

Waco 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 Waco Reservoir were surveyed in 2018 with gill nets and in 2019 with electrofishing and trap nets. This report summarizes the results of the surveys and contains a management plan for the reservoir based on those findings.

Reservoir Description: Waco Reservoir is an 8,465-acre impoundment of the North, Middle, and South Bosque Rivers within the Brazos River Basin, McLennan County. Water level was two feet low during the spring 2018 gill net survey, two and a half feet low during the summer 2019 vegetation survey and approximately three feet low during the 2019 electrofishing and trap net surveys. Fish habitat at the time of sampling was dominated by natural, rock, and gravel shorelines. Bank and boat access (12 ramps) to the reservoir is abundant.

Management history: Important sport fish include Largemouth Bass, White Bass, Hybrid Striped Bass (HSB), White Crappie, and catfishes. Sport fish have always been managed with statewide regulations, with the exception of Blue Catfish which have been regulated with a 30 to 45-inch slot limit since 2009. The management plan from the 2012 survey report focused on annual monitoring of noxious vegetation, enhancing aquatic habitat with native vegetation, additional monitoring of HSB and addressing potential aquatic invasive species (AIS) threats. Two years later, zebra mussels were found at a single location on the lake, and management efforts have largely concentrated on AIS ever since. Although an alternate stocking regime for HSB was initiated in 2016 to evaluate fry versus fingerling stockings, those efforts were changed to an evaluation of Palmetto vs Sunshine Bass fingerling performance as part of a statewide evaluation. Aquatic habitat enhancement remains a management priority yet has many challenges on Waco Reservoir.

Fish Community: A gill net survey was not conducted in spring 2020 due to the Covid 19 outbreak and associated state shelter-in-place orders. Spring 2018 gill net data are the most recent data available for these species.

- **Prey species:** All major forage species except Bluegill were collected below historical averages. Most Gizzard Shad were a suitable size for predators.
- **Catfishes:** Blue and Channel Catfish were collected with gill nets at rates of 4.4 fish/nn and 3.5 fish/nn respectively. Blues had good to excellent body condition while Channel Catfish body condition was fair.
- **Temperate Bass:** White Bass catch rates (3.3 fish/nn) were above the historical average in 2018 and HSB catch rates (6.2 fish/nn) were the highest on record. Both species maintained good body condition.
- **Largemouth Bass:** Largemouth Bass were collected by electrofishing at 157.0/h which was below the historical average and well short of the previous survey. Body condition was fair to good across length classes. Florida Largemouth Bass influence increased to 62%.
- **White Crappie:** White Crappie were collected at 9.0 fish/nn which was well above the historical average. Black Crappie were collected near their historical average.

Management Strategies: Continue managing sport fishes, except Blue Catfish, with statewide regulations. Discontinue native aquatic plant enhancement efforts. Continue to evaluate Palmetto and Sunshine Bass fingerling recruitment, increasing sampling effort to collect age structures by 2024. Continue to inform the public about the negative impacts of AIS and maintain appropriate signage at access points. Conduct angler access, vegetation and trap net surveys in 2023, electrofishing surveys in 2021 and 2023 and gill net surveys in 2022 and 2024.

Introduction

This document is a summary of fisheries data collected from Waco Reservoir in 2018-2019. 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 species of fishes was collected, this report deals primarily with major sport fishes and important prey species. Historical data are presented with the 2018-2019 data for comparison.

Reservoir Description

Waco Reservoir is an 8,465-acre impoundment of the North, Middle, and South Bosque Rivers within the Brazos River Basin, McLennan County. It is operated by the U.S. Army Corps of Engineers (USACE) and primary water uses included flood control, municipal water supply and recreation. Mean and maximum depths are 28 and 92 feet, respectively. Waco has a drainage area of 1,670 square miles, a storage capacity of 104,100 acre-feet, and a shoreline length of 60 miles. Habitat at the time of sampling was dominated by natural, rock, and gravel shorelines. Littoral vegetation is dominated by common buttonbush. Water level has been variable since the last report, from four feet below full pool to 20 feet above full pool. Water level was two feet low during the spring 2018 gill net survey and summer 2019 vegetation survey, and approximately three feet low during the 2019 electrofishing and trap net surveys (Figure 1a and 1b). Other descriptive characteristics for Waco Reservoir are in Table 1.

Angler Access

Bank and boat access on Waco Reservoir are fair to good with 12 public boat ramps, two marinas and multiple USACE parks and green areas including many primitive access points along the North, Middle and South Bosque Rivers (Table 2). Public fishing piers are nonexistent but would benefit bank angler access tremendously given the lake's proximity to the City of Waco.

Management History

Previous management strategies and actions: Management strategies and actions from the previous survey report (Tibbs and Baird 2016) included:

1. Discontinuing annual monitoring for noxious vegetation and resurveying vegetation and habitat in summer 2019.

Action: Noxious vegetation surveys were discontinued in 2016. A general vegetation survey was conducted in September 2019. A new physical habitat survey was not conducted, because physical shoreline habitat has not changed recently, and the 2012 survey is still appropriate.

2. Requesting appropriate species of native vegetation from the Texas Freshwater Fisheries Center (TFFC) aquatic plant nursery or culturing them in the Waco Wetlands Aquatic Plant Nursery, and planting when appropriate; transplanting from existing colonies within the reservoir to start new colonies when possible; investigating alternative funding sources to promote aquatic habitat enhancement on the reservoir.

Action: The 2016 strategies were meant to be a continuation of prior efforts but this work has been fraught with problems (e.g., periods of reservoir drought/high water following plantings; freezing, cracking and displacement of infrastructure and mesocosms within the plant nursery itself; inability to pump water into the Waco Wetlands for extended periods of time). Because of these issues, no native vegetation has been planted in Waco since the last report, but other types of habitat work are being considered for the future. Recommendations follow in the Management Strategies.

3. Monitoring the HSB fishery with gill nets in 2018 and 2020, alternating fry (50/acre) and fingerling (5/acre) stockings of Palmetto or Sunshine Bass, collecting a Category III age and growth sample in 2020 to document survival of fry relative to fingerlings (comparing differences between Palmetto and Sunshine Bass if both were used) and working with local partners to ensure education and compliance of HSB regulations by anglers.

Action: The HSB fishery was sampled with ten gill nets in 2018 but the Covid 19 outbreak and associated state shelter-in-place orders prevented the 2020 survey (and scheduled Category III age and growth analysis) from being completed. The alternating fry and fingerling stocking regime outlined in the 2016 Management plan was replaced in late 2016 by broader research comparing recruitment of stocked Palmetto and Sunshine Bass in multiple reservoirs across the state. This research involves a stocking regime of equal rates of Palmetto and Sunshine Bass fingerlings annually. District staff have worked with local partners like the USACE, Friends of Lake Waco, Central Texas Fly Rodders Association and TPWD game wardens to educate HSB anglers on the differences in temperate bass species and the proper regulations for each.

4. Cooperating with the USACE to maintain appropriate AIS signage, educate the public about AIS, make a speaking point about AIS when presenting to constituent and user groups and keep track of all inter-basin water transfer routes to facilitate potential AIS responses.

Action: Educational signage previously posted was replaced with new signage warning boaters that the reservoir was infested with Zebra Mussels. District biologists have continued to educate constituents about AIS in presentations, conversations and social media since the last report. Inter-basin water transfers are a permanent fixture in this report and will be updated as needed. Additional information on zebra mussels can be found in this report.

5. Identifying needs (such as angler-oriented projects) on Waco Reservoir that would best be accomplished by a citizen group, and updating the Friends of Lake Waco chapter on management efforts and potential projects in which they may be interested in participating in.

Action: One major partnership (the 2018 Handshake Agreement initiated by the Lake Waco USACE) has been very successful in working toward creating new access points for anglers at two locations. The first one (paddle craft only), is mostly complete and open for use, and is immediately below the tailrace in Bosque Park. The other is still under construction and is for small trailered boats and paddle craft in the upper end of the Middle Bosque arm within the reservoir. The current Friends of Lake Waco chapter is largely inactive, but this partnership has involved several other citizen groups, including the Central Texas Fly-fishing Club, Keep Waco Beautiful, the Tri-Beta honor Society from Baylor and numerous volunteers from the USACE and elsewhere.

Harvest regulation history: Sportfishes in Waco Reservoir are currently managed with statewide regulations with the exception of Blue Catfish. The Blue Catfish regulation changed on September 1, 2009. Blue Catfish are currently managed with a 30- to 45-inch slot limit, where Blue Catfish less than 30 inches or greater than 45 inches can be retained; only one Blue Catfish greater than 45 inches may be retained each day, and the daily bag limit is 25 Blue and Channel Catfish in any combination (Table 3).

Stocking history: Waco Reservoir was last stocked with Blue Catfish in 2004, Florida Largemouth Bass in 2013 and 2014, and Palmetto and Sunshine Bass annually since 2017. The complete stocking history is in Table 4.

Vegetation/habitat management history: A summary of vegetation and habitat management history through 2011 can be found in Tibbs and Baird (2016). Hydrilla has not been observed in Waco Reservoir since 2011, including comprehensive vegetation surveys in 2015 and 2019. Native plants were grown in the Waco Wetlands Aquatic Plant Nursery, or collected from existing stands, and planted throughout the reservoir in 2012, 2013, 2014 and 2015 with the help of summer interns and volunteers from the Student Conservation Association (SCA) and Baylor University. These plantings consisted of hundreds of individual Pickerel Weed, Water Willow, Bulrush and Button Bush plants seeded into several dozen sites throughout the reservoir, yet no new visible stands of vegetation were created based on monitoring results.

Water Transfer: Waco Reservoir is primarily used for flood control, municipal water supply, and recreation. There is one raw water intake station on the reservoir which transfers water offsite to the City of Waco Water Utilities Services Department treatment plant adjacent to the dam. From the dissolved air flotation (DAF) plant, partially treated water is pumped to two filtration plants, and then to nearly 200,000 customers in Central Texas. There are no inter-basin transfers.

Reservoir capacity: A summary of Waco Reservoir's past water capacity and volumetric surveys can be found in Tibbs and Baird (2016). No new volumetric surveys have been conducted since the Texas Water Development Board's 2011 survey.

