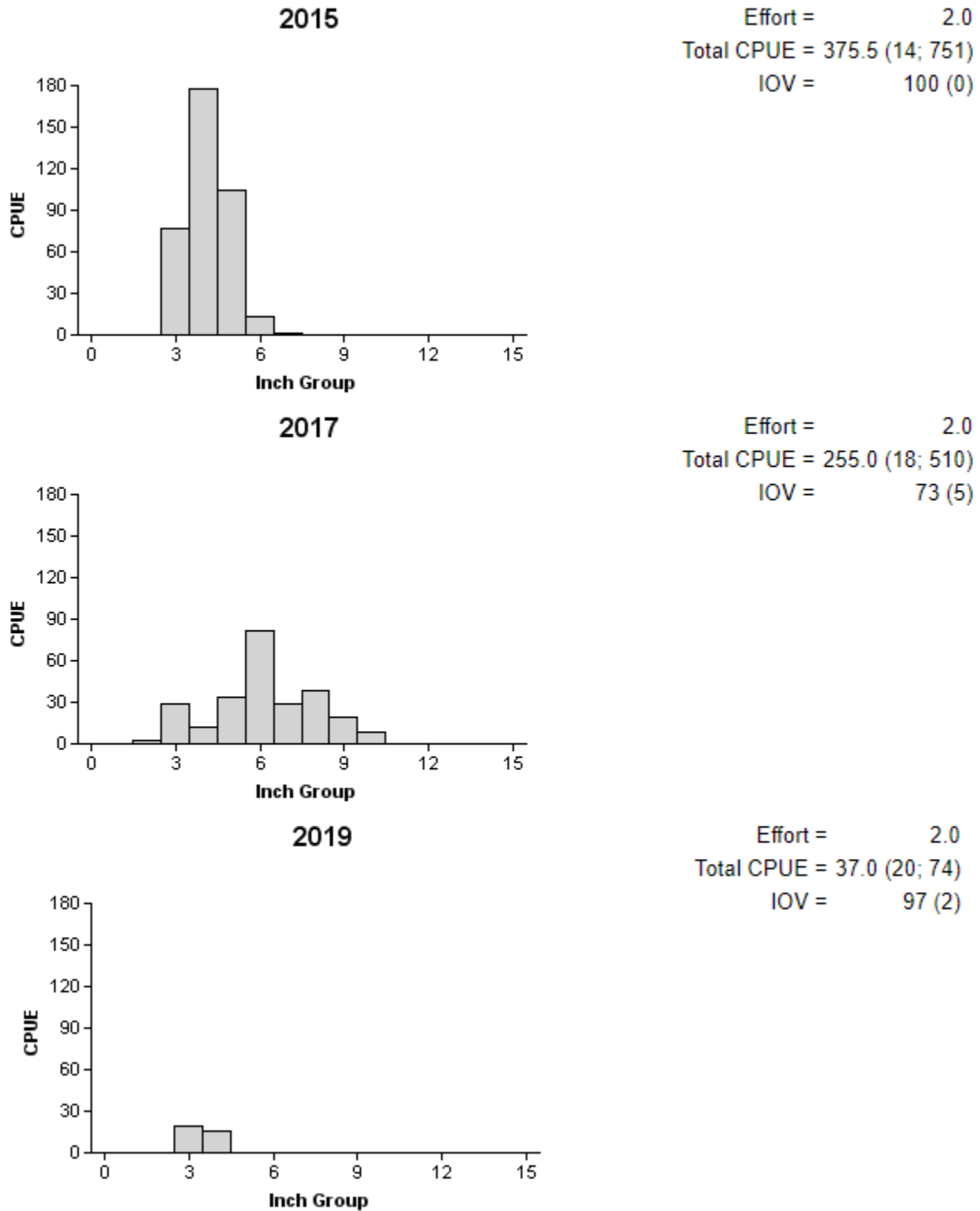


Figure 2. Number of Gizzard Shad caught per hour (CPUE) and population indices (RSE and N for CPUE and SE for IOV are in parentheses) for fall electrofishing surveys, Arrowhead Reservoir, Texas, 2015, 2017, and 2019.

