Waco Reservoir

2023 Fisheries Management Survey Report

PERFORMANCE REPORT

As Required by

FEDERAL AID IN SPORT FISH RESTORATION ACT

TEXAS

FEDERAL AID PROJECT F-221-M-5

INLAND FISHERIES DIVISION MONITORING AND MANAGEMENT PROGRAM

Prepared by:

Michael S. Baird, District Management Supervisor

Inland Fisheries Division
Waco District, Waco, Texas

David Yoskowitz, Ph.D.
Executive Director

Timothy Birdsong
Director, Inland Fisheries

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Survey and Management Summary

Fish populations in Waco Reservoir were surveyed in spring 2022 using gill netting, fall 2023 using electrofishing, winter 2024 using trap netting and spring 2024 using gill netting. Historical data are presented with the 2022-2024 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: 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 nearly reached a historic low of 450.34 above mean sea level on October 24, 2023. Habitat features consisted of natural, rock and gravel shorelines, and limited flooded timber, boat docks and piers. Bank and boat access to the reservoir is good.

Management History: Important sport fish include catfishes, hybrid striped bass (HSB), White Bass, Largemouth Bass, and White Crappie. Sport fish have always been managed with statewide regulations, with the exception of Blue Catfish which were regulated with a 30 to 45-inch slot limit from 2009 to 2021. The statewide regulation for Blue and Channel Catfish changed on September 1, 2021; the current regulations are in this report. Zebra mussels were found at a single location on the lake in 2014, and management efforts have largely concentrated on AIS since that time. Lake Waco was delisted from infested to undetected/negative status in 2020, yet zebra mussel monitoring efforts continue today. The statewide evaluation of palmetto bass vs sunshine bass fingerling performance is incomplete, yet palmetto bass were not stocked in 2020, 2021 or 2022. Native vegetation plantings were discontinued in 2020 due to interim drought, flooding, and inconsistent water levels. Instead, management efforts have focused on building freshwater reefs in appropriate areas, consisting of artificial habitat like Georgia structures, PVC cubes and commercially available Mossback structures. Nearly 75 artificial structures have been placed in Waco since 2021. Recent management efforts consist of zebra mussel eDNA monitoring, vegetation surveys, aquatic invasive species (AIS) education, habitat enhancement efforts and monitoring the HSB fishery.

Fish Community

- **Prey species:** Collected prey species included Gizzard Shad, Threadfin Shad, Bluegill, Longear Sunfish, and Redear Sunfish. Catch rates for both shad species were above historical averages. Most Gizzard Shad were available as prey to sport fish. Sunfish species were collected below historical averages.
- **Catfishes:** Collected catfishes included Blue Catfish and Channel Catfish. The Blue Catfish population was strong with excellent recruitment and body condition while the Channel Catfish population structure was depressed from the previous survey. Channels still had good to excellent body condition.
- **Temperate basses:** Collected temperate bass included White Bass and HSB. Both species were present in the reservoir in good numbers. Body condition for Whites was good, while HSB condition was only fair.
- **Black Bass:** Collected black bass included Largemouth Bass and Spotted Bass. Largemouth Bass were collected well below their historical average, but poor sampling conditions are likely to blame for the low catch rates. Body condition was good to excellent for Largemouth Bass, and Florida Bass genetic influence remains good at 60%. All individuals identified as Spotted Bass were found to be Spotted x Guadalupe Bass hybrids.
- **Crappie:** Collected crappies included White Crappie and Black Crappie. White Crappie were not abundant, but collected individuals had excellent body condition. Black Crappie were collected in very low numbers.

Management Strategies: Continue managing sport fishes at Waco Reservoir with current regulations. Continue bi-annual zebra mussel monitoring in partnership with Texas State University. Conduct an

electrofishing survey in fall 2025, angler access, vegetation, and electrofishing surveys in late-summer and fall 2027, and trap netting and gill netting surveys in 2028. Continue stocking HSB at 15 fish/acre, request Lonestar Bass and sunfishes, perform additional habitat enhancements in cooperation with interested partners, and continue working to inform the public about the negative impacts of AIS.

Introduction

This document is a summary of fisheries data collected from Waco Reservoir from 2022-2024. 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 2022-2024 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 at the conservation pool of 462 feet above mean sea level (MSL). Waco Reservoir is eutrophic with a TSI *chl-a* of 57.16 (Texas Commission on Environmental Quality, 2022). Habitat at the time of sampling was dominated by natural over-hanging trees and terrestrial vegetation, rock, and gravel shorelines, limited flooded timber, boat docks and piers. Aquatic vegetation was either absent or dry due to low reservoir water level when the survey was conducted. Water level nearly reached a historic low in October 2023 (450.34' above MSL) but filled quickly in late October and early November 2023. Water level was 3.8' low during the spring 2022 gill netting survey, 10.8' low during the summer 2023 vegetation survey, 11.6' low during the fall 2023 electrofishing survey, 1.9' above conservation pool during the late winter 2023 trap netting survey, and 0.5' above conservation pool during the spring 2024 gill netting survey (Figure 1). 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 (Baird and Tibbs 2020) included:

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. Pending the results of the 2020 plankton tows and analysis, delist Waco from infested status to undetected/negative status, replace boater advisory signage with general Clean, Drain, Dry signage, and issue a news release on the successful eradication efforts.

   Action: Waco was sampled in 2020 at the standard six sites with plankton tows and all sampling was negative for zebra mussel veligers or eDNA. The lake was then delisted from infested status to undetected/negative status, and general Clean, Drain, Dry signage was provided to the Lake Waco USACE. Texas Parks and Wildlife Department released a major news story on the subject in January 2021, along with many other local news stories and videos including several on Facebook and YouTube.

2. Continue genetic tissue analysis of Spotted Bass or suspected Spotted x Guadalupe Bass hybrids when collected from electrofishing surveys or from rod and reel surveys on Waco Reservoir tributaries. Pending the results of additional informal surveys, issue a news release on the results.

   Action: No rod and reel surveys were conducted however nine individuals thought to be Spotted Bass or Spotted x Guadalupe Bass hybrids were collected during fall 2023 sampling. All but one of these individuals were genetically determined to be Spotted x Guadalupe Bass hybrids.

3. Gill net in spring 2022 and 2024 to monitor the condition of the HSB fishery and collect a category III age and growth sample in either 2022 or 2024. Continue requesting HSB stockings to accommodate research plans. Work with local partners to continue educating anglers to ensure compliance of temperate bass regulations.

   Action: The HSB fishery was sampled with 15 gill nets in late winter 2022 and 10 gill nets in spring 2024; those data are in this report.

4. Discontinue native vegetation plantings on Waco Reservoir. 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. Update the TPWD website with freshwater reef locations and GPS coordinates so that interested anglers can find and fish them.

   Action: Native vegetation plantings have been discontinued, and artificial habitat enhancement projects involving the building and placing of structures into freshwater reefs have taken their place. Texas Parks and Wildlife Department has partnered with Lake Waco USACE to place approximately 75 artificial structures into the reservoir since the last report.