Zebra Mussels: In June 2014, a plankton tow near the Lake Waco Marina was analyzed for zebra mussel veligers and/or eDNA - and was found to be negative. Three months later, on September 26, 2014, a zebra mussel infestation was discovered by City of Waco staff at the Ridgewood Country Club boat ramp. Subsequently, a work barge was discovered in Ridgewood Marina that was covered with zebra mussels. This barge was removed on October 1 and the owners were ticketed and fined by TPWD game wardens. The extent of the small population of adult zebra mussels next to the ramp was quantified, and plans were made to cover the zebra mussels with 30 mil PVC pond liners weighted with sandbags. From October 21- 23, 2014, nine 150'x35' tarps were placed and covered with sandbags to prevent movement. The tarps were monitored over winter to limit damage due to waves and loss of sandbags, both of which occurred. The tarps were removed March 17-19, 2015 at which time two live adult zebra mussels were located by divers although a comprehensive survey was not completed at that time. In July 2015, plankton tows collected suspected veligers from Speegleville, Twin Bridges and Lake Waco Marina however, the eDNA results were all negative. A comprehensive visual and tactile survey of marina structures, boat dock and shoreline in the vicinity of the project was completed by TPWD Waco Management and Regional Offices on August 25 - 26, 2015; no adult zebra mussels were observed or collected at that time. All November 2015 plankton tows were negative for zebra mussel veligers and eDNA. All eDNA samples analyzed since November 2015 have been negative. See Appendix D for all historical plankton tows and eDNA results from Waco Reservoir.

Methods

Surveys were conducted to achieve survey and sampling objectives in accordance with the objective-based sampling (OBS) plan for Waco Reservoir (Tibbs and Baird 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 (1.0 hour at 12, 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 –White Crappie were collected using trap nets (10 net nights at 10 stations). Catch per unit effort for trap nets was recorded as the number of fish caught per net night (fish/nn).

Gill netting – Channel Catfish, Blue Catfish, Hybrid Striped Bass and White Bass were collected using gill nets (10 net nights at 10 stations). Catch per unit effort for gill nets was recorded as the number of fish caught per net night (fish/nn).

Genetics – Genetic analysis of Largemouth Bass and Spotted Bass was conducted according to the Fishery Assessment Procedures (TPWD, Inland Fisheries Division, unpublished manual revised 2017). Micro-satellite DNA analysis was used to determine genetic composition of individual fish since 2005.

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). Hybrid Striped Bass PSD was calculated according to Dumont and Neely (2011). 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 X SE of the estimate/estimate) was calculated for all CPUE statistics.

Habitat – The 2011 structural habitat survey was conducted according to Tibbs and Baird (2012). The 2015 and 2019 vegetation surveys were conducted using an adaptation of the point method (TPWD, Inland Fisheries Division, unpublished manual revised 2017). Points were randomly generated on the shoreline and averaged a minimum of one point per shoreline mile. Aquatic vegetation has always been found close to the shore in Waco Reservoir, so stratifying the random points to exclude deep-water areas increased precision and resulted in better data.

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

Results and Discussion

Habitat: The last structural habitat survey estimated 55.9 miles (87.6%) of natural shoreline, 4.8 miles (7.5%) of rock shoreline, 2.1 miles (3.2%) of gravel shoreline and 1.1 miles (1.7%) of bulk headed shoreline (Tibbs and Baird 2012). The littoral zone vegetation encountered during summer 2019 was nearly exclusively Buttonbush (found at 25 of 61 randomly selected shoreline points; Table 6). Water willow was observed at only one site.

Prey species: The Fall 2019 electrofishing catch rates of Threadfin and Gizzard Shad were 86.0/h and 127.0/h respectively (Figure 2; Appendices A and B). The Index of vulnerability (IOV) for Gizzard Shad was good, and 67% were available to existing predators as forage. Other important forage species collected were Bluegill (285.0/h), Longear Sunfish (48.0/h), Redear Sunfish (4.0/h), Green Sunfish (7.0/h), and Warmouth (3.0/h; Appendix A). Bluegill size structure has remained consistent over the last three surveys and supports small numbers of large panfish for anglers. Only Bluegill and Green Sunfish were collected above their historical average (Figure3; Appendices B).

Catfishes: Blue and Channel Catfish were collected with gill nets at rates of 4.4 fish/nn and 3.5 fish/nn respectively in 2018 (Figures 4 and 5; Appendices A and B). Blue Catfish catch rates were above their historical average while Channel catfish catch rates were below (Appendix B). The OBS goal for Blue and Channel Catfish size structure ($N \geq 50$ stock) fell short for both species ($N = 44$ and 35 individuals respectively; Figures 4 and 5). The Blue Catfish population showed better balance over previous surveys as the PSD improved from the previous two surveys; 25 in 2014, 20 in 2016 and 52 in 2018. Individuals also had good to excellent body condition and there were similar or improved numbers of quality and preferred - length fish from previous surveys (Figure 4). The Channel Catfish population showed the opposite trend, individual body condition was fair and there were fewer numbers of legal and quality-sized fish for anglers as compared to the previous survey (Figure 5).

Flathead Catfish are generally caught incidentally to targeted catfish species. This species was not targeted, or collected during 2018 gill net surveys, but are still included in Appendix B.

Temperate Bass: The OBS plan for Waco Reservoir's White Bass included collecting a minimum of 50 stock length fish to allow comparison of trend data, population structure indices and length-frequency histograms among years (Table 5). The gill net catch rate for White Bass was 3.3/nn in 2018 compared to 4.2/nn and 7.1/nn in 2014 and 2016 (Figure 6; Appendices A and B). This catch rate equated to 33 stock-length fish so the OBS target was not met. The proportion of legal-sized fish in the population remained similar to the past two surveys, but body condition, although good, has declined since 2016 (Figure 6).

Low density (5 fingerlings/acre) HSB stockings began in 2009 through a cooperative effort between TPWD and the City of Waco. Hybrid Striped Bass were then collected with gill nets at 1.4/nn in 2012, 2.5/nn in 2014 and 4.7/nn in 2016 (Appendix B). Given this excellent recruitment, the 2016 management plan outlined an alternating fry and fingerling stocking regime similar to HSB research done on Belton Reservoir (Tibbs and Baird 2018), in an effort to determine if the fishery could be maintained through lower cost fry stockings. This plan, however, was replaced in late 2016 by broader research comparing the recruitment and performance of both Palmetto Bass and Sunshine Bass stocked as fingerlings in multiple reservoirs across the state. Waco Reservoir has received fingerling stockings of Palmetto and Sunshine Bass for the last three years (Table 4). The HSB fishery was sampled with ten gill nets in 2018 but the Covid 19 outbreak and associated state shelter-in-place orders prevented the 2020 survey (Genetics and Category III age and growth analysis) from being completed.

Hybrid Striped Bass were collected with gill nets at a rate of 6.2 fish/nn in 2018 and this catch rate is the highest on record (Figure 7; Appendices A and B). The OBS goal for HSB size structure ($N \geq 50$ stock) was met ($N = 62$ individuals; Table 5; Figure 7). Length frequencies continue to show distinct year classes of HSB and nearly 30% of the current sample consists of legal - length fish which are available for anglers (Figure 7). Body condition was also good and consistent across length classes (Figure 7).

Black Basses: Largemouth Bass were collected by electrofishing at 157.0/h in 2019 and was below the historical average (Figure 8; Appendices A and B). The OBS goals for Largemouth Bass abundance ($CPUE_{Stock}$; $RSE \leq 25$) and size structure ($N_{Stock} \geq 50$) were achieved ($RSE = 21$ and 109 stock-sized fish collected (Figure 8). The catch of legal - length bass increased to 25.0/h from 18.0/h in 2015 and body condition was fair to good across most length classes (Figure 8). Florida Largemouth Bass influence ($n = 28$ individuals analyzed) increased to 62% in the most recent survey (Table 7).

Recent interest in the range of the Guadalupe Bass in central Texas has prompted genetic testing at many locations previously thought to be occupied by Spotted or Smallmouth Bass only. Guadalupe Bass hybrids have been identified in river systems throughout the district such as the Paluxy, Brazos and Leon already. Genetic analysis was conducted on nine individuals identified as Spotted Bass during 2019 electrofishing, and all were found to be Spotted x Guadalupe Bass hybrids (Appendix A). Percent Guadalupe Bass alleles for these individuals ranged from 9 – 98%.

Crappie: White Crappie were collected with trap nets at 9.0/nn in 2019, well above the historical average for the species (Figure 9; Appendices A and B). The OBS goal for size structure ($N \geq 50$ stock) was met with 78 individuals of stock size or more (Table 5 and Figure 9). The population was fairly well balanced with a PSD of 65 (Figure 9). Body condition was excellent across all size classes.

Black Crappie are a low-density population in Waco Reservoir and are generally caught incidentally to White Crappie. Few were collected during the 2019 trap net surveys (Appendices A and B).

Fisheries management plan for Waco Reservoir, Texas

Prepared – July 2020

ISSUE 1: The Aquatic Nuisance Species Task Force document outlining zebra mussel guidelines for Texas states that infested water bodies can only be delisted following 5 years of testing/monitoring with negative results (including eDNA). July 2020 will mark 5 years since the last *suspected* veliger was found in a plankton tow from Waco Reservoir (Appendix D). All other forms of evidence of zebra mussels in the reservoir have been absent since that time as well.

MANAGEMENT STRATEGIES

1. Sample the reservoir during spring and fall 2020 at the standard six sites with plankton tows to identify any zebra mussel veligers or eDNA.
2. Pending the results of the 2020 plankton tows and analysis, delist Waco from infested status to undetected/negative status.
3. Replace boater Advisory signage with general Clean, Drain, Dry signage.
4. Issue a news release on the successful eradication efforts.

ISSUE 2: July 2020 will mark 5 years since the last *suspected* veliger was found in a plankton tow from Waco Reservoir. All other forms of evidence of zebra mussels in the reservoir have been absent since that time as well. Although the potential delisting of Waco Reservoir from infested status to undetected/negative status could happen within the next year, the *current* status is still infested and as such, these strategies are still in effect

MANAGEMENT STRATEGIES

1. Cooperate with the controlling authority to maintain warning signage at access points.
2. Maintain contact with marina owners about AIS, and provide them with posters, literature, etc. so that they can continue to educate their customers.
3. Provide training to City of Waco interns on zebra mussels annually as needed prior to summer efforts.
4. Make a speaking point about AIS when presenting to constituent and user groups. Keep track of (i.e., map) existing and future inter-basin water transfers to facilitate potential AIS responses.

ISSUE 3: Recent genetic analysis was conducted on nine individuals identified as Spotted Bass during 2019 electrofishing (n = 10 total collected), and all were found to be Spotted x Guadalupe Bass hybrids. Percent Guadalupe Bass alleles for these individuals ranged from 9 – 98%.

MANAGEMENT STRATEGIES

1. Continue genetic tissue analysis of Spotted Bass or suspected Spotted x Guadalupe Bass hybrids when collected from electrofishing surveys on Waco Reservoir.
2. Perform rod and reel surveys for Spotted Bass, Guadalupe Bass and their hybrids in the upper reaches of tributaries of Waco Reservoir, and collect genetic tissue from suspect individuals.
3. Pending the results of additional informal surveys, issue a news release on the results.