## Bluegill

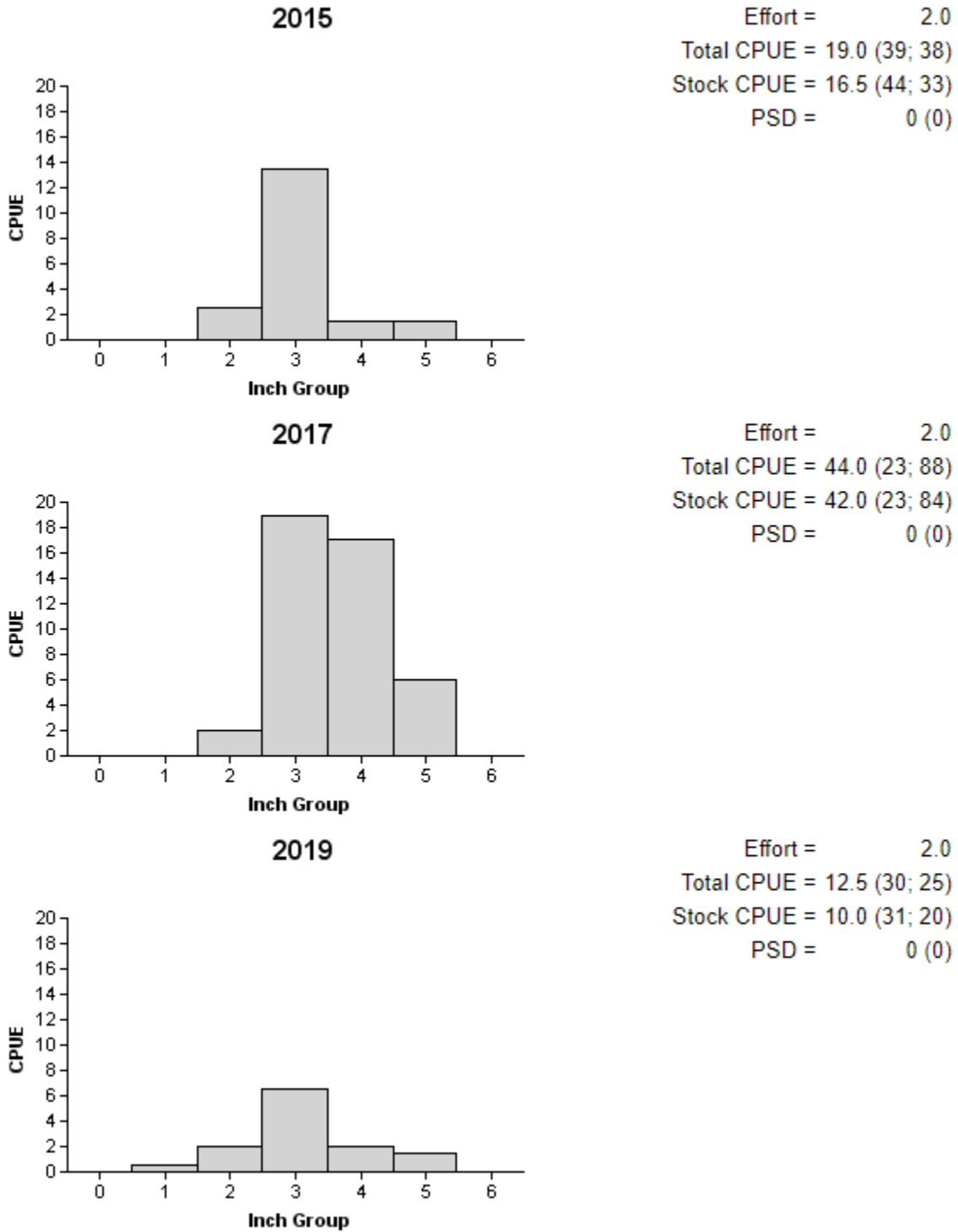


Figure 3. Number of Bluegill caught per hour (CPUE) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for fall electrofishing surveys, Arrowhead Reservoir, Texas, 2015, 2017, and 2019.

## Blue Catfish

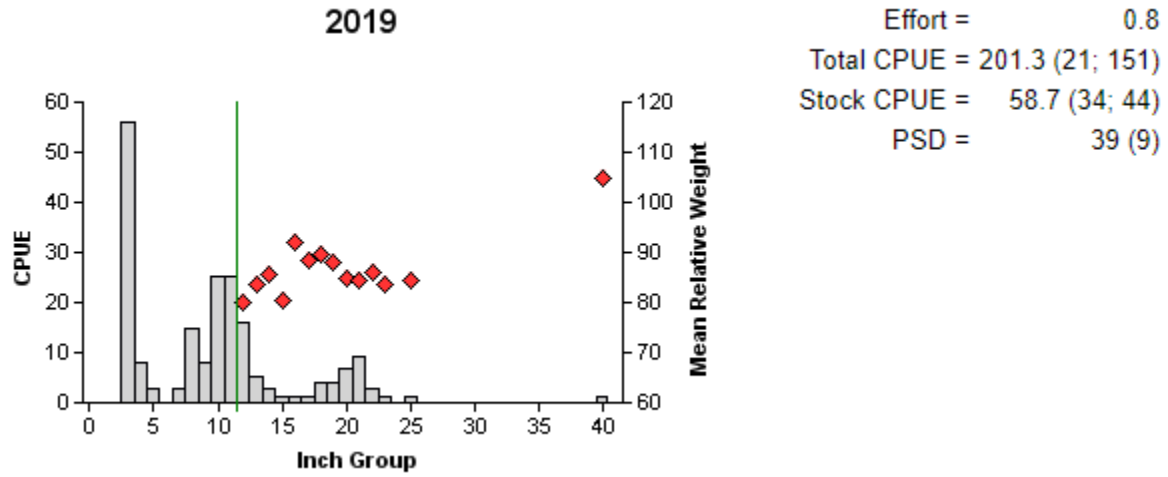


Figure 4. Number of Blue Catfish caught per net night (CPUE) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) fall low-frequency electrofishing survey, Arrowhead Reservoir, Texas, 2019. Vertical line indicates minimum length limit.

Table 10. Creel survey statistics for Blue Catfish at Arrowhead Reservoir, Texas, from June 2007 through May 2008 and June 2018 through May 2019. Total catch per hour is for anglers targeting Blue Catfish and total harvest is the estimated number of Blue Catfish harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Creel survey statistic	Year	
	2007/2008	2018/2019
Surface area (acres)	13,629	13,939
Directed effort (h)	2,940.9 (33)	13,210.3 (20)
Directed effort/acre	0.2 (33)	0.9 (20)
Total catch per hour	0.5 (108)	0.7 (73)
Total harvest	5,697.5 (59)	10,300.3 (40)
Harvest/acre	0.4 (59)	0.7 (40)
Percent legal released	21.0	12.4