5. Cooperate with the controlling authority to maintain appropriate AIS signage at access points. Maintain contact with marina owners about AIS, and provide them with posters, literature, etc. so that they can continue to educate their customers. Provide training to City of Waco interns on zebra mussels annually as needed prior to summer efforts. 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.

   Action: Appropriate AIS signage (Clean, Drain, Dry signage) was provided to the Lake Waco USACE after the lake was delisted from infested status to undetected/negative status. District biologists have made a speaking point about AIS, how to prevent their spread, and potential effects on Waco Reservoir while speaking to anglers over the past several years. Interbasin water transfers will be updated as needed.

Harvest regulation history: Sportfishes in Waco Reservoir are currently managed with statewide regulations with the exception of Blue and Channel Catfish. The Blue and Channel Catfish regulation changed on September 1, 2021, and now the regulation is no minimum length limit; daily bag of 25 (in any combination – no more than 5 can be 20 inches or greater in length, and no more than one of those can be 30 inches or longer). The current harvest regulations are listed in Table 3.

Stocking history: Waco Reservoir was last stocked with Blue Catfish in 2004, Florida Largemouth Bass in 2013 and 2014, and HSB in 2022 and 2023. The complete stocking history is in Table 4.

Vegetation/habitat management history: A summary of vegetation and habitat management history can be found in Tibbs and Baird (2016) and Baird and Tibbs (2020). No additional vegetative habitat management work has been conducted.

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: A summary of Waco Reservoir's zebra mussel history can be found in Baird and Tibbs (2020). Waco Reservoir was delisted from infested status to undetected/negative status in late 2020 and multiple sources and news releases documented the event. Bi-annual monitoring is still conducted in partnership with Texas State University.

Methods

Surveys were conducted to achieve survey and sampling objectives in accordance with the objective-based sampling (OBS) plan for Waco Reservoir (Baird and Tibbs 2020). 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 2022).

Common names of fishes and their hybrids in this report are used following Page et al. (2023) with an exception for Largemouth Bass. While we recognize recent changes to black bass names, Texas reservoirs contain a mix of Florida Bass, Largemouth Bass, and their intergrade offspring. Therefore, Largemouth Bass is used in this report for simplicity as well as consistency with previous reports.

Electrofishing – Largemouth Bass, sunfishes, Gizzard Shad and Threadfin Shad were collected by nighttime electrofishing (1.0 hour at 12, 5-min stations) in 2023. Catch per unit effort (CPUE) for electrofishing was recorded as the number of fish caught per hour (fish/h) of actual electrofishing. Electrofishing in 2023 was conducted using a Smith-Root Apex electrofisher, while previous surveys used GPP 7.5 electrofisher.

Trap netting – Crappie were collected by late winter (February) trap netting (10 net nights at 10 stations) in 2024. The 2024 survey is the first late-winter trap netting survey completed on Waco Reservoir. Catch per unit effort (CPUE) for trap netting was recorded as the number of fish caught per net night (fish/nn).

Gill netting – Channel Catfish, Blue Catfish, HSB, White Bass and White Crappie were collected by spring gill netting (15 net nights at 15 stations in 2022 and 10 net nights at 10 stations in 2024). Catch per unit effort (CPUE) for gill netting 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 2022). Micro-satellite DNA analysis was used to determine genetic composition of individual fish since 2005. Electrophoresis analysis was used prior to 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 Neumann et al. (2012). Hybrid striped bass PSD was calculated according to Dumont and Neely (2011). TPWD has stocked both hybrid striped bass crosses (palmetto bass and sunshine bass) in the past. Most hybrid striped bass currently produced by TPWD hatcheries are sunshine bass. Even though PSD length categories and standard weight equation were developed based on palmetto bass populations, they are applied to sunshine bass under the assumption that there is little difference in the growth of the two hybrids. 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 and creel statistics.

Habitat – The 2011 structural habitat survey was conducted according to Tibbs and Baird (2012). The 2023 vegetation survey was conducted using an adaptation of the point method (TPWD, Inland Fisheries Division, unpublished manual revised 2022). 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 2024).

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). Littoral zone habitat in summer 2023 was dominated by natural shoreline and terrestrial vegetation (100% or 61 of 61 randomly selected shoreline points). No aquatic vegetation was observed during the survey.

Prey species: Gizzard Shad and Threadfin Shad catch rates were 381.0/h and 271.0/h, respectively, and higher than their historical averages (Figure 2; Appendices A and B). The IOV for Gizzard Shad was good, indicating that 88% of Gizzard Shad were available to existing predators; this was higher than IOV estimates in previous years. Total CPUE of Gizzard Shad was considerably higher in 2023 compared to 2019 and 2015 (Figure 2). Other forage species collected were Bluegill (253.0/h), Longear Sunfish (24.0/h), and Redear Sunfish (6.0/h; Figures 3, 4 and 5; Appendices A and B). Few sunfish reach preferred size classes in Waco Reservoir, and few anglers actively seek them.

Catfishes: Blue Catfish were collected at a rate of 6.0 fish/nn, which is the highest catch rate for the species in Waco Reservoir (Figure 6; Appendices A and B). The OBS goals for Blue Catfish, general monitoring to collect abundance (CPUE – Total; RSE ≤ 25) and size structure (PSD and length-frequency; N ≥ 50 stock) data, were achieved with 56 stock-length individuals and an RSE value of 24 (Table 5; Figure 6). The PSD value decreased between 2020 and 2024, from 45 to 27, reflecting higher proportions of smaller fish in the population due to the exceptional 11 to 14-inch length classes represented. Relative weight (Wr), or body condition, was excellent for most length classes.

Channel Catfish were collected at a rate of 3.1 fish/nn, which is below the historical average for the species (Figure 7; Appendices A and B). The OBS goals for Channel Catfish, general monitoring to collect abundance (CPUE – Total; RSE ≤ 25) and size structure (PSD and length-frequency; N ≥ 50 stock) data, were not achieved with 27 stock-length individuals and an RSE value of 29 (Table 5; Figure 7). The PSD value in 2024 (7) was well below that of 2020 (25) and reflects a population skewed toward smaller length classes; few Channel Catfish were in the quality length category, and none were collected in the preferred length category. Relative weight (Wr), or body condition, was excellent for most length classes (Figure 7).

Temperate Bass: White Bass were collected at a rate of 7.9 fish/nn, which is similar to the previous survey and well above the historical average (Figure 8; Appendices A and B). The OBS goals for White Bass, general monitoring to collect abundance (CPUE – Total; RSE ≤ 25) and size structure (PSD and length-frequency; N ≥ 50 stock) data, were partially achieved with 79 stock-length individuals and an RSE value of 30 (Table 5; Figure 8). Proportional size distribution (PSD) improved from the 2018 survey (Figure 8). Relative weight (Wr), or body condition, was excellent for sublegal length classes and good for legal length classes (Figure 8).