ISSUE 4: The current focus on HSB stockings for Waco Reservoir is to compare the recruitment and performance of Palmetto and Sunshine Bass stocked as fingerlings. This is part of a broader research project occurring on several reservoirs throughout the state. Waco Reservoir has received fingerling stockings of Palmetto and Sunshine Bass for the last three years as part of this effort. The HSB fishery was sampled with ten gill nets in 2018 but the Covid 19 outbreak and associated state shelter-in-place orders prevented the 2020 survey (Genetics and Category III age and growth analysis) from being completed.

MANAGEMENT STRATEGIES

1. Gill net in spring 2022 and 2024 to monitor the condition of the HSB fishery.
2. Continue requesting HSB stockings to accommodate research plans.
3. Collect a Category III age and growth sample of HSB in either 2022 or 2024 depending on the research project timeline.
4. Work with local partners to continue educating anglers to ensure compliance of temperate bass regulations.

ISSUE 5: Efforts from the aquatic habitat enhancement initiative begun in 1998 produced early successes by 2003. The permanent increase in conservation pool began in late 2003 and effectively reduced all aquatic vegetation (native and noxious alike) in the reservoir to remnant populations of a few species. Prolonged high-water levels in 2007 knocked-back most aquatic vegetation once again. Although small amounts of Hydrilla coverage has been observed over the years, it has never been expansive enough to be viewed as a benefit for sport fishes or an issue for recreational access. More contemporary efforts have been made to introduce or promote the spread of native aquatic vegetation to improve fish habitat, including many years of planting and transplanting native species within the reservoir. Unfortunately, these efforts have consistently failed due to a variety of factors. Other means of improving habitat for fish are more efficient and popular with anglers.

MANAGEMENT STRATEGIES

1. Discontinue native vegetation plantings on Waco Reservoir.
2. Build artificial habitat structures and deploy in complexes (i.e., freshwater reefs) throughout the Reservoir as funding is available either through TPWD or partner groups.
3. Update the TPWD website with freshwater reef locations and GPS coordinates so that interested anglers can find and fish them.

Objective Based Sampling Plan and Schedule 2020-2024

Sport fish, forage fish, and other important fishes

Sport fishes in Waco Reservoir include Largemouth Bass, Hybrid Striped Bass (HSB), White Bass, Channel Catfish, Blue Catfish, and White Crappie. Important forage fish species include Gizzard Shad, Threadfin Shad, Bluegill, Redear and Longear Sunfish.

Low-density fisheries

Spotted Bass, Flathead Catfish, and Black Crappie occur in very low abundance in Waco Reservoir and are generally caught incidentally to other targeted species. We will continue collecting and reporting data for these species and upgrade their status if appropriate.

Survey objectives, fisheries metrics, and sampling objectives

Fall Electrofishing: This survey will be used to evaluate Largemouth Bass (general monitoring objective) and primary forage species: Bluegill, Redear Sunfish, Longear Sunfish, Gizzard Shad and Threadfin Shad (exploratory monitoring objective). Trend data consisting of CPUE and size structure (all listed species), and body condition and genetics (Largemouth Bass) have been collected during fall since 1999 with random five-minute nighttime electrofishing stations. A minimum of nine traditional electrofishing stations will be sampled again in 2023. Largemouth Bass populations will be monitored using CPUE, size structure and relative weight as metrics to make comparisons with historical and future datasets. Target precision for CPUE will be an RSE-Stock ≤ 25 and target sample size for size structure will be $N \geq 50$ stock, allowing us to calculate proportional size distributions with 80% confidence. Largemouth Bass body condition will be determined by measuring and weighing at least 5 fish per represented inch group \geq stock-length. If goals are not attained in 9 stations, but catch rates indicate they're reasonable, sampling will continue at random stations until the goals are met. Since the primary forage species objectives are exploratory, no target precision or target sampling sizes will be sought for these species; additional sampling will not be necessary beyond that which is done for Largemouth Bass.

Additional genetics will be analyzed on all fish identified as Spotted Bass during electrofishing and/or rod and reel surveys prior to the next report.

Winter Trap Netting: This survey will be used to evaluate White Crappie (general monitoring objective). Trend data consisting of CPUE, size structure and body condition for this species have been collected since 2004 with winter trap nets. A minimum of 10 randomly selected trap net stations will be sampled in winter 2023. White Crappie populations will be monitored using CPUE, size structure and relative weight as metrics to make comparisons with historical and future datasets. Target precision for CPUE will be an RSE-Stock ≤ 25 and target sample size for size structure will be $N \geq 50$ stock, allowing us to calculate proportional size distributions with 80% confidence. White Crappie body condition will be determined by measuring and weighing at least 5 fish per represented inch group \geq stock-length. If goals are not attained in 10 stations, but catch rates indicate they're reasonable, sampling will continue at random stations until the goals are met.

Spring Gill Netting: This survey will be used to evaluate Blue Catfish, Channel Catfish, White Bass and HSB. Trend data consisting of CPUE, size structure and body condition for these species have been collected biennially since 2004 with spring gill nets. A minimum of 10 randomly selected gill net stations will be sampled in both spring 2022 and 2024. All four populations will be monitored using CPUE, size structure and relative weight as metrics to make comparisons with historical and future datasets. Target precision for CPUE will be an RSE-Stock ≤ 25 and target sample size for size structure will be $N \geq 50$

stock, allowing us to calculate proportional size distributions with 80% confidence. Blue Catfish, Channel Catfish, White Bass and HSB body condition will be determined by measuring and weighing at least 5 fish per represented inch group \geq stock-length. If goals are not attained in 10 stations, but catch rates indicate they're reasonable, sampling will continue at random stations until the goals are met. Additionally, we will likely set additional gill nets as well as collect genetics and age and growth from HSB according to procedures developed to evaluate Palmetto vs. Sunshine recruitment within the statewide framework of the previously mentioned research project. The procedures are still in the process of being developed.

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Tables and Figures

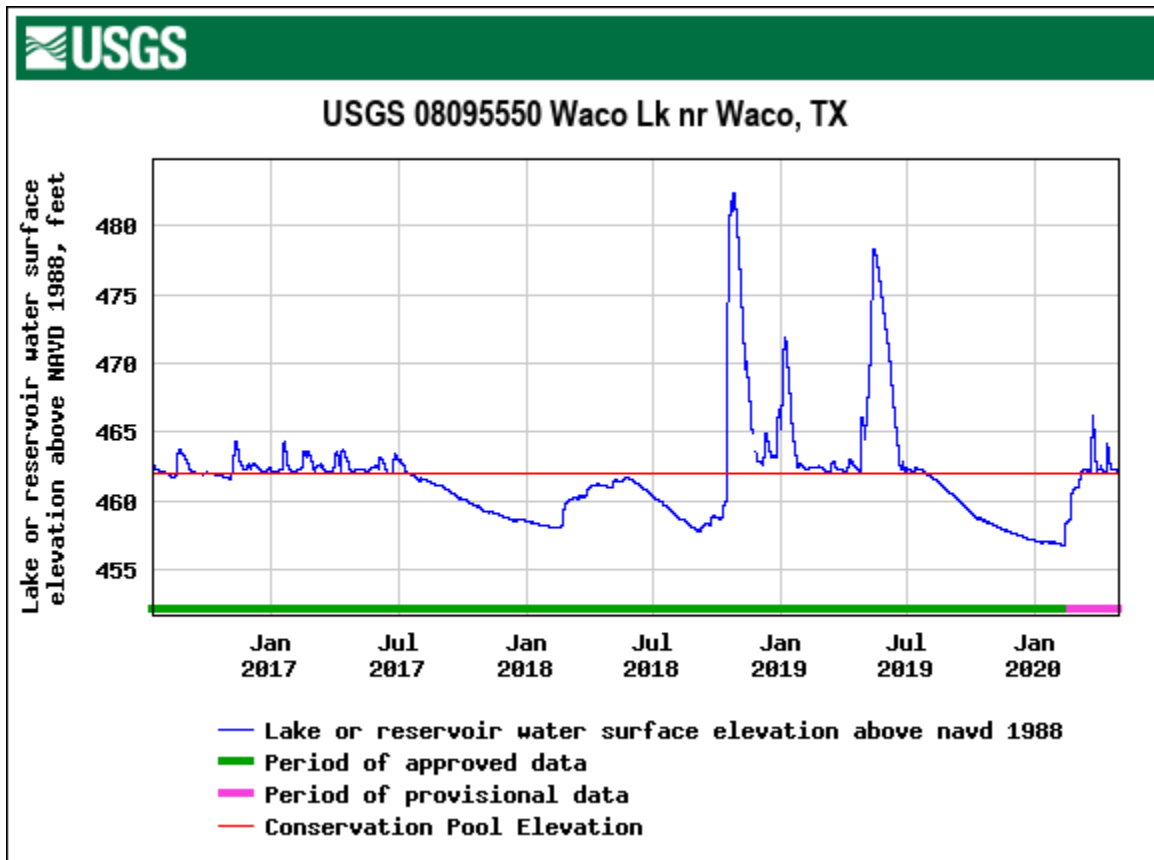


Figure 1a. Daily mean water levels for Waco Reservoir from July 15, 2016 through April 29, 2020. NAVD 1988 refers to the North American Vertical Datum of 1988. The red line indicates Conservation pool (462.0). Figure from the USGS website.