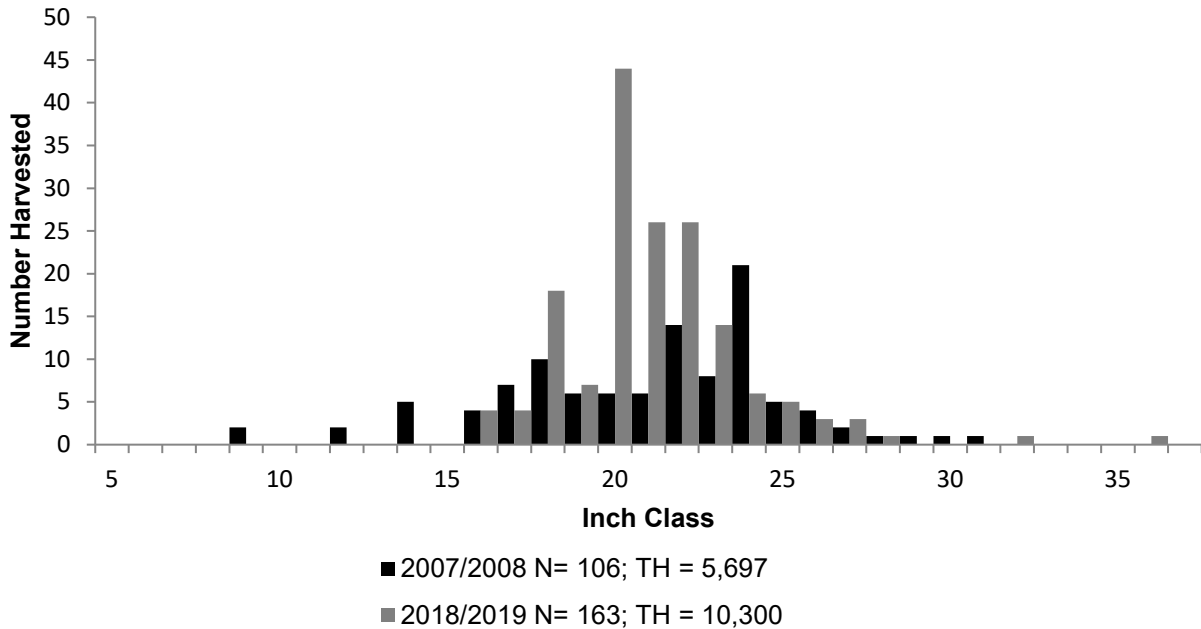


Figure 5. Length frequency of harvested Blue Catfish observed during creel surveys at Arrowhead Reservoir, Texas, June 2007 through May 2008 and June 2018 through May 2019, all anglers combined. N is the number of harvested Blue Catfish observed during creel surveys, and TH is the total estimated harvest for the creel period.

Table 11. Creel survey statistics for Blue Catfish at Arrowhead Reservoir, Texas, from September 2016 through February 2017 for rod and reel angling. Total catch per hour is for anglers targeting Blue Catfish and total harvest is the estimated number of Blue Catfish harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Creel survey statistic	Year
	2016/2017
Surface area (acres)	14,969
Directed effort (h)	8,027.7 (22)
Directed effort/acre	0.5 (22)
Total catch per hour	0.6 (50)
Total harvest	3,383.6 (66)
Harvest/acre	0.2 (66)
Percent legal released	26.5

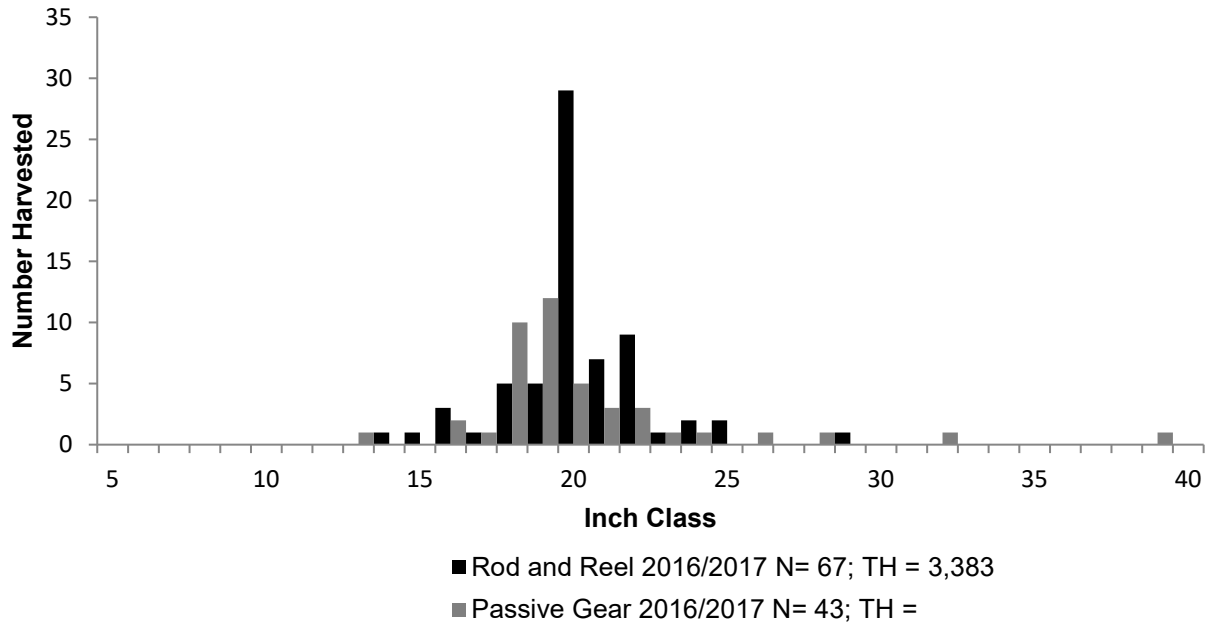


Figure 6. Length frequency of harvested Blue Catfish observed during creel surveys at Arrowhead Reservoir, Texas, September 2016 through February 2017, for rod and reel anglers and passive gear anglers. N is the number of harvested Blue Catfish observed during creel surveys, and TH is the total estimated harvest for the creel period.