Hybrid striped bass were collected at a rate of 4.9 fish/nn, well below the rate of 16.2 fish/nn in 2022 (Figure 9; Appendices A and B). The OBS goals for HSB, general monitoring to collect abundance

(CPUE – Total; RSE ≤ 25) and size structure (PSD and length-frequency; N ≥ 50 stock) data, were not achieved in 2024 with only 48 stock-length individuals and an RSE value of 35. The targeted HSB gill net survey in 2022 did meet both OBS objectives with 242 stock-length individuals and an RSE value of 24 (Table 5; Figure 9). Size structure favored larger individuals in 2022 (PSD 69) and smaller individuals in 2024 (PSD 35). Relative weight (Wr), or body condition, was good to excellent in 2022 and fair to good in 2024.

The 2022 survey targeting HSB was conducted as part of a broader research project meant to compare the recruitment and performance of both palmetto bass and sunshine bass stocked as fingerlings in multiple reservoirs across the state. Waco Reservoir received fingerling stockings of both palmetto and sunshine bass in 2017, 2018 and 2019, totaling 148,332 palmetto bass and 95,661 sunshine bass (Table 4). Two hundred twenty-three individuals were collected from 15 gill net sets in 2022, genetically identified using scale tissue and aged using otoliths; 158 of these individuals were stocked during the study years (Figures 9, 10 and 11). Although 35% more palmetto bass were stocked over the three-year study period, 57% of the HSB collected in 2022 were sunshine bass, suggesting sunshine bass recruited and performed better than palmetto bass in Waco Reservoir during this period (Table 4; Figures 9,10 and 11). Both species reached the minimum length limit of 18 inches around age-3; individuals younger than age-3 and older than age-5, were stocked outside of the study years (Table 4; Figures 10 and 11).

Black Bass: Largemouth Bass were collected at 79.0 fish/h, well below the historical average (Figure 12; Appendices A and B). Drought and poor sampling conditions in 2023 (i.e., water level at 11.6' below conservation pool) likely contributed to low catch rates of Largemouth Bass in this survey. The OBS goals for this species, general monitoring to collect abundance (CPUE – Total; RSE ≤ 25) and size structure (PSD and length-frequency; N ≥ 50 stock) data, were achieved with 60 stock-length individuals and an RSE value of 22 (Figure 12). The population is nicely balanced, and individuals commonly make it to preferred (15-inches) and, less commonly, memorable (20-inches) length categories (Figure 12). Florida Largemouth Bass influence remained good at 60% (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 2023 electrofishing, and all but one were found to be Spotted x Guadalupe Bass hybrids. Coincidentally, nine individuals were also submitted for genetic analysis in 2019, and all were found to be Spotted x Guadalupe Bass hybrids. Percent Guadalupe Bass alleles for the 2019 individuals ranged from 9 – 98%

Crappie: White Crappie were collected with trap nets and spring gill nets at 1.2 fish/nn and 3.0 fish/nn respectively, and the catch rates for both surveys were well below the historical averages (Figures 13 and 14; Appendices A and B). The OBS trap netting goals for White Crappie, general monitoring to collect abundance (CPUE – Total; RSE ≤ 25) and size structure (PSD and length-frequency; N ≥ 50 stock) data, were partially achieved with 10 stock-length individuals and an RSE value of 22 (Table 5; Figure 13). The PSD value was good (60), reflecting a balanced population, yet the overall population structure was poor (Figure 13). White Crappie reach the memorable length category (12-inches) commonly in Waco Reservoir. Relative weight (Wr), or body condition, was excellent across all length classes (Figure 13).

Black Crappie remain a low-density population (0.2 fish/nn) in Waco Reservoir (Appendices A and B).

Fisheries Management Plan for Waco Reservoir, Texas

Prepared – July 2024

ISSUE 1: Lake Waco was delisted from infested to undetected/negative status for zebra mussels in 2020 but remains at risk to new infestations.

MANAGEMENT STRATEGIES

1. Continue to work with Texas State University to sample Waco biannually during spring and fall at the standard sites with plankton tows to identify any zebra mussel veligers or eDNA.
2. Continue to work with the Lake Waco USACE to maintain general Clean, Drain, Dry signage at all access points.

ISSUE 2: Waco Reservoir experienced historic drought conditions during 2022 and 2023, and Largemouth Bass and sunfish catch rates were near or at all-time lows.

MANAGEMENT STRATEGIES

1. Request Lone Star Bass fingerlings, which are 2nd generation offspring of pure Florida strain ShareLunker Largemouth Bass ≥ 13 pounds, at a rate of 1,000/km shoreline, two additional years before the next report.
2. Consider constructing spawning beds or habitat in several areas of the reservoir to improve populations of nest spawners like sunfishes.
3. Deploy structure (freshwater reefs) in appropriate areas throughout the lower end of the reservoir to provide much-needed habitat for forage and sportfishes.
4. Conduct an additional electrofishing survey prior to fall 2027 and a standard electrofishing survey in fall 2027 to closely monitor Largemouth Bass population structure and trends.

ISSUE 3: Waco Reservoir is an urban reservoir that sits on the western edge of Waco, a city with a population of over 144,000 people. Waco is also a part of the *Texas Triangle,* outlined by the Dallas-Fort Worth, Houston, and San Antonio metroplexes; this area of the state holds over 30 million residents – and is expected to continue to grow. Although bank access on Waco Reservoir is considered good, most of these areas are difficult to access and offer poor fishing opportunities. Waco Reservoir and its constituency would benefit greatly from a public fishing pier.

MANAGEMENT STRATEGIES

1. Begin speaking to local partners and interested parties about the possibility of a fishing pier and be able to explain the different grant opportunities offered by TPWD.

2. Determine optimal areas for a fishing pier and be able to discuss any advantages and disadvantages from a fisheries management perspective.

ISSUE 4: Many AIS threaten aquatic habitats and organisms in Texas and can adversely affect the state ecologically, environmentally, and economically. For example, zebra mussels 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 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 AIS 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 post appropriate signage at access points around the reservoir.
2. Educate the public about AIS through social media and the internet.
3. Make a speaking point about AIS when presenting to constituent and user groups.
4. Keep track of (i.e., map) existing and future interbasin water transfers to facilitate potential AIS responses.

Objective-Based Sampling Plan and Schedule (2024–2028)

Sport fish, forage fish, and other important fishes

Sport fishes in Waco Reservoir include Largemouth Bass, HSB, White Bass, catfishes, and White Crappie. Important forage include Gizzard Shad, Threadfin Shad, Bluegill, Redear and Longear Sunfish.

Sport fishes with low-density populations

Spotted Bass, Flathead Catfish, and Black Crappie occur in very low abundance in Waco Reservoir and are generally caught incidentally to other targeted species; status will be upgraded if needed.