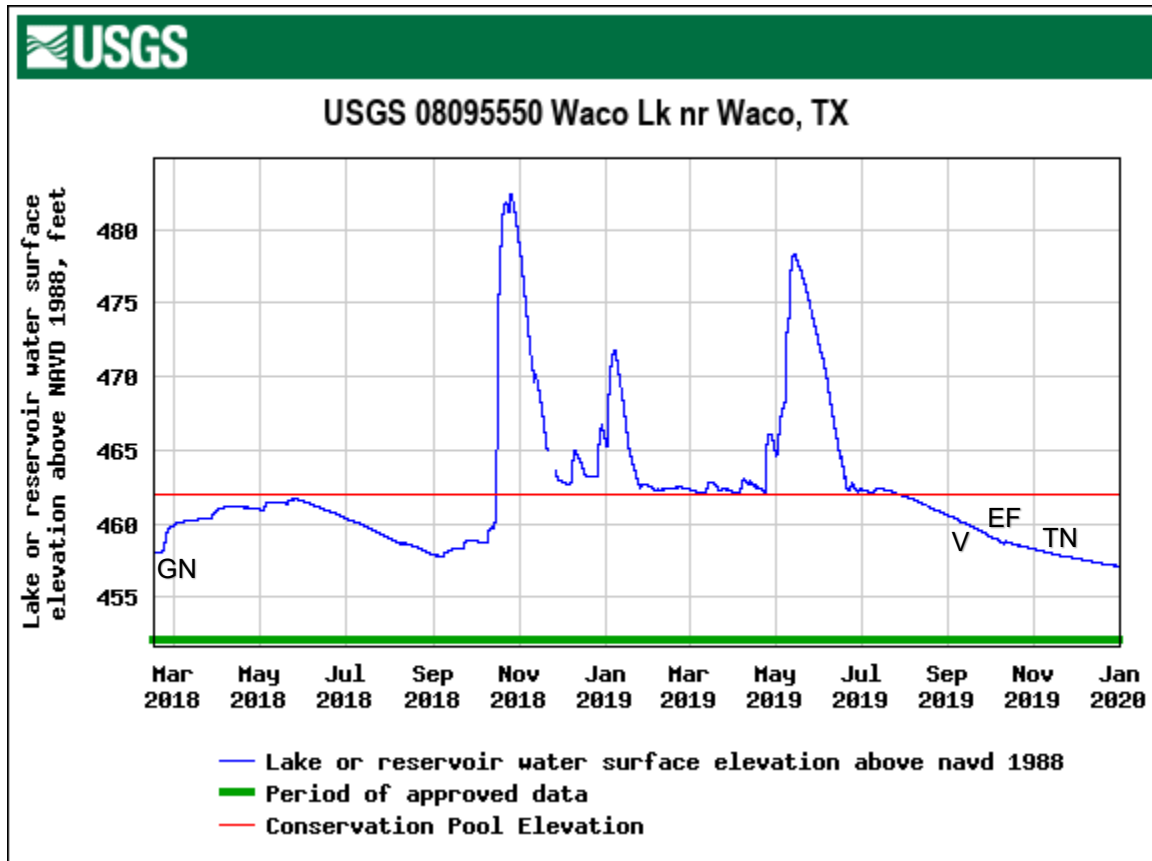


Figure 1b. Daily mean water level elevations in feet above mean sea level (MSL) recorded for Waco Reservoir, Texas, February 2018 through April 2020. NAVD 1988 refers to the North American Vertical Datum of 1988. The red line indicates Conservation pool (462.0) and scheduled surveys are indicated by V (vegetation), EF (electrofishing), TN (trap netting) and GN (gill netting).

Table 1. Characteristics of Waco Reservoir, Texas 2019 – 2020

Characteristic	Description
Year Constructed	1965
Controlling authority	USACE
County	McLennan
Reservoir type	Tributary
Shoreline Development Index (SDI)	5.0
Conductivity	325 umhos/cm

Table 2. Boat ramp characteristics for Waco Reservoir, Texas, September 2019. Reservoir elevation at time of survey was 459.8 feet above MSL (2.2 feet below conservation pool).

Boat ramp	Latitude/Longitude (dd)	Parking capacity (N)	Condition
Airport Beach	31.59636/-97.23046	80	Very good
Airport Park	31.60110/-97.24166	22	Good
Airport Park Marina	31.59531/-97.23046	20	Good
Flat Rock	31.60629/-97.26981	25	Adequate
Koehne Park	31.54085/-97.21802	15	Good
Midway Park	31.52609/-97.22869	28	Good
Reynold's Creek	31.59025/-97.24950	22	Very good
Ridgewood Marina	31.53386/-97.22563	10	Adequate
Speegleville Park	31.55563/-97.23569	46	Very good
Twin Bridges	31.53792/-97.23920	72	Very good
Old Reynolds Creek	31.59030/-97.24955	38	Adequate
Old Speegleville	31.56131/-97.24506	22	Good

Table 3. Harvest regulations for Waco Reservoir, 2019 – 2020.

Species	Bag Limit	Minimum-Maximum Length (inches)
Catfish: Channel, Blue ¹ and hybrids	25 (any combination)	12 – no limit
Catfish: Flathead	5	18 – no limit
Bass: White	25	10 – no limit
Hybrid Striped Bass	5	18 – no limit
Bass: Largemouth	5 (any combination)	14 – no limit
Bass: Spotted, Guadalupe ² and hybrids	5 (any combination)	no limit – no limit
Crappie: White, Black and hybrids	25 (any combination)	10 – no limit

¹Blue Catfish are currently managed with a 30- to 45-inch slot limit, where Blue Catfish less than 30 inches or one Blue Catfish greater than 45 inches can be retained each day; the daily bag limit is 25 for Blue Catfish, Channel Catfish, their hybrids and subspecies.

²All genetic samples from black bass identified as Spotted Bass in 2019 were found to be Spotted x Guadalupe Bass hybrids with percent Guadalupe Bass alleles ranging from 9 to 98%.

Table 4. Stocking history for Waco Reservoir, Texas. Life stages are fry (FRY), fingerlings (FGL), advanced fingerlings (AFGL), adults (ADL) and unknown (UNK). Life stages for each species are defined as having a mean length that falls within the given length range. For each year and life stage the species mean total length (Mean TL; in) is given. For years where there were multiple stocking events for a particular species and life stage the mean TL is an average for all stocking events combined.

Species	Year	Number	Life Stage	Mean TL (in)
Blue Catfish	1988	15	ADL	15.8
	1989	72,800	FGL	2.7
	2000	91,499	FGL	2.1
	2004	6,610	AFGL	6.0
	2004	125,011	FGL	2.1
	Total	295,935		
Channel Catfish	1972	90,000	AFGL	7.9
	1990	60,768	FGL	3.9
	Total	150,768		
Florida Largemouth Bass	1981	19,875	FRY	1.0
	1982	19,980	FRY	1.0
	1983	4,500	AFGL	5.0
	1983	20,350	FRY	1.0
	1994	300,466	FGL	1.3
	1996	35,076	FGL	1.3
	2004	143,249	FGL	1.6
	2013	415,086	FGL	1.5
	2014	424,755	FGL	1.8
	Total	1,383,337		
Largemouth Bass	1971	400,000	FRY	0.7
	Total	400,000		
Palmetto Bass (Striped X White Bass hybrid)	1975	72,233	UNK	0.0
	1977	73,121	UNK	0.0
	1979	65,700	UNK	0.0
	2009	42,776	FGL	1.4
	2010	37,555	FGL	1.8
	2011	42,727	FGL	1.6
	2013	43,566	FGL	1.7
	2014	41,069	FGL	1.7
	2016	41,293	FGL	1.6
	2017	51,735	FGL	1.8
	2018	61,875	FGL	2.3
	2019	34,722	FGL	1.9
	Total	608,372		

Table 4. Stocking history for Waco Reservoir, Texas. Life stages are fry (FRY), fingerlings (FGL), advanced fingerlings (AFGL), adults (ADL) and unknown (UNK). Life stages for each species are defined as having a mean length that falls within the given length range. For each year and life stage the species mean total length (Mean TL; in) is given. For years where there were multiple stocking events for a particular species and life stage the mean TL is an average for all stocking events combined.

Species	Year	Number	Life Stage	Mean TL (in)
ShareLunker Largemouth Bass	2008	2,884	FGL	1.5
	Total	2,884		
Striped Bass	1983	72,300	UNK	0.0
	1995	116,260	FGL	1.3
	1996	80,768	FGL	1.3
	Total	269,328		
Sunshine Bass (White Bass x Striped Bass hybrid)	2015	425,000		0.2
	2017	47,800		1.5
	2018	14,820		1.9
	2019	33,041		1.5
	Total	520,661		
Threadfin Shad	1984	500	AFGL	3.0
	Total	500		
Walleye	1974	138,000	FRY	0.2
	1975	70,000	FRY	0.2
	1976	78,500	FRY	0.2
	1978	1,357,000	FRY	0.2
	Total	1,643,500		

Table 5. Objective-based sampling plan components for Waco Reservoir, Texas 2018 – 2019.

Gear/target species	Survey objective	Metrics	Sampling objective
<i>Electrofishing</i>			
Largemouth Bass	Abundance	CPUE-Stock	RSE-Stock ≤ 25
	Genetics	% FLMB	N = 28, any age
Bluegill ^a	Exploratory	Presence/Absence	Practical effort
Redear Sunfish ^a	Exploratory	Presence/Absence	Practical effort
Longear Sunfish ^a	Exploratory	Presence/Absence	Practical effort
Gizzard Shad ^a	Exploratory	Presence/Absence	Practical effort
Threadfin Shad ^a	Exploratory	Presence/Absence	Practical effort
<i>Gill netting</i>			
Channel Catfish	Size Structure	PSD, length frequency	N ≥ 50 stock
Blue Catfish	Size Structure	PSD, length frequency	N ≥ 50 stock
Hybrid Striped Bass	Size Structure	PSD, length frequency	N ≥ 50 stock
White Bass	Size Structure	PSD, length frequency	N ≥ 50 stock
<i>Trap netting</i>			
White Crappie	Size Structure	PSD, length frequency	N ≥ 50 stock

^a Since the primary forage species objectives are exploratory, no target precision or target sampling sizes will be sought; additional sampling will not be necessary beyond that which is done for Largemouth Bass.

Table 6. Survey of aquatic vegetation, Waco Reservoir, Texas, 2015 and 2019. The percent of randomly selected points where species occurred is listed for 2015 and 2019. Water level was roughly two feet below conservation pool at the time of the surveys.

Vegetation	2015	2019
American water willow	7% (4 of 61)	1.6% (1 of 61)
Common buttonbush	46% (28 of 61)	41% (25 of 61)