## Channel Catfish

Table 12. Creel survey statistics for Channel Catfish at Arrowhead Reservoir, Texas, from June 2007 through May 2008 and June 2018 through May 2019. Total catch per hour is for anglers targeting Channel Catfish and total harvest is the estimated number of Channel Catfish harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Creel survey statistic	Year	
	2007/2008	2018/2019
Surface area (acres)	13,629	13,939
Directed effort (h)	2,326.8 (31)	2,356.8 (43)
Directed effort/acre	0.2 (31)	0.2 (43)
Total catch per hour	0.4 (75)	0.2 (100)
Total harvest	4,539.1 (73)	1,619.3 (122)
Harvest/acre	0.3 (73)	0.1 (122)
Percent legal released	14.1	7.1

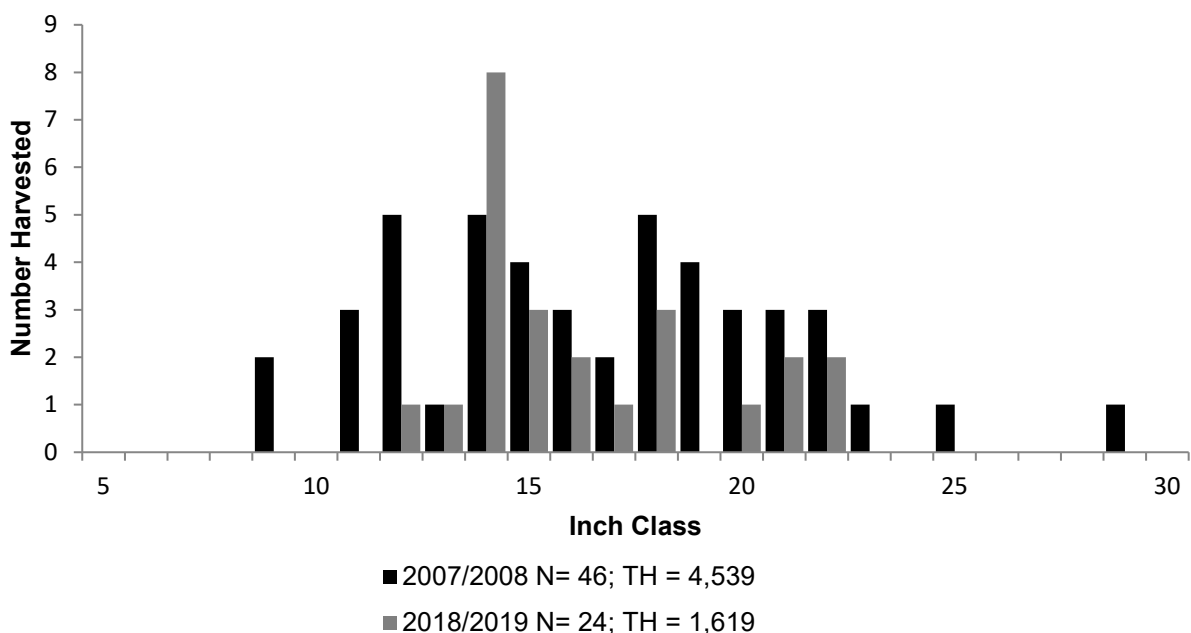


Figure 7. Length frequency of harvested Channel Catfish observed during creel surveys at Arrowhead Reservoir, Texas, June 2007 through May 2008 and June 2018 through May 2019, all anglers combined. N is the number of harvested Channel Catfish observed during creel surveys, and TH is the total estimated harvest for the creel period.

## White Bass

Table 13. Creel survey statistics for White Bass at Arrowhead Reservoir, Texas, from June 2007 through May 2008 and June 2018 through May 2019. Total catch per hour is for anglers targeting White Bass and total harvest is the estimated number of White Bass harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Creel survey statistic	Year	
	2007/2008	2018/2019
Surface area (acres)	13,629	13,939
Directed effort (h)	8,675.9 (22)	4,116.4 (30)
Directed effort/acre	0.6 (22)	0.3 (30)
Total catch per hour	1.6 (45)	3.3 (33)
Total harvest	23,121.2 (26)	14,382.6 (40.8)
Harvest/acre	1.7 (26)	1.0 (40.8)
Percent legal released	43	30

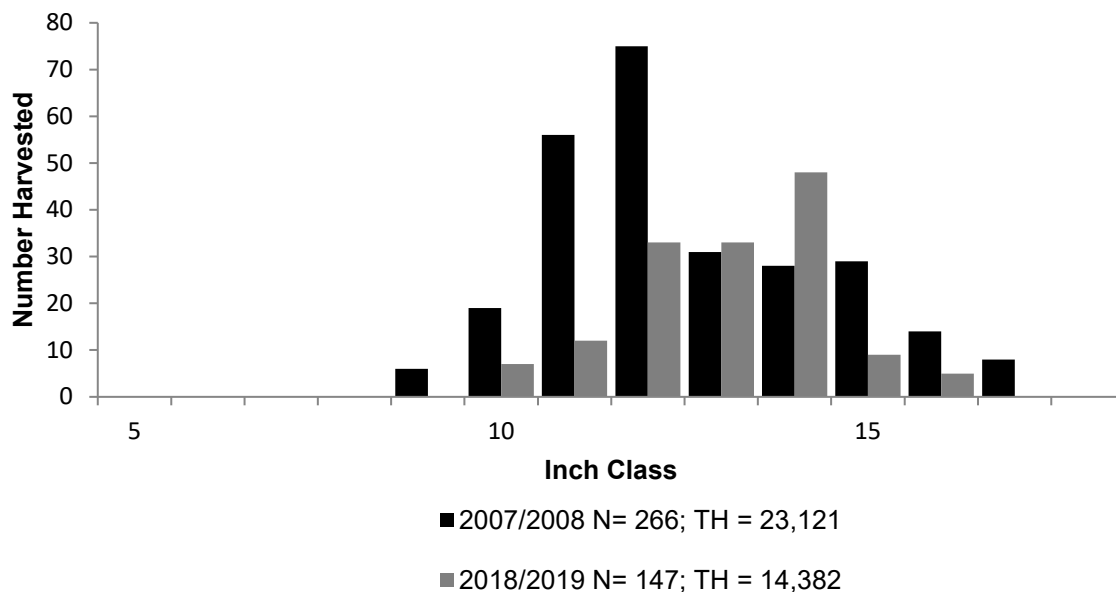


Figure 8. Length frequency of harvested White Bass observed during creel surveys at Arrowhead Reservoir, Texas, June 2007 through May 2008 and June 2018 through May 2019, all anglers combined. N is the number of harvested White Bass observed during creel surveys, and TH is the total estimated harvest for the creel period.