Survey objectives, fisheries metrics, and sampling objectives

Fall Electrofishing: These surveys will be used to evaluate Largemouth and Spotted Bass, Bluegill, Redear Sunfish, Longear Sunfish, Gizzard Shad and Threadfin Shad populations. A minimum of 12 randomly-selected 5-min electrofishing stations will be sampled at night during the fall, once prior to 2027, and again during fall 2027. Black Bass and sunfish species will be monitored using abundance (CPUE-Stock), size structure (PSD and length frequency), and condition (mean relative weight) as metrics to make comparisons with historical and future data sets. Target precision for CPUE-Stock will be an RSE-Stock ≤ 25 and target sample size for size structure will be N ≥ 50 stock, allowing us to calculate proportional size distributions with 80% confidence. Black Bass body condition will be determined by measuring and weighing at least 5 fish per represented inch group ≥ stock-length. A genetic sample of 30 randomly selected Largemouth Bass will be collected in 2027 to access stocking success and/or Florida Bass influence within the population. Additional genetics will be analyzed on all fish identified as Spotted Bass. Index of vulnerability (IOV) will be calculated for Gizzard Shad to assess the relative proportion of individuals in the population suitable as prey for sport fish.

Late winter trap netting: This survey will be used to evaluate White Crappie, which is the dominant crappie species in Waco Reservoir. White Crappie were last sampled with late winter trap netting and spring gill netting in 2024 (1.2 fish/nn and 3.0 fish/nn respectively). The goal of the 2028 survey will be general monitoring (using CPUE, size structure and relative weight as metrics) to characterize the White Crappie population and make comparisons with historical and future data. Catch per unit effort target precision will be an RSE ≤ 25. Target sample size will be an N ≥ 50 stock-sized fish to determine population size structure, allowing us to calculate proportional size distributions with 80% confidence. Ten random trap netting stations will be sampled during late winter 2028. White Crappie body condition will be determined by measuring and weighing at least 5 fish per represented inch group ≥ stock-length. If catch rates indicate collecting the proposed number of fish is reasonable, sampling will continue at random trap netting stations until that target is reached.

Spring Gill Netting: This survey would be used to evaluate Blue Catfish, Channel Catfish, White Bass and HSB. A minimum of ten randomly selected gill netting stations will be sampled in spring 2028. All four species will be monitored using abundance (CPUE-Stock), size structure (PSD and length frequency), and condition (mean relative weight) as metrics to make comparisons with historical and future data sets. Target precision for CPUE-Stock will be an RSE-Stock ≤ 25 and target sample size for size structure will be N ≥ 50 stock, allowing us to calculate proportional size distributions with 80% confidence. Body condition will be determined by measuring and weighing at least 5 fish per represented inch group ≥ stock-length for each species. If the goal for a species isn't attained in 10 randomly selected stations, and catch rates indicated that collecting the proposed number of fish is reasonable, sampling will continue at random stations until targets are reached.

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Tables and Figures

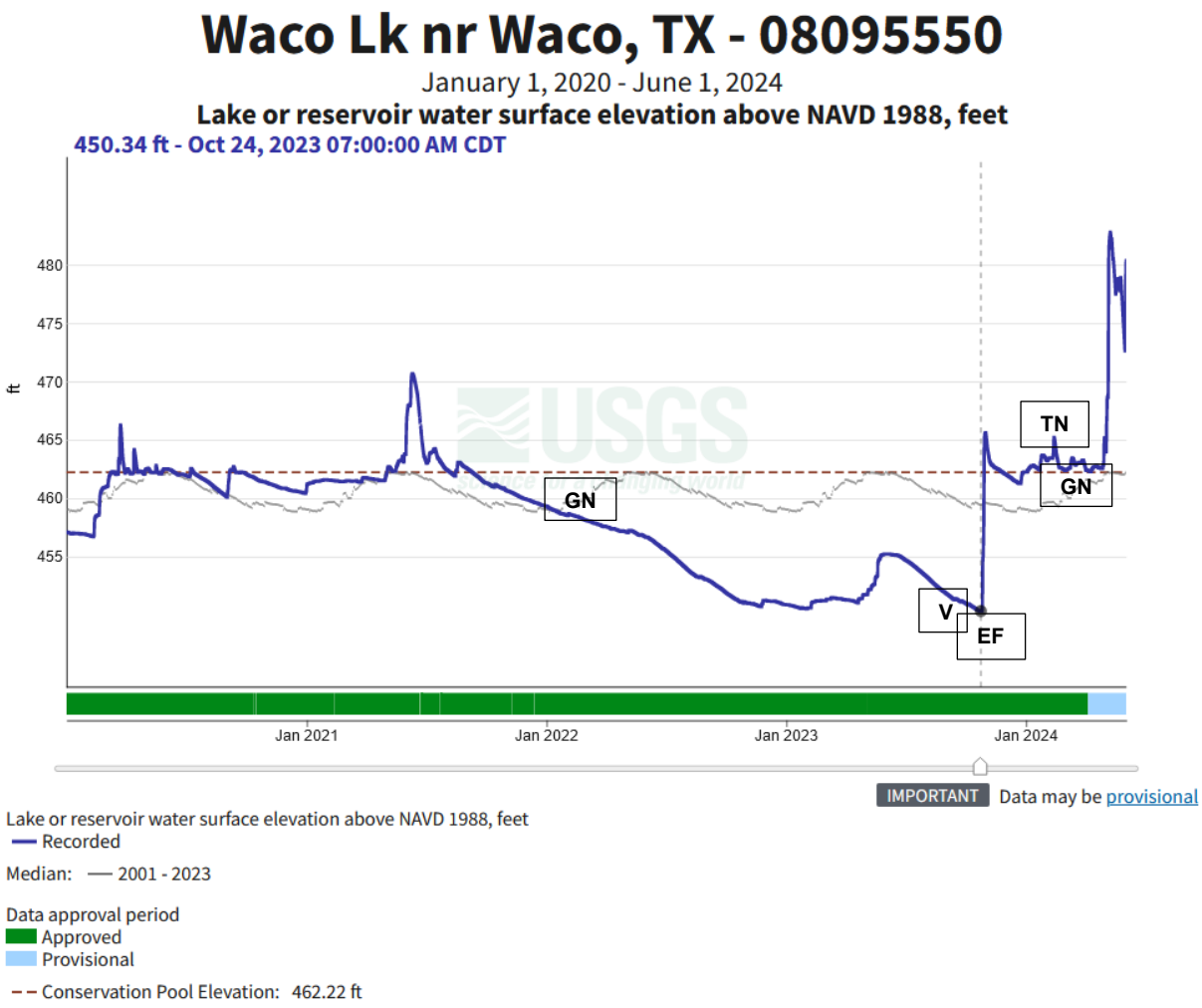


Figure 1. Daily water level elevations in feet above MSL recorded for Waco Reservoir, Texas, January 1, 2020, through June 1, 2024. The figure is from the United States Geological Survey (USGS) website. NAVD 1988 refers to the North American Vertical Datum of 1988. The vertical dashed line represents the lowest water elevation during the period (450.34 MSL), the horizontal dashed line indicates Conservation pool (462.0), the thick line represents daily water level elevations, and the thin line represents median water elevations during the period. Sampling times for vegetation (V), electrofishing (EF), trap netting (TN) and gill netting (GN) are noted.