17
Gizzard Shad

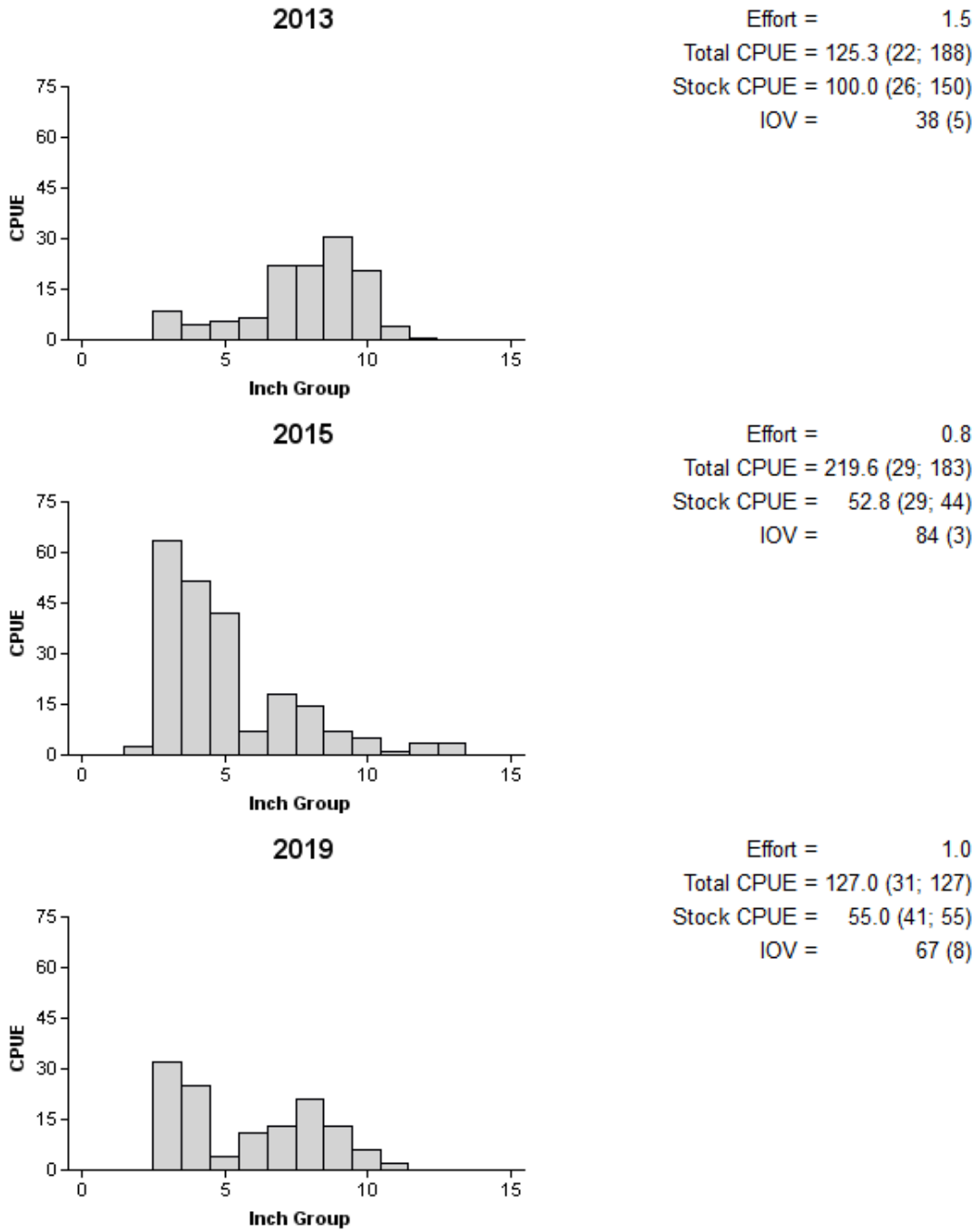


Figure 2. Number of Gizzard Shad caught per hour (CPUE) and population indices (RSE and N for CPUE and SE for IOV are in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2013, 2015 and 2019.

18
Bluegill

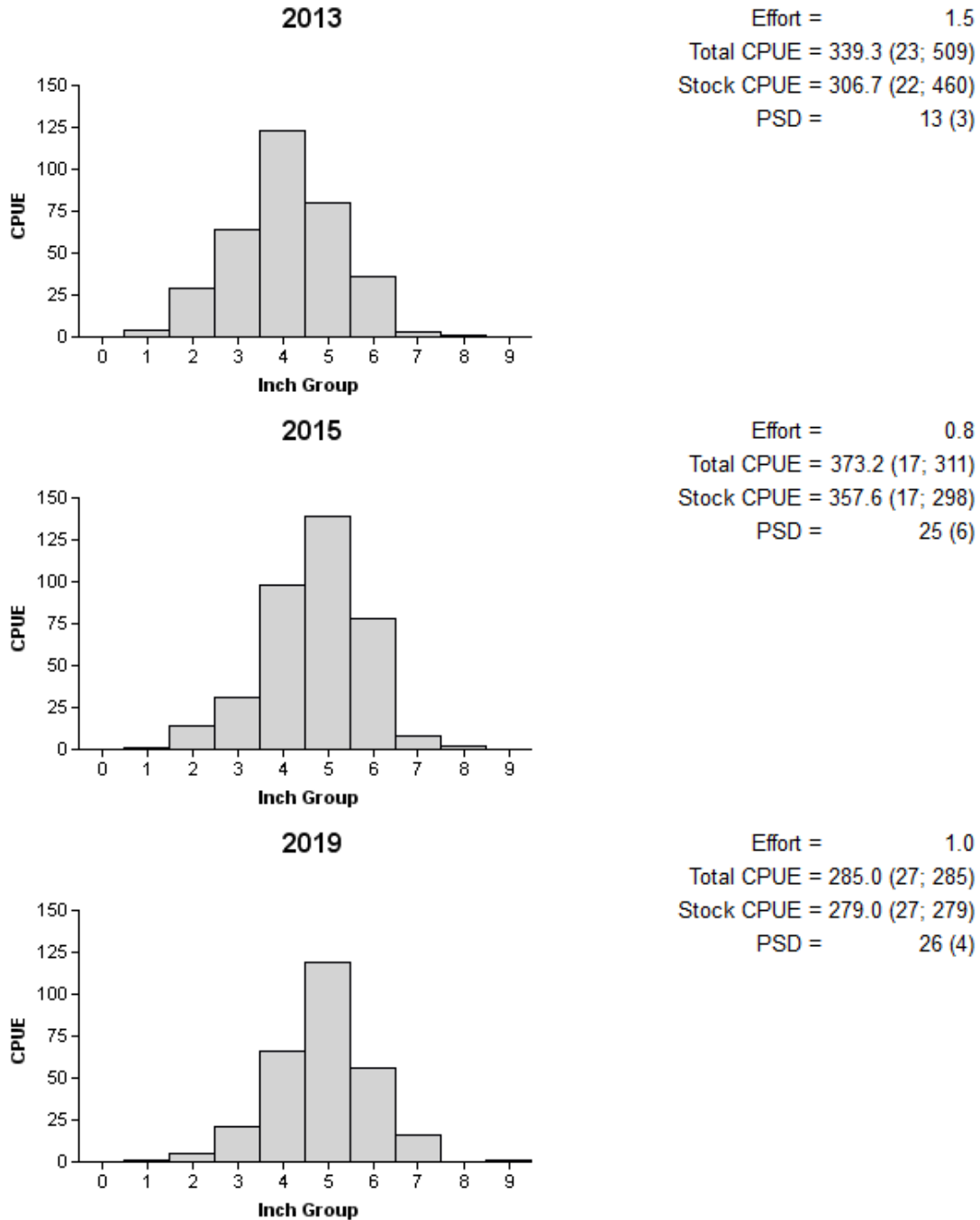


Figure 3. Number of Bluegill caught per hour (CPUE) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2013, 2015 and 2019.

19
Blue Catfish

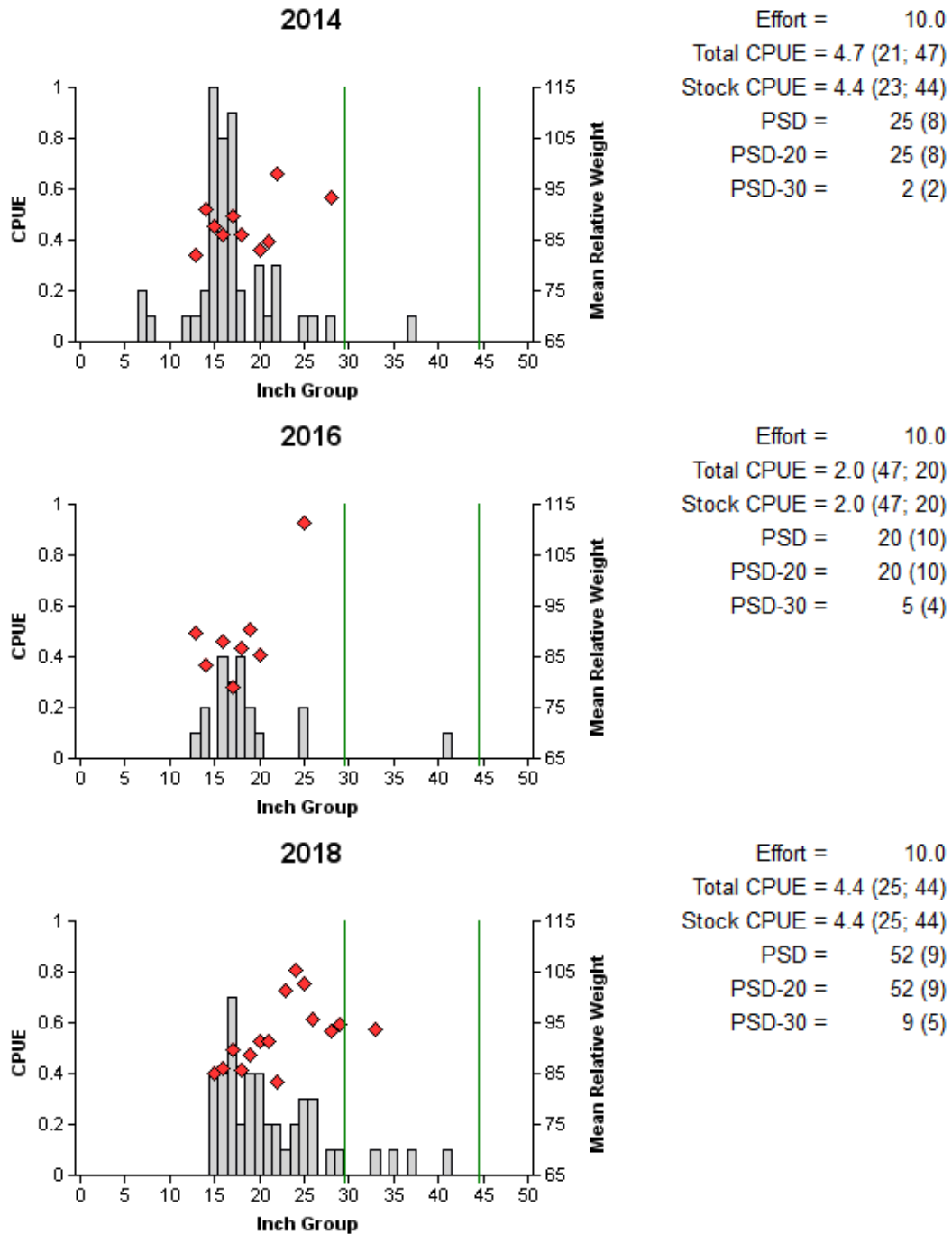


Figure 4. Number of Blue Catfish caught per net night (CPUE, bars), mean relative weights (diamonds) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for spring gill net surveys, Waco Reservoir, Texas, 2014, 2016 and 2018. Vertical lines represent 30 to 45-inch slot limit.