## Largemouth Bass

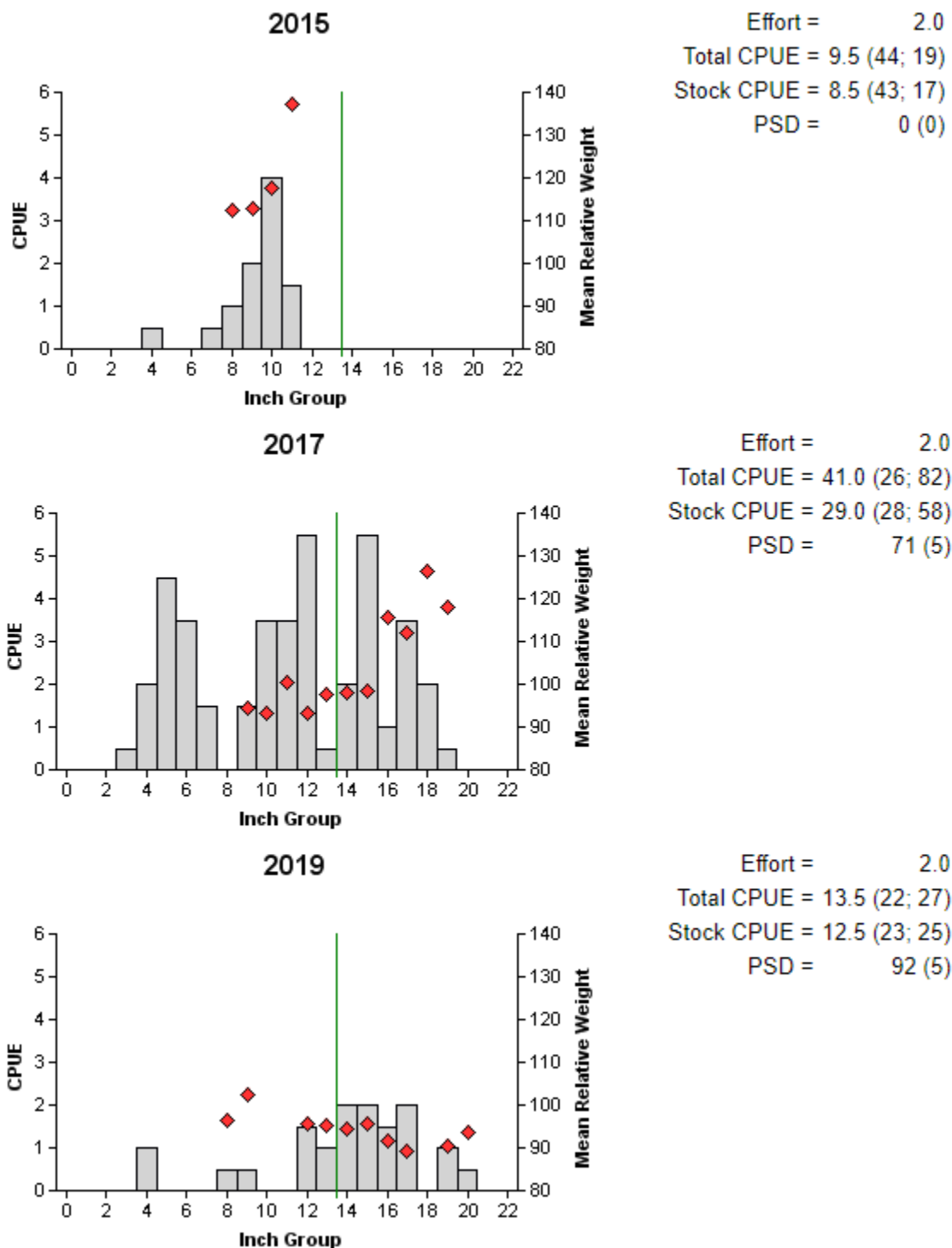


Figure 9. Number of Largemouth Bass caught per hour (CPUE, bars), mean relative weight (diamonds), and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for fall electrofishing surveys, Arrowhead Reservoir, Texas, 2015, 2017, and 2019. Vertical line indicates minimum length limit.

Table 14. Creel survey statistics for Largemouth Bass at Arrowhead Reservoir, Texas, from June 2007 through May 2008 and June 2018 through May 2019. Catch rate is for all anglers targeting Largemouth Bass. Harvest is partitioned by the estimated number of fish harvested by non-tournament anglers and the number of fish retained by tournament anglers for weigh-in and release. The estimated number of fish released by weight category is for anglers targeting Largemouth Bass. Relative standard errors (RSE) are in parentheses.