Table 1. Characteristics of Waco Reservoir, Texas.

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 2023. Reservoir elevation at time of survey was 451.2 feet above MSL (10.8' 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/-9726981	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, Texas.

Species	Bag Limit	Minimum-Maximum Length (inches)
Catfish: Channel Catfish, Blue Catfish[1] their hybrids and subspecies	25 (only 5 ≥ 20”; 1 ≥ 30”)	None
Catfish: Flathead	5	18 – inch minimum
Bass: White	25	10 – inch minimum
Bass: hybrid striped bass	5	18 – inch minimum
Bass: Largemouth	5 (any combination)	14 – inch minimum
Bass: Spotted, Guadalupe and hybrids[2]	5 (any combination)	None
Crappie: White, Black and hybrids	25 (any combination)	10 – inch minimum

[1]The Blue and Channel Catfish regulation is no minimum length limit; daily bag of 25 (in any combination – no more than 5 can be 20 inches or greater in length, and no more than one of those can be 30 inches or longer).

[2] Daily bag for Largemouth Bass, Spotted Bass, and Guadalupe Bass = 5 fish in any combination.

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
	2023	334,010	FRY	0.2

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)
Palmetto Bass (Striped X White Bass hybrid)	Total	942,382		
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	FRY	0.2
	2017	47,800	FGL	1.5
	2018	14,820	FGL	1.9
	2019	33,041	FGL	1.5
	2020	450,000	FRY	0.2
	2021	105,003	FGL	1.8
	2022	86,099	FGL	1.8
	2022	397,368	FRY	0.2
	2023	127,000	FGL	1.7
	Total	1,686,131		
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 1. Objective-based sampling plan components for Waco Reservoir, Texas 2022–2024.

Gear/target species	Survey objective	Metrics	Sampling objective
Electrofishing			
Largemouth Bass	Abundance	CPUE–Stock	RSE-Stock ≤ 25
	Size structure	PSD, length frequency	N ≥ 50 stock
	Condition	W_r	10 fish/inch group (max)
	Genetics	% FLMB	N = 30, any age
Bluegill [a]	Exploratory	Presence/Absence	Practical effort
Longear [a]	Exploratory	Presence/Absence	Practical effort
Redear [a]	Exploratory	Presence/Absence	Practical effort
Gizzard Shad [a]	Exploratory	Presence/Absence	Practical effort
	Prey availability	IOV	N ≥ 50
Trap netting			
White Crappie	Abundance	CPUE–Stock	RSE-Stock ≤ 25
	Size structure	PSD, length frequency	N ≥ 50 stock
	Condition	W_r	10 fish/inch group (max)
Gill netting			
Channel Catfish	Abundance	CPUE–stock	RSE-Stock ≤ 25
	Size structure	PSD, length frequency	N ≥ 50 stock
	Condition	W_r	10 fish/inch group (max)
Blue Catfish	Abundance	CPUE–stock	RSE-Stock ≤ 25
	Size structure	PSD, length frequency	N ≥ 50 stock
	Condition	W_r	10 fish/inch group (max)
Hybrid Striped Bass	Abundance	CPUE-stock	RSE-Stock ≤ 25
	Size structure	PSD, length frequency	N ≥ 50 stock
	Age and Growth	Age	N = all ≥ stock
	Condition	W_r	10 fish/inch group (max)
	Genetics	Species ID	N = all individuals
White Bass	Abundance	CPUE-stock	RSE-Stock ≤ 25
	Size Structure	PSD, length frequency	N ≥ 50 stock
	Condition	W_r	10 fish/inch group (max)

[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.

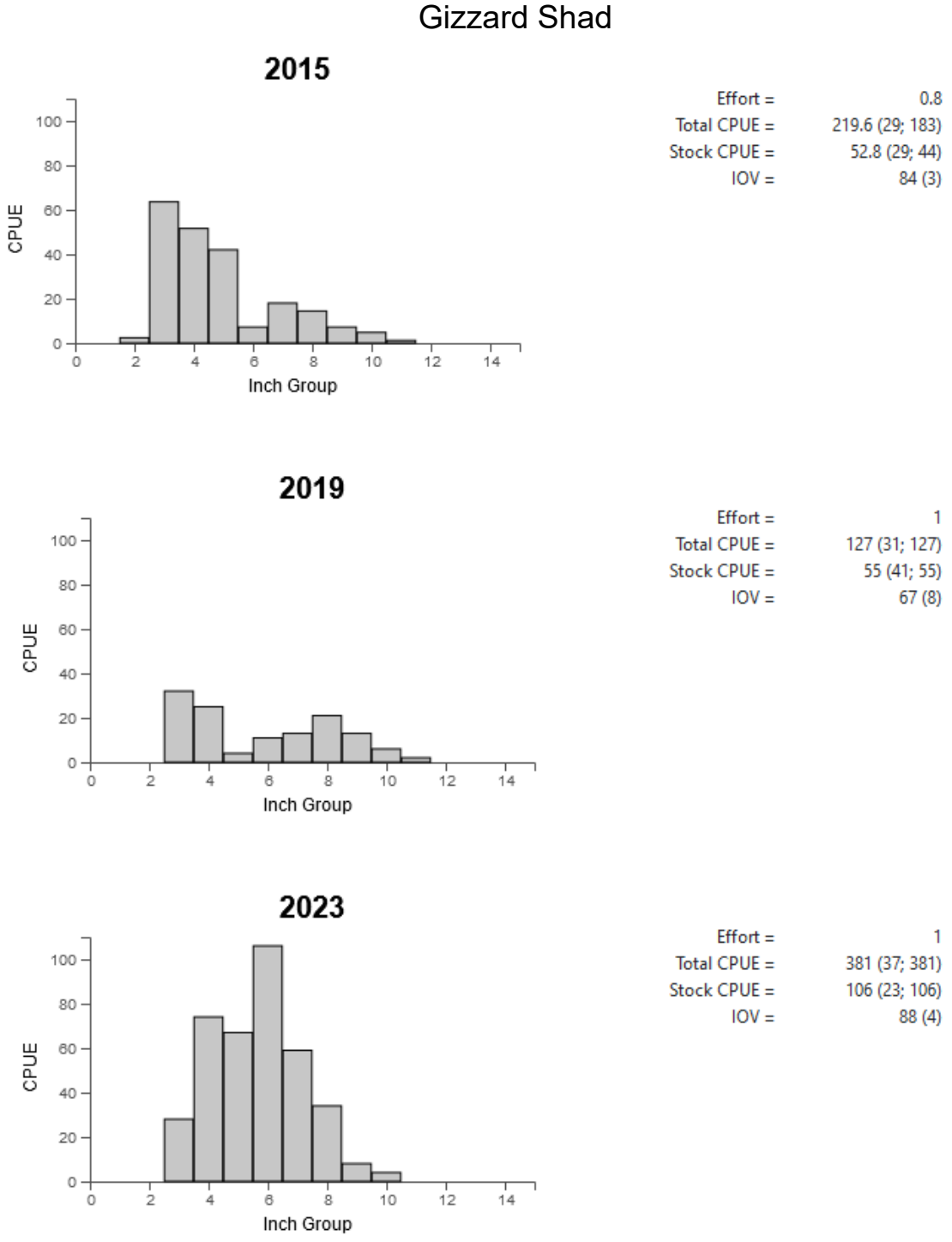


Figure 2. Number of Gizzard Shad caught per hour (CPUE, bars) and population indices (RSE and N for CPUE and SE for IOV in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2015, 2019, and 2023.