20
Channel Catfish

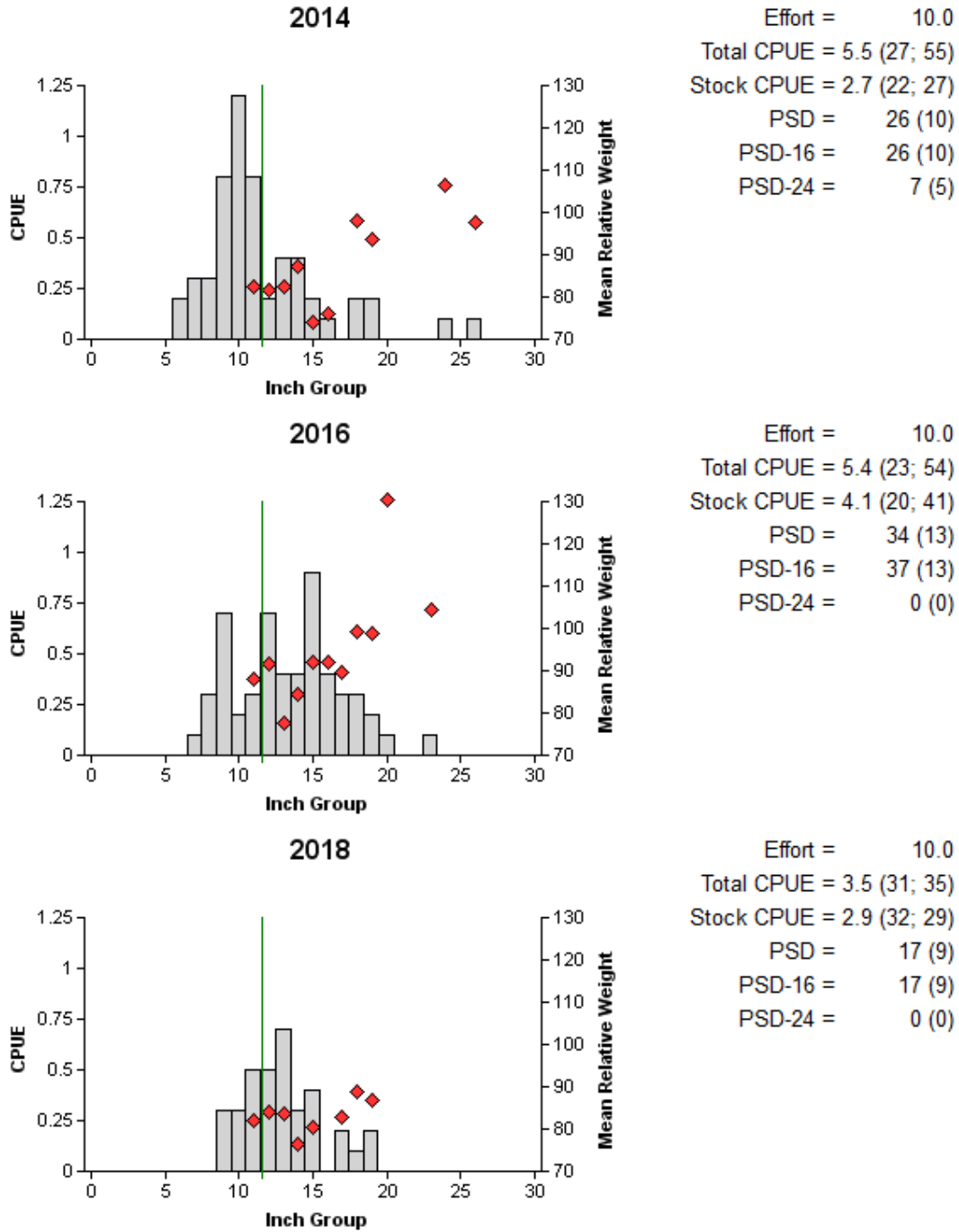


Figure 5. Number of Channel Catfish caught per net night (CPUE, bars), mean relative weights (diamonds) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for spring gill net surveys, Waco Reservoir, Texas, 2014, 2016 and 2018. Vertical line represents 12-inch minimum length limit.

21
White Bass

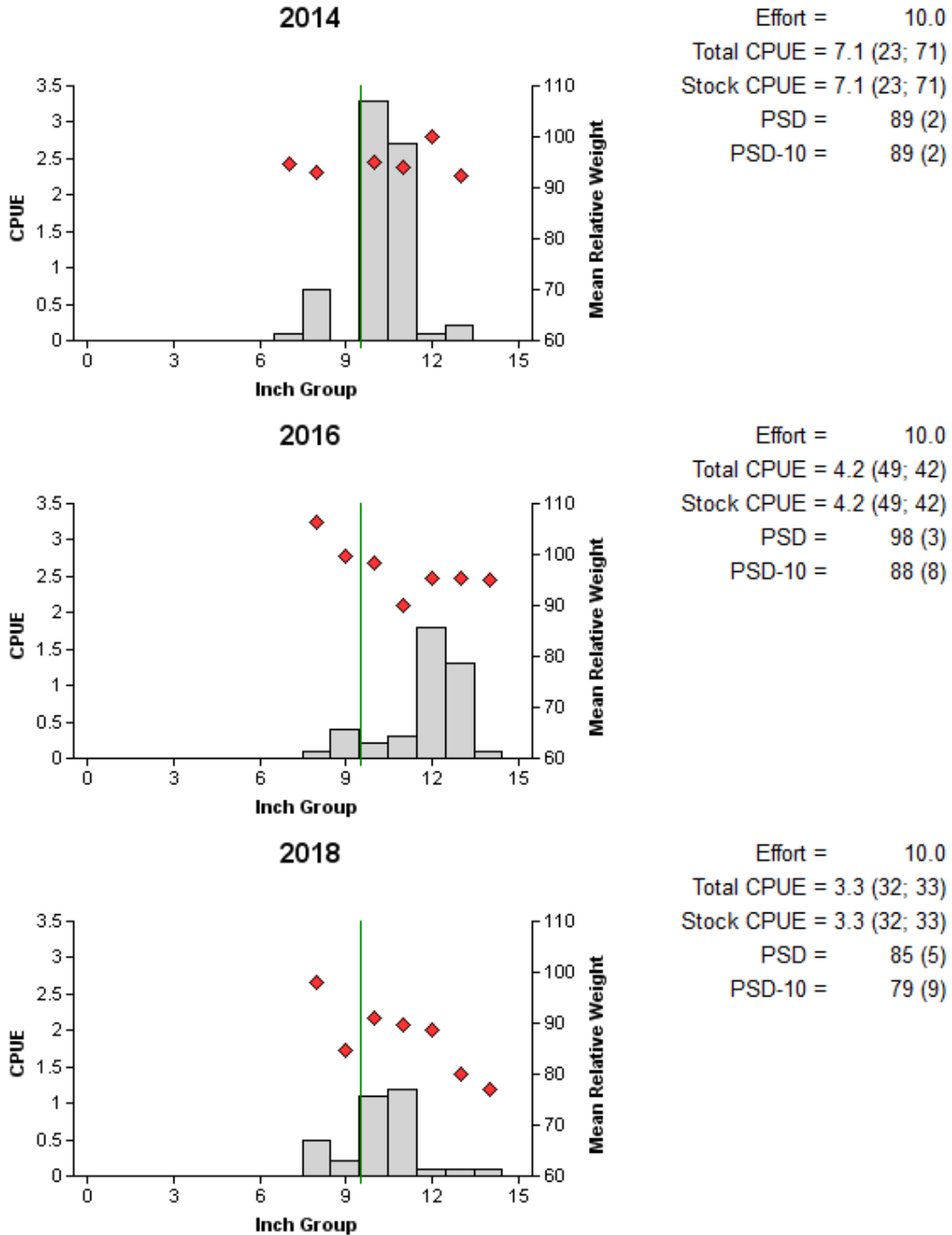


Figure 6. Number of White Bass caught per net night (CPUE, bars), mean relative weights (diamonds) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for spring gill net surveys, Waco Reservoir, Texas, 2014, 2016 and 2018. Vertical line represents 10-inch minimum length limit.

Hybrid Striped Bass

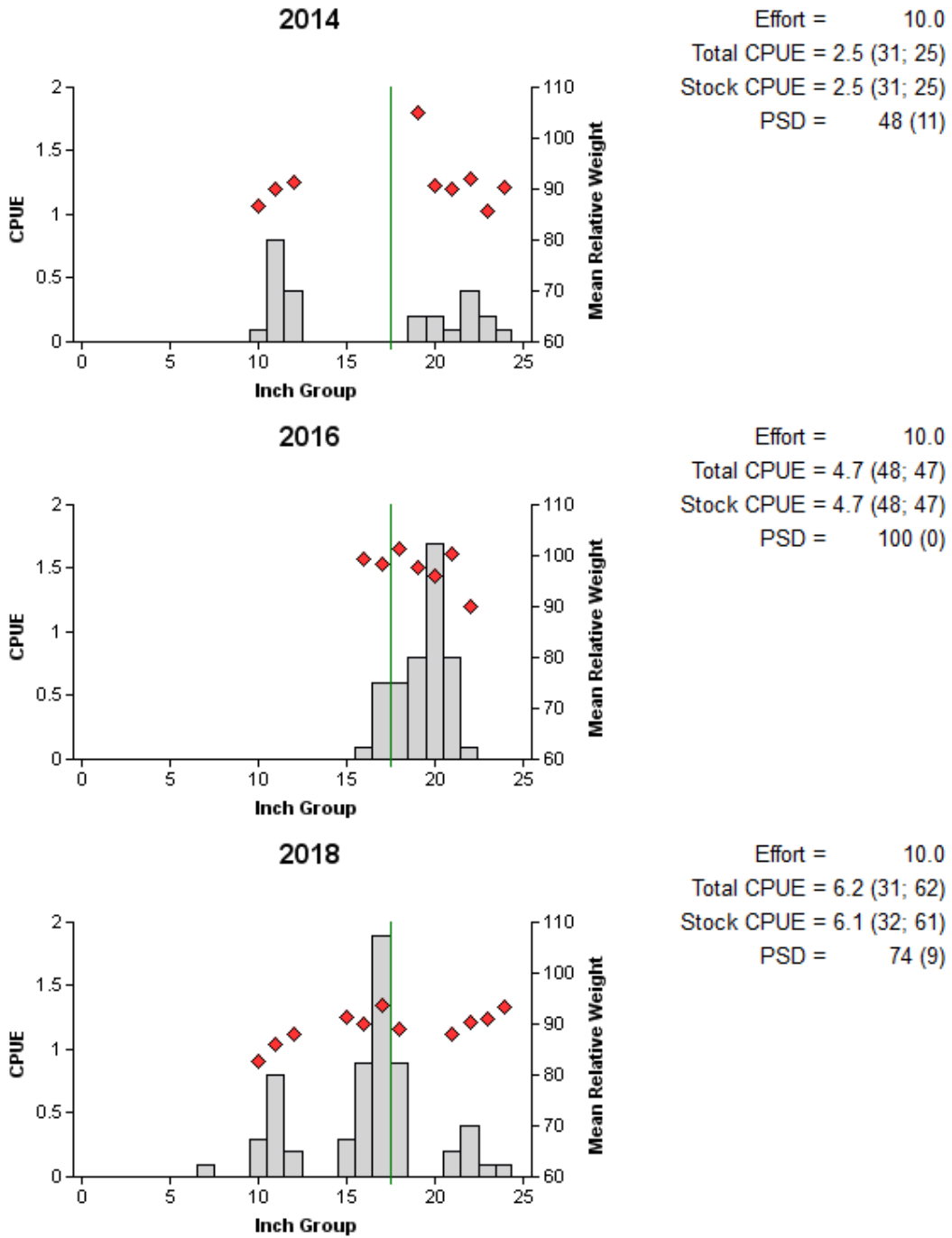


Figure 7. Number of Hybrid Striped Bass caught per net night (CPUE, bars), mean relative weights (diamonds) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for spring gill net surveys, Waco Reservoir, Texas, 2014, 2016 and 2018. Vertical line represents 18-inch minimum length limit.