Statistic	2007/2008	2018/2019
Surface area (acres)	13,629	13,939
Directed angling effort (h)		
Tournament	7,848.5 (28)	9,189.2 (24)
Non-tournament	24,304.3 (17)	7,619.7 (21)
All black bass anglers combined	32,152.8 (18)	16,808.9 (19)
Angling effort/acre	2.4 (18)	1.2 (19)
Catch rate (number/h)	0.9 (25)	0.4 (60)
Harvest		
Non-tournament harvest	3,178 (57)	944 (344)
Harvest/acre	0.2 (57)	0.1 (344)
Tournament weigh-in and release	3,686 (87)	2,248 (75)
Release by weight		
<4.0 lbs	NA	3,322 (82)
4.0-6.9 lbs	NA	1,204 (82)
7.0-9.9 lbs	NA	8 (88)
≥10.0 lbs	NA	0 (-)
Percent legal released (non-tournament)	70	43

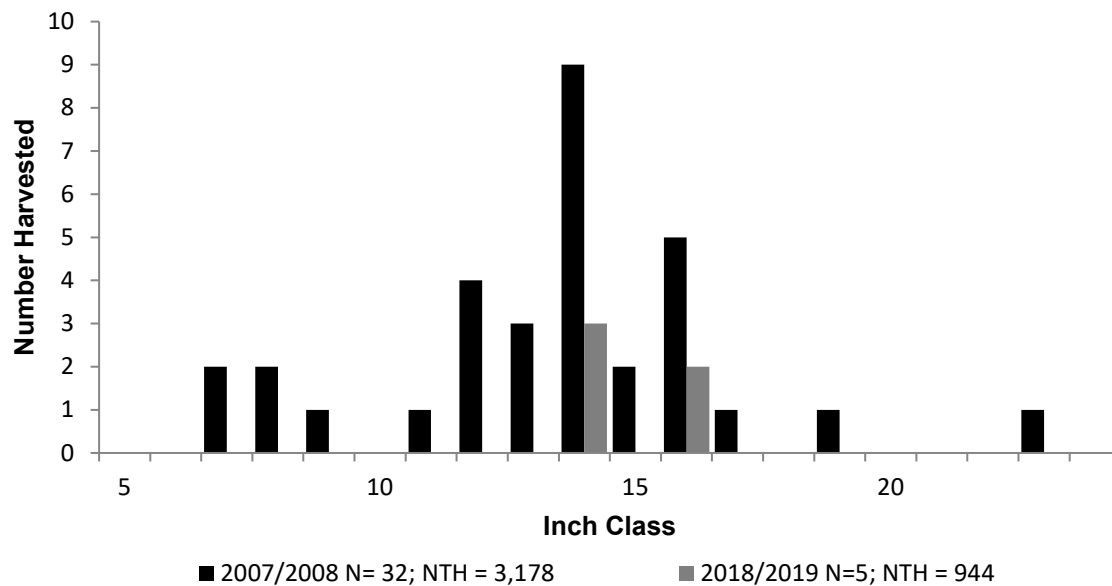


Figure 10. Length frequency of non-tournament harvested Largemouth Bass observed during creel surveys at Arrowhead Reservoir, Texas, June 2007 through May 2008 and June 2018 through May 2019, all anglers combined. N is the number of harvested Largemouth Bass observed during creel surveys, and NTH is the estimated non-tournament harvest for the creel period.