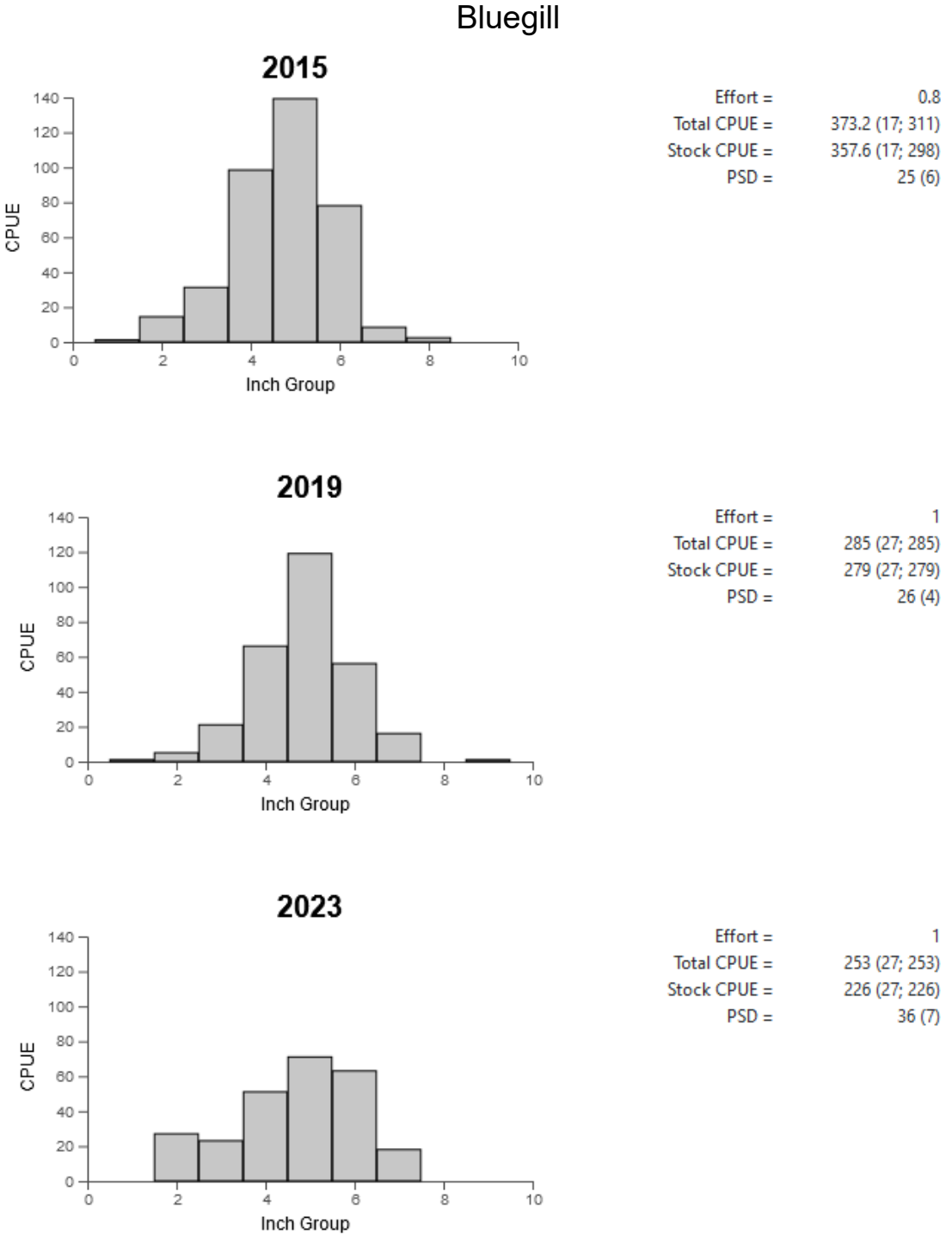


Figure 3. Number of Bluegill caught per hour (CPUE, bars) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2015, 2019, and 2023.