Largemouth Bass

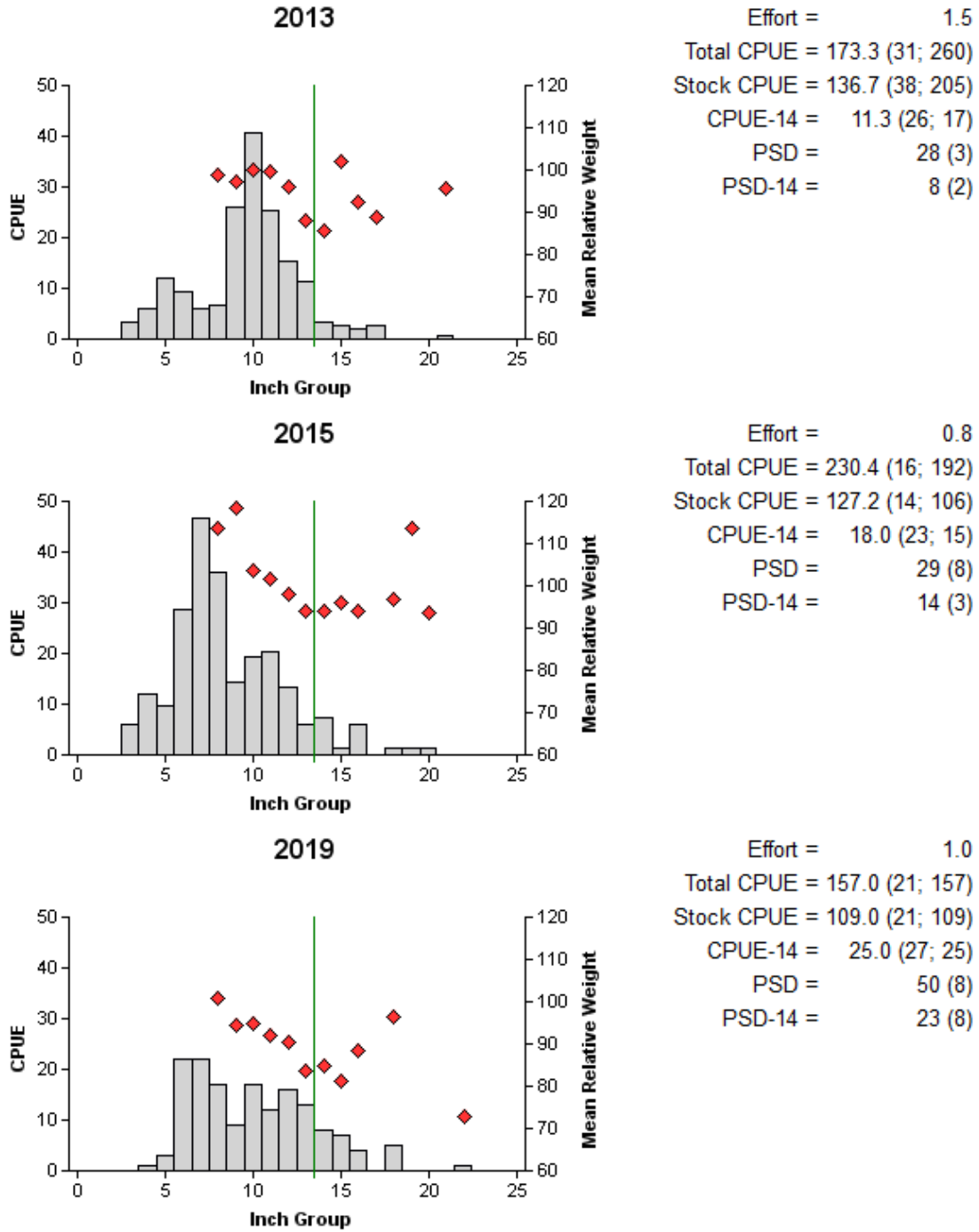


Figure 8. Number of Largemouth Bass caught per hour (CPUE, bars), mean relative weights (diamonds) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2013, 2015 and 2019. Vertical line represents 14-inch minimum length limit.

Table 7. Results of genetic analysis of Largemouth Bass collected by fall electrofishing, Waco Reservoir, Texas, 2005, 2011, 2015 and 2019. FLMB = Florida Largemouth Bass, NLMB = Northern Largemouth Bass, Intergrade = hybrid between a FLMB and a NLMB. Genetic composition was determined by micro-satellite DNA analysis.

Year	Sample size	Number of Fish			% FLMB alleles	% FLMB
		FLMB	Intergrade	NLMB		
2005	30	0	30	0	43	0
2011	30	0	28	2	48	0
2015	30	1	29	0	59	3
2019	28	0	28	0	62	0

White Crappie

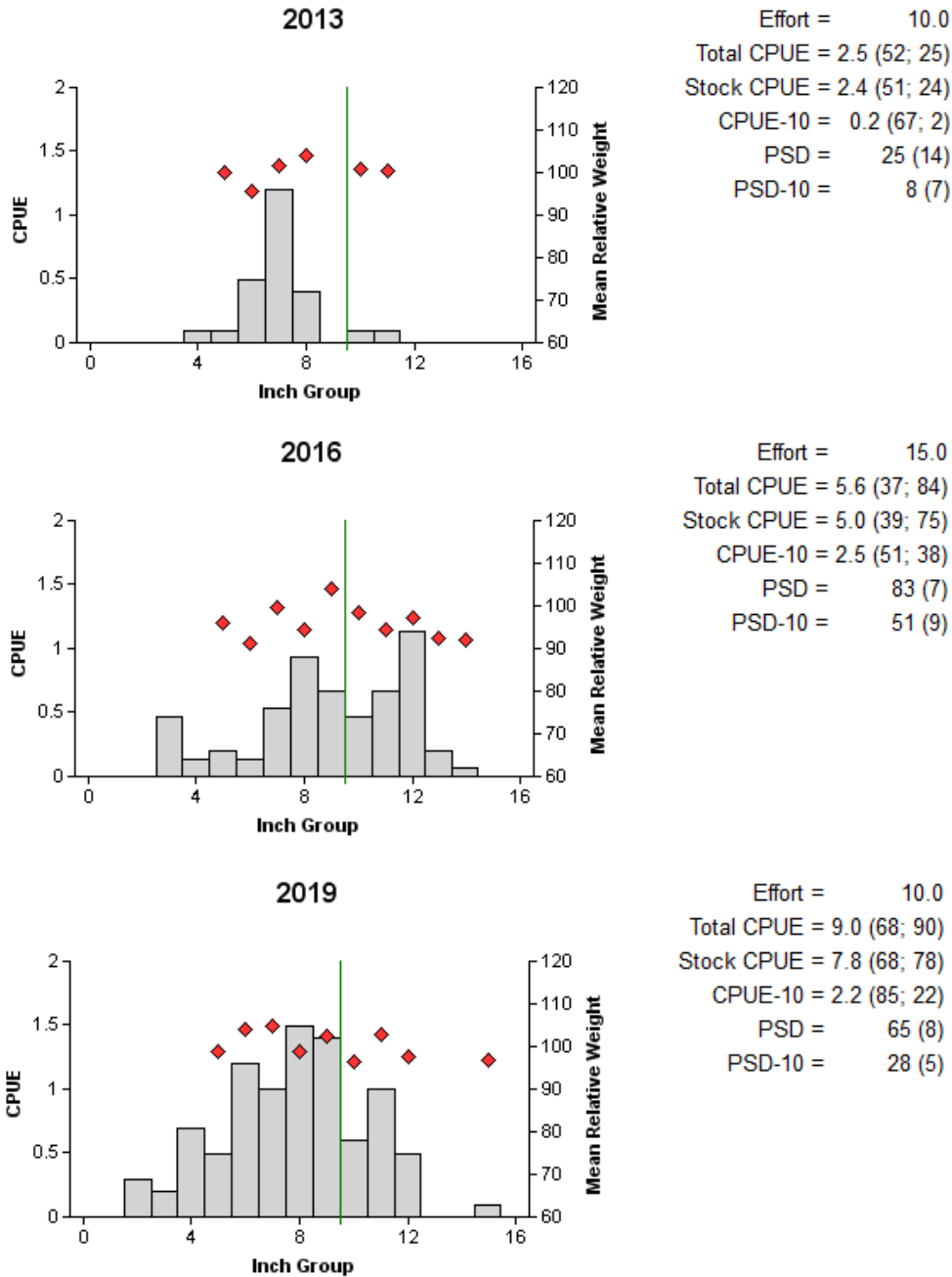


Figure 9. Number of White Crappie caught per net night (CPUE, bars), mean relative weights (diamonds) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for winter trap net surveys, Waco Reservoir, Texas, 2013, 2016 and 2019. The 2016 survey was completed later in winter and consists of 15 net nights. Vertical line represents 10-inch minimum length limit.

Proposed Sampling Schedule

Table 8. Proposed sampling schedule for Waco Reservoir, Texas. Survey period is June through May. Gill net surveys are conducted in the spring while trap net surveys are conducted in the fall and winter. Standard survey denoted by S and additional survey denoted by A.

	Survey Year			
	2020-2021	2021-2022	2022-2023	2023-2024
Vegetation				S
Access				S
Electrofishing				S
Trap Net				S
Gill Net		A		S
Report				S

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

Number (N), relative standard error (RSE), and catch rate (CPUE) of all target species collected from all gear types from Waco Reservoir, Texas, 2018-2019.