## White Crappie

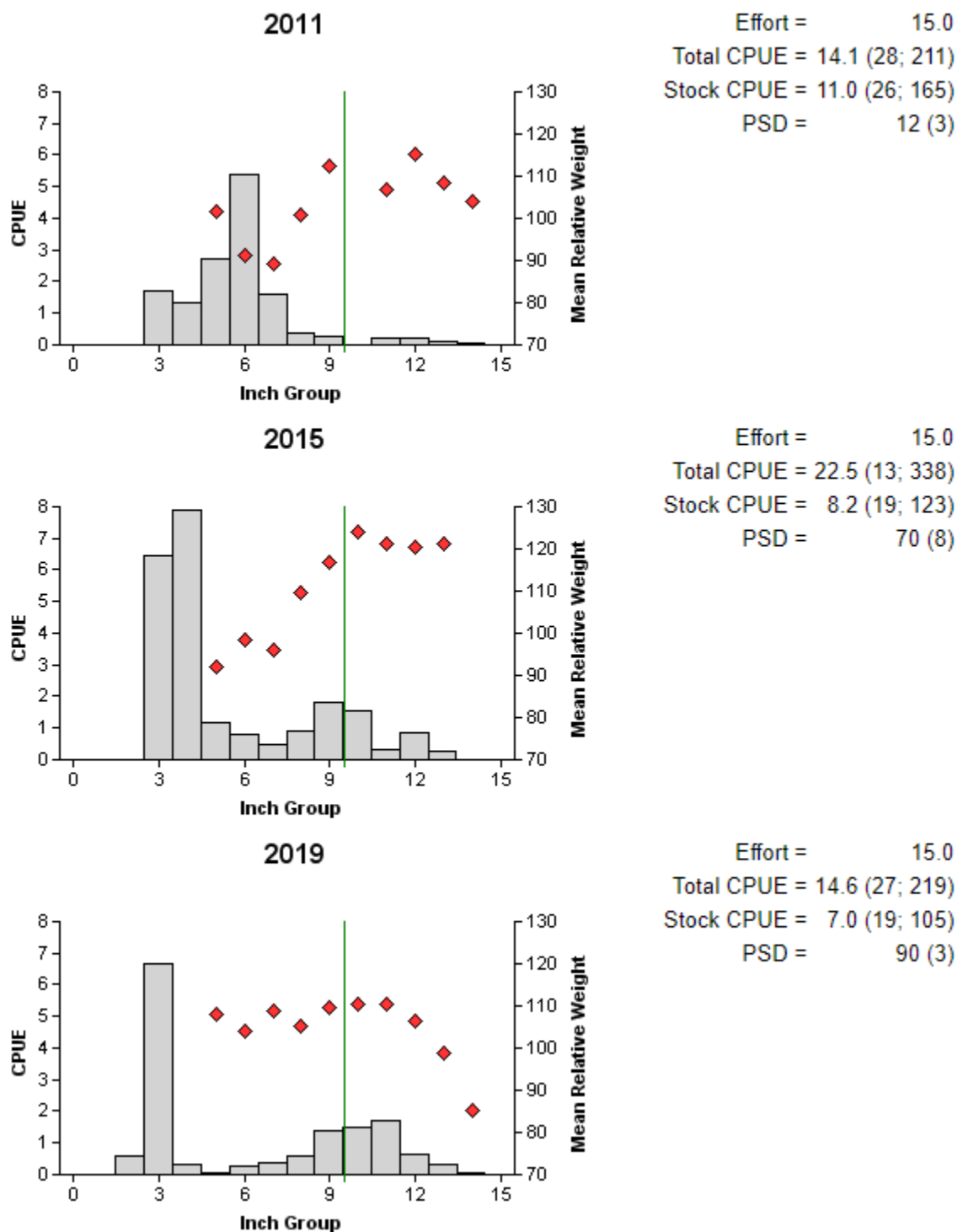


Figure 11. Number of White Crappie caught per net night (CPUE, bars), mean relative weight (diamonds), and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for fall trap netting surveys, Arrowhead Reservoir, Texas, 2011, 2015, and 2019. Vertical line indicates minimum length limit.

Table 15. Creel survey statistics for White Crappie at Arrowhead Reservoir, Texas, from June 2007 through May 2008 and June 2018 through May 2019. Total catch per hour is for anglers targeting White Crappie and total harvest is the estimated number of White Crappie harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Creel Survey Statistic	Year	
	2007/2008	2018/2019
Surface area (acres)	13,629	13,939
Directed effort (h)	67,356.2 (14)	68,559.0 (16)
Directed effort/acre	4.9 (14)	4.9 (16)
Total catch per hour	2.6 (25)	2.3 (20)
Total harvest	96,818.2 (21)	104,433.0 (26)
Harvest/acre	7.1 (21)	7.5 (26)
Percent legal released	9	11

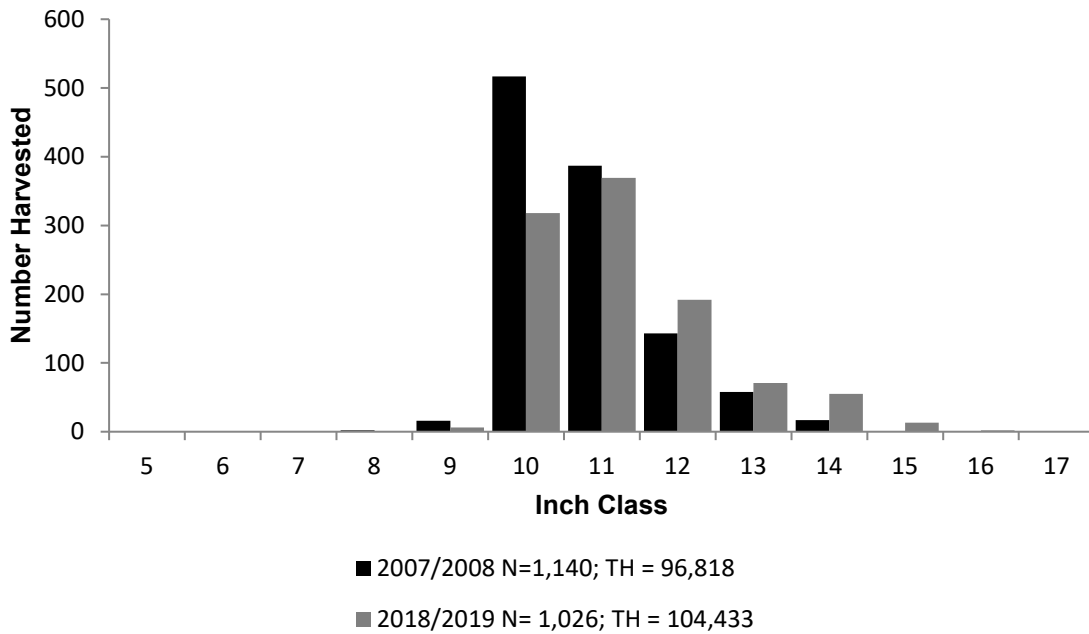


Figure 12. Length frequency of harvested White Crappie observed during creel surveys at Arrowhead Reservoir, Texas, June 2007 through May 2008 and June 2018 through May 2019, all anglers combined. N is the number of harvested White Crappie observed during creel surveys, and TH is the total estimated harvest for the creel period.

## Proposed Sampling Schedule

Table 16. Proposed sampling schedule for Arrowhead Reservoir, Texas. Survey period is June through May. Electrofishing and trap netting surveys are conducted in the fall. Standard survey denoted by S and additional survey denoted by A.

	Survey year			
	2020-2021	2021-2022	2022-2023	2023-2024
Angler Access				S
Structural Habitat				
Vegetation				S
Electrofishing – Fall	A			S
Electrofishing – Low frequency				S
Trap netting				S
Creel survey				
Report				S

## APPENDIX A – Catch rates for all species from all gear types

Number (N) and catch rate (CPUE) (RSE in parentheses) of all species collected from all gear types from Arrowhead Reservoir, Texas, 2019. Sampling effort was 15 net nights for trap netting, and 2 hours for electrofishing.