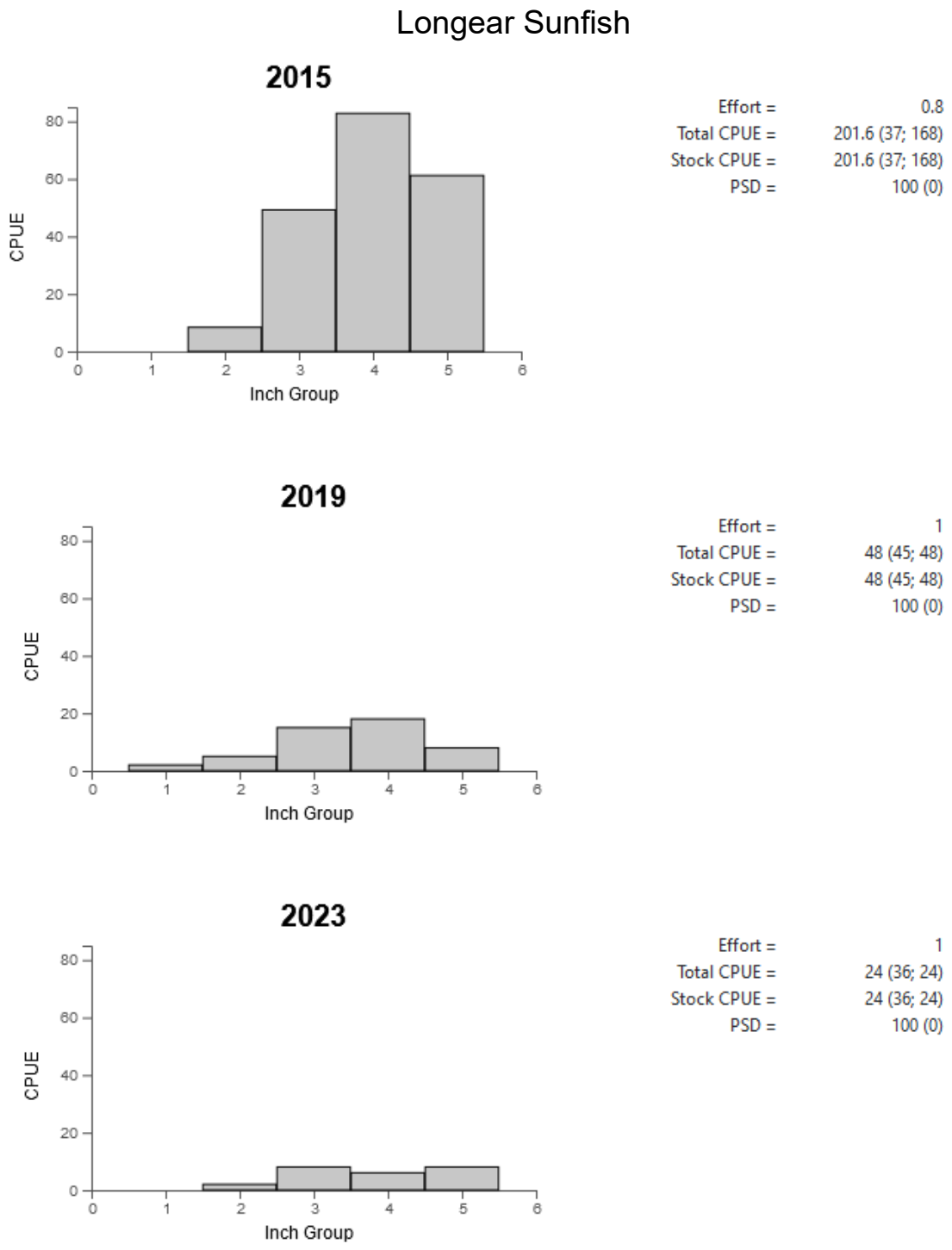


Figure 4. Number of Longear Sunfish caught per hour (CPUE, bars) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2015, 2019, and 2023.

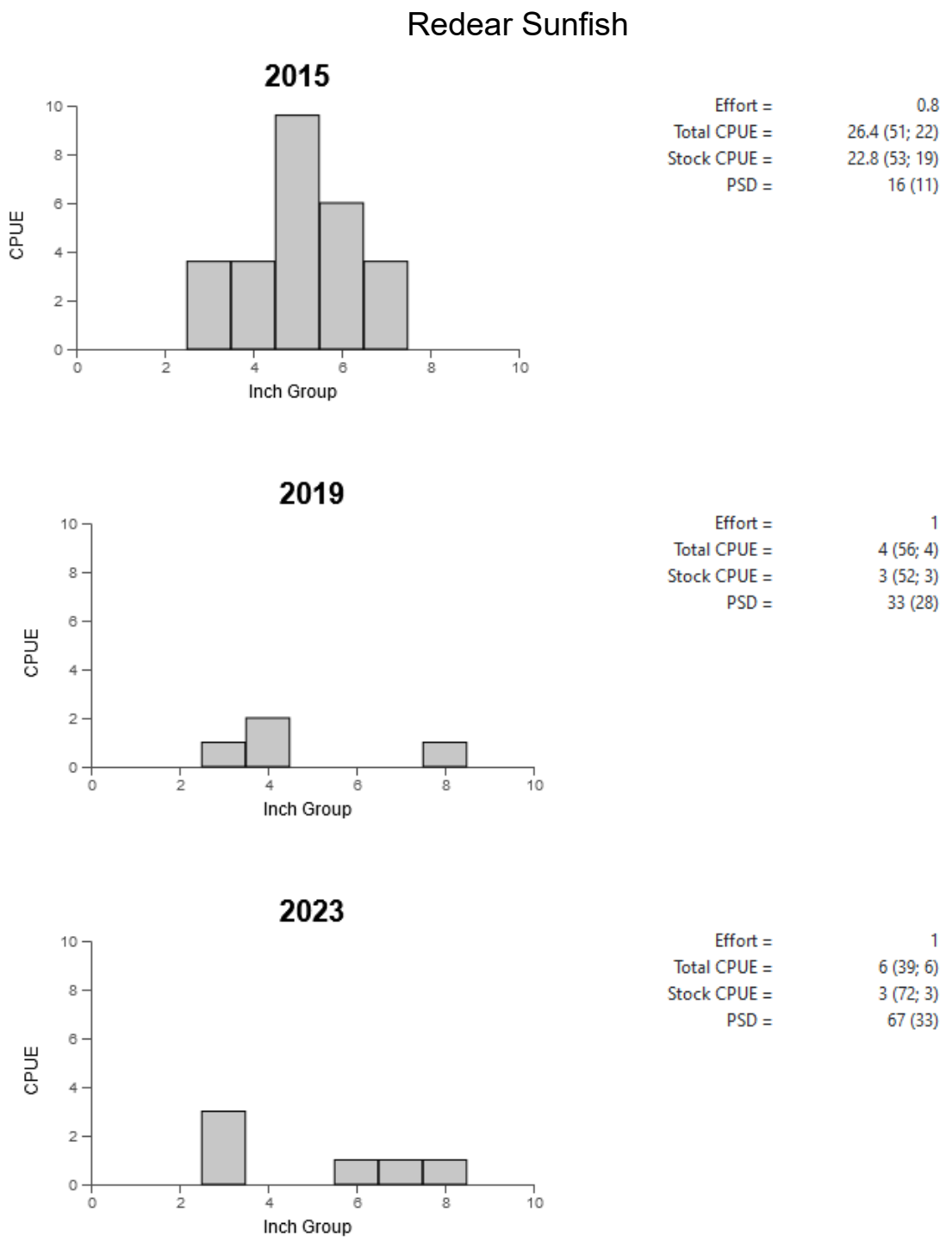


Figure 5. Number of Redear Sunfish caught per hour (CPUE, bars) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2015, 2019, and 2023.