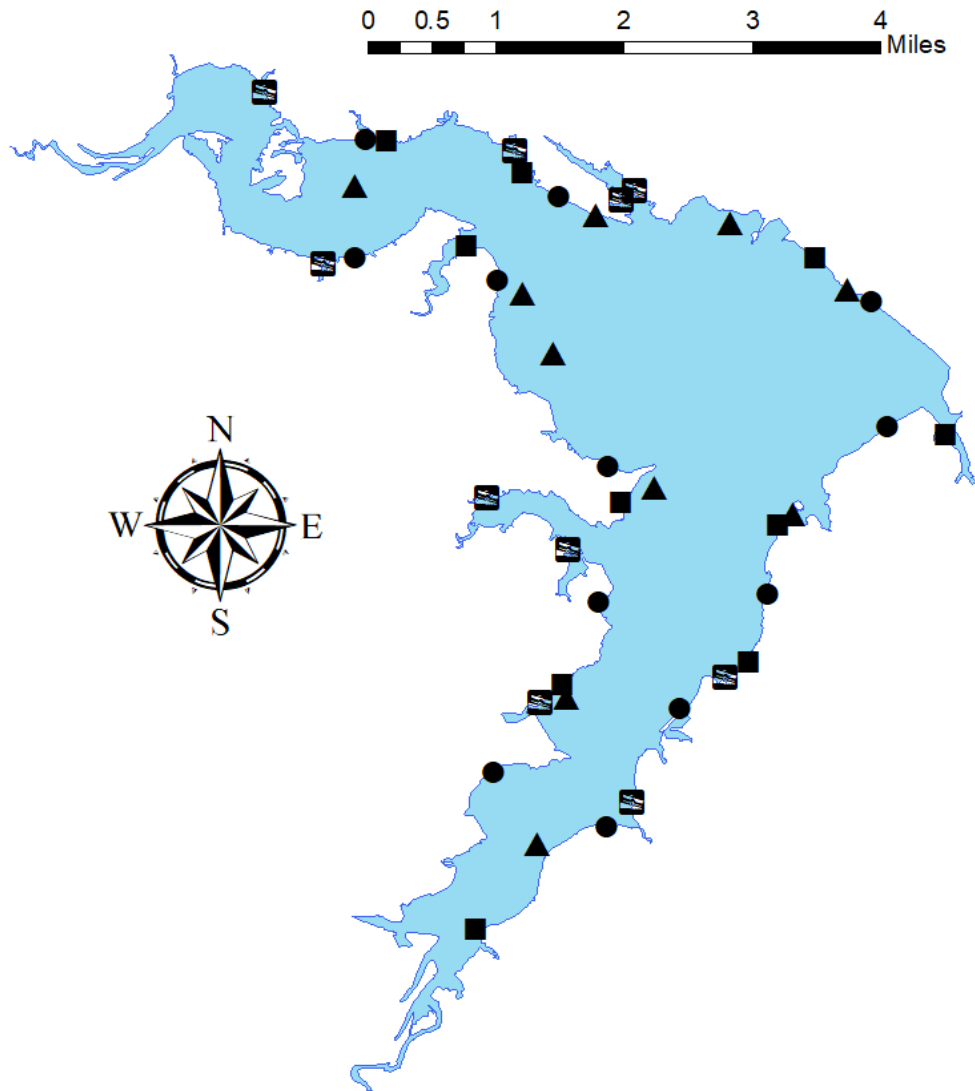
Species	Gill Netting		Trap Netting		Electrofishing	
	N/RSE	CPUE	N/RSE	CPUE	N/RSE	CPUE
Gizzard Shad					127/31	127.0
Threadfin Shad					86/35	86.0
Blue Catfish	44/25	4.40				
Channel Catfish	35/31	3.50				
White Bass	33/32	3.30				
Hybrid Striped Bass	62/31	6.20				
Green Sunfish					7/86	7.0
Warmouth					3/52	3.0
Bluegill					285/27	285.0
Longear Sunfish					48/45	48.0
Redear Sunfish					4/56	4.0
Hybrid Spotted Bass					10/41	10.0
Largemouth Bass					157/21	157.0
White Crappie	71/28	7.10	90/68	9.0		
Black Crappie	11/46	1.1	3/51	0.3		

APPENDIX B – Historical catch rates for targeted species by gear type

Historical catch rates (CPUE) of targeted species by gear type for standard surveys on Waco Reservoir, Texas, 1996 to present. All stations were randomly selected. Electrofishing stations utilized a 5.0 Smith-Root GPP (Gas Powered Pulsator) through 2010, after which a 7.5 Smith-Root GPP was used. Objective based sampling began in 2015. Species averages are in bold. Dashes represent no data; N/A indicates that the species did not exist in the reservoir at that time.

Gear	Species	Sampling Period											Avg.
		96	99	00	01	03/04	05/06	07/08	11/12	13/14	15/16	18/19	
Electrofishing													
	Largemouth Bass	74.0	176.7	71.3	194.0	194.0	154.7	420.7	189.3	173.3	230.4	157.0	185.0
	Spotted Bass	0.7	11.3	26.7	4.7	2.7	2.7	8.7	17.3	1.3	58.8	10.0	13.2
	Gizzard Shad	409.3	34.7	71.3	317.3	91.3	110.0	614.0	110.7	125.3	219.6	127.0	202.8
	Threadfin Shad	8.0	0.7	1.3	32.0	3.3	168.7	174.0	108.0	137.3	289.2	86.0	91.2
	Bluegill Sunfish	120.0	92.7	156.7	342.7	314.7	238.7	314.0	388.7	339.3	373.2	285.0	266.6
	Redear Sunfish	2.7	5.3	12.0	19.3	22.7	25.3	22.7	32.7	46.0	26.4	4.0	19.9
	Longear Sunfish	24.7	12.0	68.7	73.3	130.7	40.0	99.3	114.0	78.7	201.6	48.0	81.0
	Green Sunfish	0.0	0.7	1.3	0.0	6.0	0.0	2.0	6.0	0.0	10.8	7.0	3.1
	Warmouth	2.0	2.7	2.0	1.3	7.3	3.3	2.7	2.0	2.0	7.2	3.0	3.2
Gill nets													
	Blue Catfish	0.0	0.1	-	-	3.2	3.7	5.3	2.8	4.7	2.0	4.4	2.9
	Channel Catfish	5.7	7.2	-	-	5.7	2.1	7.5	7.0	5.5	5.4	3.5	5.5
	White Bass	1.3	1.8	-	-	0.4	2.8	0.9	4.3	7.1	4.2	3.3	2.9
	Hybrid Striped Bass	N/A	N/A	-	-	N/A	N/A	N/A	1.4	2.5	4.7	6.2	3.7
	Flathead Catfish	0.1	0.6	-	-	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.1
Trap nets													
	White Crappie	2.0	9.0	-	-	5.2	3.0	14.8	2.1	2.5	5.6	9.0	5.9
	Black Crappie	0.0	0.0	-	-	0.0	0.0	0.4	0.0	0.1	0.7	0.3	0.2

APPENDIX C – Map of sampling locations



Location of sampling sites, Waco Reservoir, Texas, 2018-2019. Trap net, gill net, and electrofishing stations are indicated by solid squares, triangles, and circles, respectively. Boat ramps are indicated by larger squares with boat/ramp symbols on them. Water level was two feet below conservation pool (462 feet above mean sea level) during the 2018 gill net survey and three feet below conservation pool during 2019 electrofishing and trap net surveys.

APPENDIX D – History of Zebra Mussel PCR/eDNA sampling

Date	Site	Latitude/Longitude (dd)	LM Morph	PCR/eDNA
6/11/14	Lake Waco Marina Dock	31.55432/-97.23629	Ostracods	Negative (3/3)
9/30/14	Speegleville	31.55386/-97.22823	Ostracods	Negative (3/3)
	Twin Bridges	31.52956/-97.23260	Ostracods	Negative (3/3)
	Ridgewood Marina	31.53475/-97.22494	Ostracods, ZM	Positive (3/3)
	Ridgewood Ramp Cove	31.53325/-97.22625	Ostracods	Negative (3/3)
10/20/14	Ridgewood Marina	31.53475/-97.22494	Ostracods	Negative (3/3)
	Twin Bridges	31.52956/-97.23260	Ostracods	Negative (3/3)
	Speegleville	31.55386/-97.22823	Ostracods	Positive (1/3)
10/21/14	Lake Waco Marina Dock	31.55432/-97.23629	Ostracods	Negative (6/6)
07/10/15	Speegleville	31.55386/-97.22823	Suspect veliger	Negative (3/3)
	Twin Bridges	31.52956/-97.23260	Suspect veliger	Negative (3/3)
	Ridgewood Marina	31.53475/-97.22494	Suspect veliger	Negative (3/3)
	Site #1	--/--	Ostracods	Negative (3/3)
	Site #2	--/--	Ostracods	Negative (3/3)
	Site #3	--/--	Ostracods	Negative (3/3)
11/29/16	Speegleville	31.55386/-97.22823	Ostracods	Negative (3/3)
	Out from Speegleville Creek	31.55517/-97.22597	Ostracods	Negative (3/3)
	Out from outlet structure	31.57774/-97.20070	Ostracods	Negative (3/3)
	Airport Marina	31.59568/-97.22935	Ostracods	Negative (3/3)
	Out from Reynolds Creek. B.R.	31.59012/-97.25818	Ostracods	Negative (3/3)
	S. of Twin Bridges	31.52941/-97.23434	Ostracods	Negative (3/3)
	S. of Ridgewood Marina B.R.	31.53346/-97.22630	Ostracods	Negative (3/3)
	N. of Ridgewood Marina B.R.	31.53515/-97.22559	Ostracods	Negative (3/3)
	Back of Ridgewood Marina	31.53619/-97.22250	Ostracods	Negative (3/3)
	Middle of Ridgewood Marina	31.53561/-97.22388	Ostracods	Negative (3/3)
05/10/17	Ridgewood Marina Cove	31.5346/-97.22479	Ostracods	Negative (3/3)
	Ridgewood B.R.	31.53325/-97.22625	Ostracods	Negative (3/3)
	Twin Bridges	31.52956/-97.23260	Ostracods	Negative (3/3)
	Airport Marina	31.59568/-97.22935	Ostracods	Negative (3/3)
	Speegleville	31.55552/-97.23373	Ostracods	Negative (3/3)
11/01/17	Speegleville	31.55552/-97.23373	Ostracods	Negative (3/3)
	Ridgewood Marina	31.53462/-97.22632	Ostracods	Negative (3/3)
	Airport Marina	31.59568/-97.22935	Ostracods	Negative (3/3)
06/07/18	Speegleville	31.55552/-97.23373	Ostracods	Negative (6/6)
	Twin Bridges	31.52956/-97.23260	Ostracods	Negative (6/6)
	Ridgewood Marina Cove	31.5346/-97.22479	Ostracods	Negative (6/6)
	Dam Face	--/--	Ostracods	Negative (6/6)
	Airport Marina	31.59568/-97.22935	Ostracods	Negative (6/6)
	Reynolds Creek B.R.	31.59012/-97.25818	Ostracods	Negative (6/6)
10/17/19	Speegleville	31.55552/-97.23373	Ostracods	Negative
	Twin Bridges	31.52956/-97.23260	Ostracods	Negative
	Ridgewood Marina Cove	31.5346/-97.22479	Ostracods	Negative
	Dam Face	--/--	Ostracods	Negative
	Airport Marina	31.59568/-97.22935	Ostracods	Negative
	Reynolds Creek B.R.	31.59012/-97.25818	Ostracods	Negative

History of Zebra Mussel PCR/eDNA sampling on Waco Reservoir, 2014 to present.



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