Species	Low-Frequency Electrofishing		Trap Netting		Electrofishing	
	N	CPUE	N	CPUE	N	CPUE
Gizzard Shad					74	37.0 (20)
Threadfin Shad			45	3.0 (53)	3,791	1,895.5 (86)
Common Carp			1	0.1 (100)		
River Carpsucker			14	0.9 (42)		
Smallmouth Buffalo			4	0.3 (44)		
Bigmouth Buffalo			1	0.1 (100)		
Blue Catfish	151	201.3 (21)	11	0.7 (41)		
Channel Catfish			1	0.1 (100)		
Flathead Catfish						
White Bass						
Warmouth					1	0.5 (100)
Orangespotted Sunfish					4	4.0 (77)
Bluegill			48	3.2 (54)	25	12.5 (30)
Longear Sunfish					4	2.0 (59)
Largemouth Bass					27	13.5 (22)
White Crappie			219	14.6 (27)		
Freshwater Drum			1	0.1 (100)		

## APPENDIX B – Map of sampling locations



Location of sampling sites, Arrowhead Reservoir, Texas, 2019-2020. Trap net, low-frequency electrofishing, and electrofishing stations are indicated by T, L, and E, respectively. Water level was near full pool at time of sampling.



## APPENDIX C – Historical catch rates of targeted species by gear type for Arrowhead Reservoir, Texas

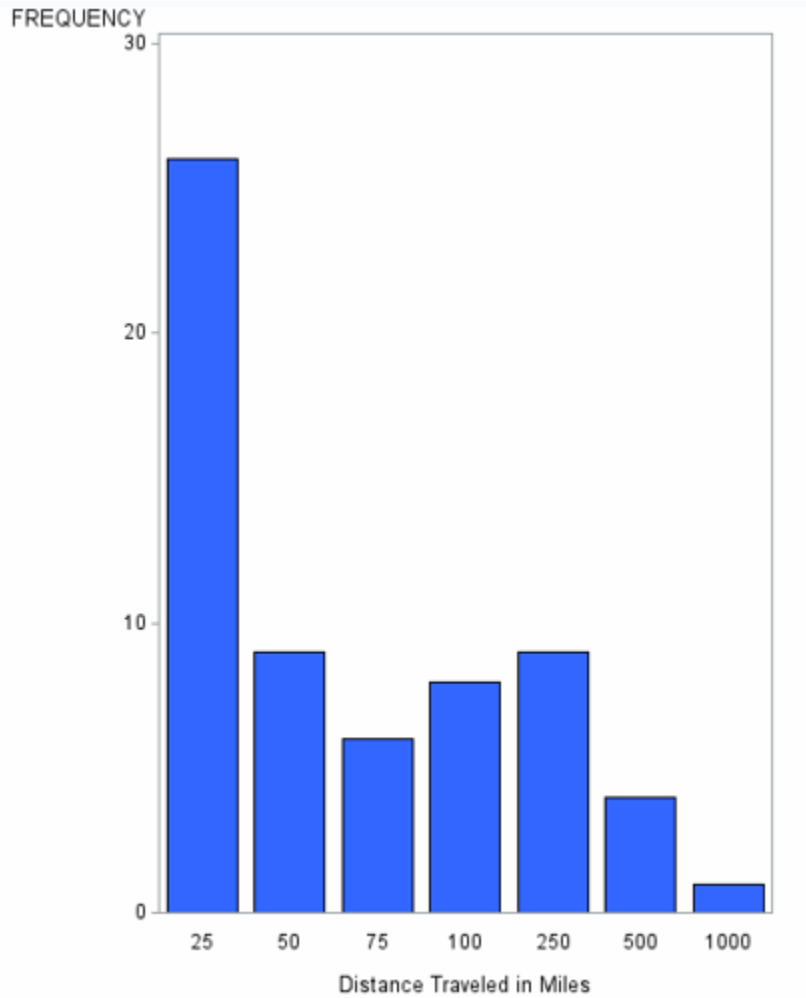
Gear	Species	Year								
		1997	1998	1999	2000	2003	2004	2005	2007	2008
Gill Netting (fish/net night)	Blue Catfish	3.3	4.5	4.4			8.9			12.5
	Channel Catfish	0.8	1.9	1.1			0.3			0.5
	White Bass	16.1	15.5	10.1			17.9			6.9
Electrofishing (fish/hour)	Gizzard Shad	405.5	210.5	200		468			576	
	Threadfin Shad	123.5	48.5	36.5		0			125	
	Green Sunfish	1.5	0.5	0.5		0			40.5	
	Warmouth	2	2.5	1		0.5			13	
	Bluegill	110.5	116	17.5		36			219.5	
	Longear Sunfish	109	37	8		19.5			58	
	Largemouth Bass	66	57.5	25		16.5			86	
Trap Netting (fish/net night)	White Crappie	87.9	13.7	10.7	11	14		18.1	38.6	

## APPENDIX C – Continued

Historical catch rates for targeted species by gear type for Arrowhead Reservoir, Texas.

Gear	Species	Year								
		2009	2011	2012	2013	2015	2016	2017	2019	Avg
Gill Netting (fish/net night)	Blue Catfish			16.8			6.7			8.2
	Channel Catfish			0.9			0			0.8
	White Bass			2.7			6.6			10.8
Electrofishing (fish/hour)	Gizzard Shad	642	940		394.7	375.5		255	37	409.5
	Threadfin Shad	22.5	0		4.7	0		32	1,895.5	208
	Green Sunfish	0	0		0	1.5		0	0	4
	Warmouth	0	4		0	0		0.5	0.5	2.2
	Bluegill	77.5	97		0	19		44	12.5	68.1
	Longear Sunfish	7	16.5		6.7	4		6.5	2	24.9
	Largemouth Bass	59	37		11.3	9.5		41	13.5	38.4
Trap Netting (fish/net night)	White Crappie		14.1			22.5			14.6	24.5
LFE (fish/hour)	Blue Catfish								201.3	201.3

## APPENDIX D – Reporting of creel ZIP code data



Frequency of anglers that traveled various distances (miles) to Arrowhead Reservoir, Texas, as determined from the June 2018 through May 2019 creel survey.



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