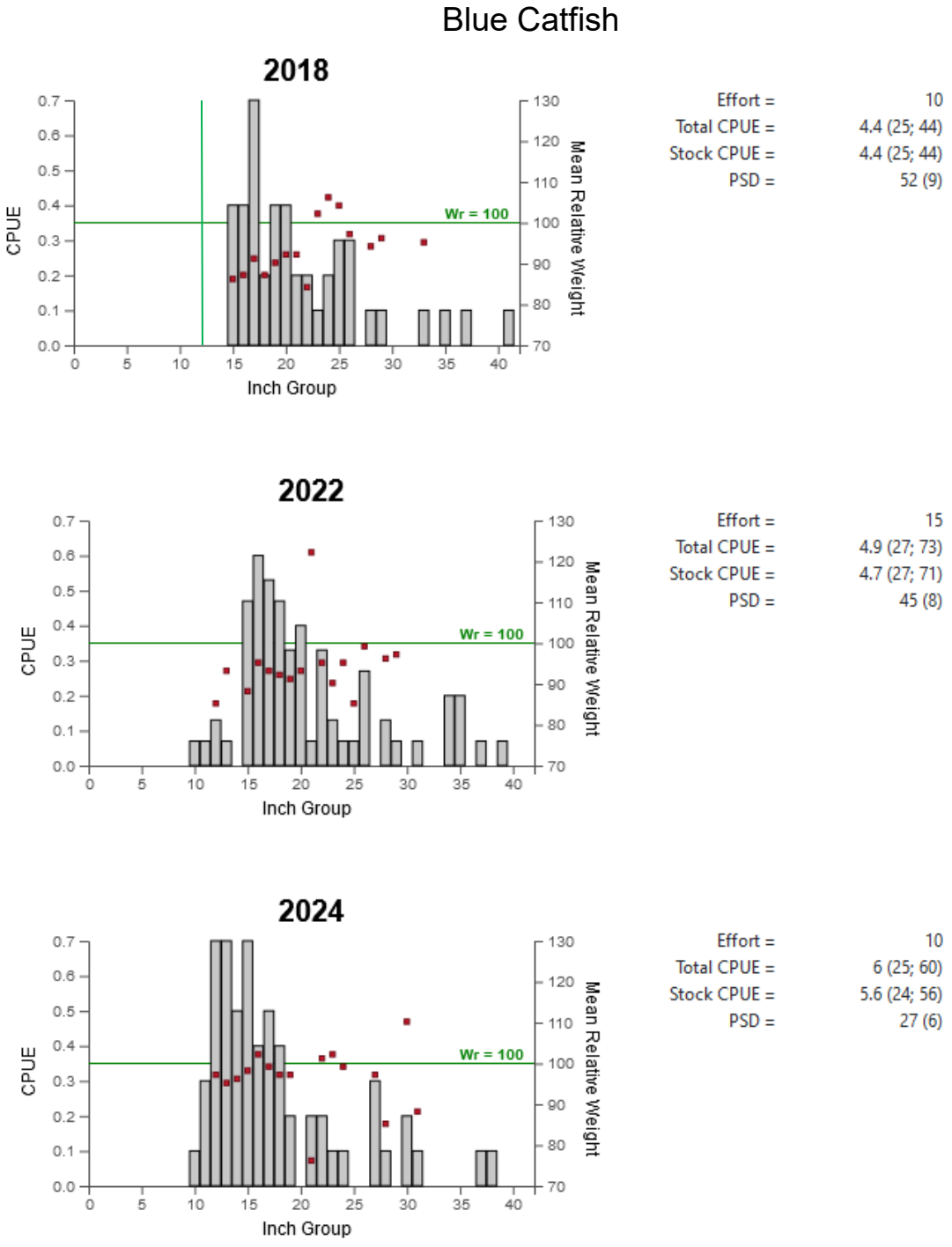


Figure 6. Number of Blue Catfish caught per net night (CPUE, bars), mean relative weights (squares) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for spring gill netting surveys, Waco Reservoir, Texas, 2018, 2022, and 2024. The minimum length limit (vertical line) for Blue Catfish was 12-inches during 2018; there was none after September 1, 2021.

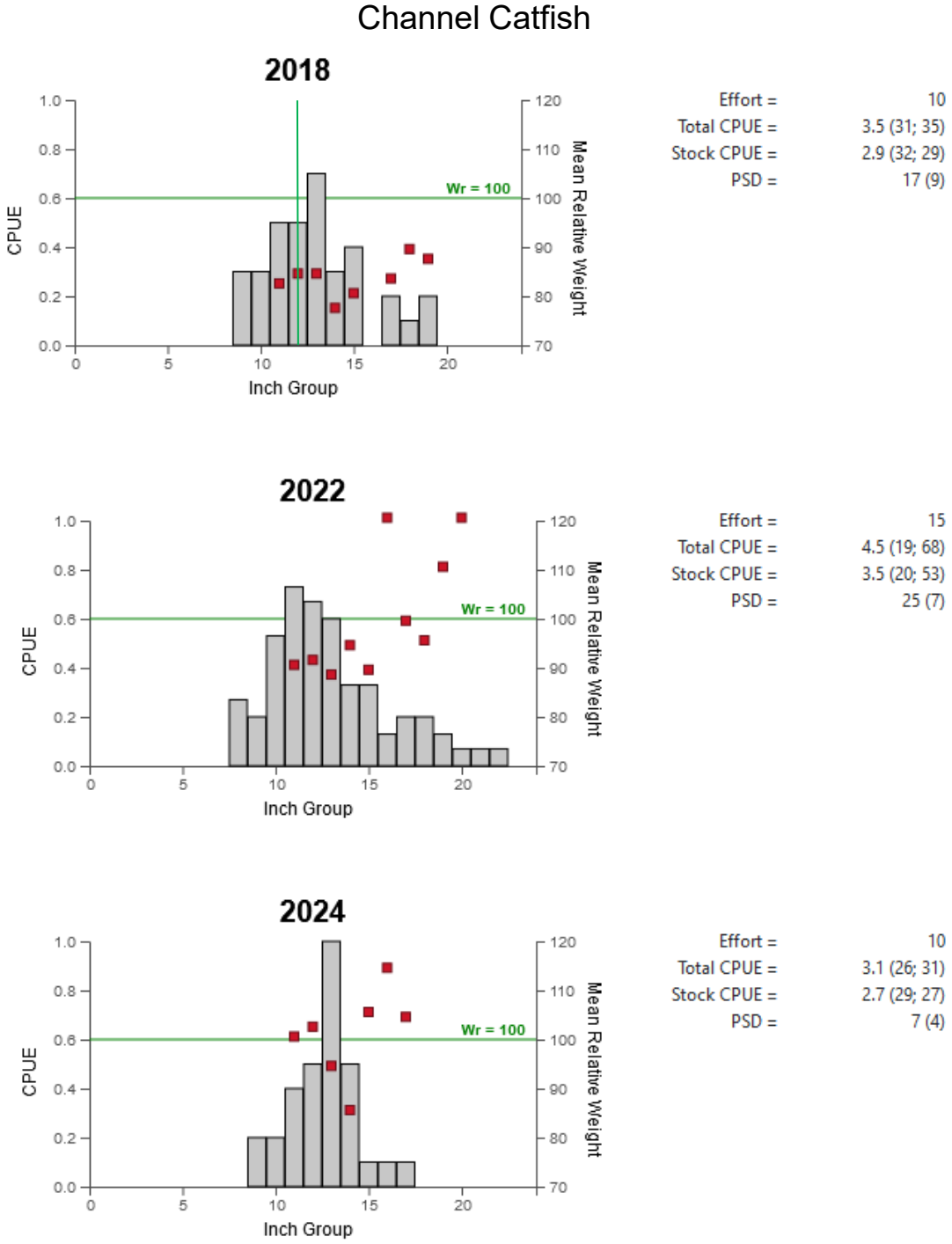


Figure 7. Number of Channel Catfish caught per net night (CPUE, bars), mean relative weights (squares) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for spring gill netting surveys, Waco Reservoir, Texas, 2018, 2022, and 2024. The minimum length limit (vertical line) for Channel Catfish was 12-inches during 2018; there was none after September 1, 2021.

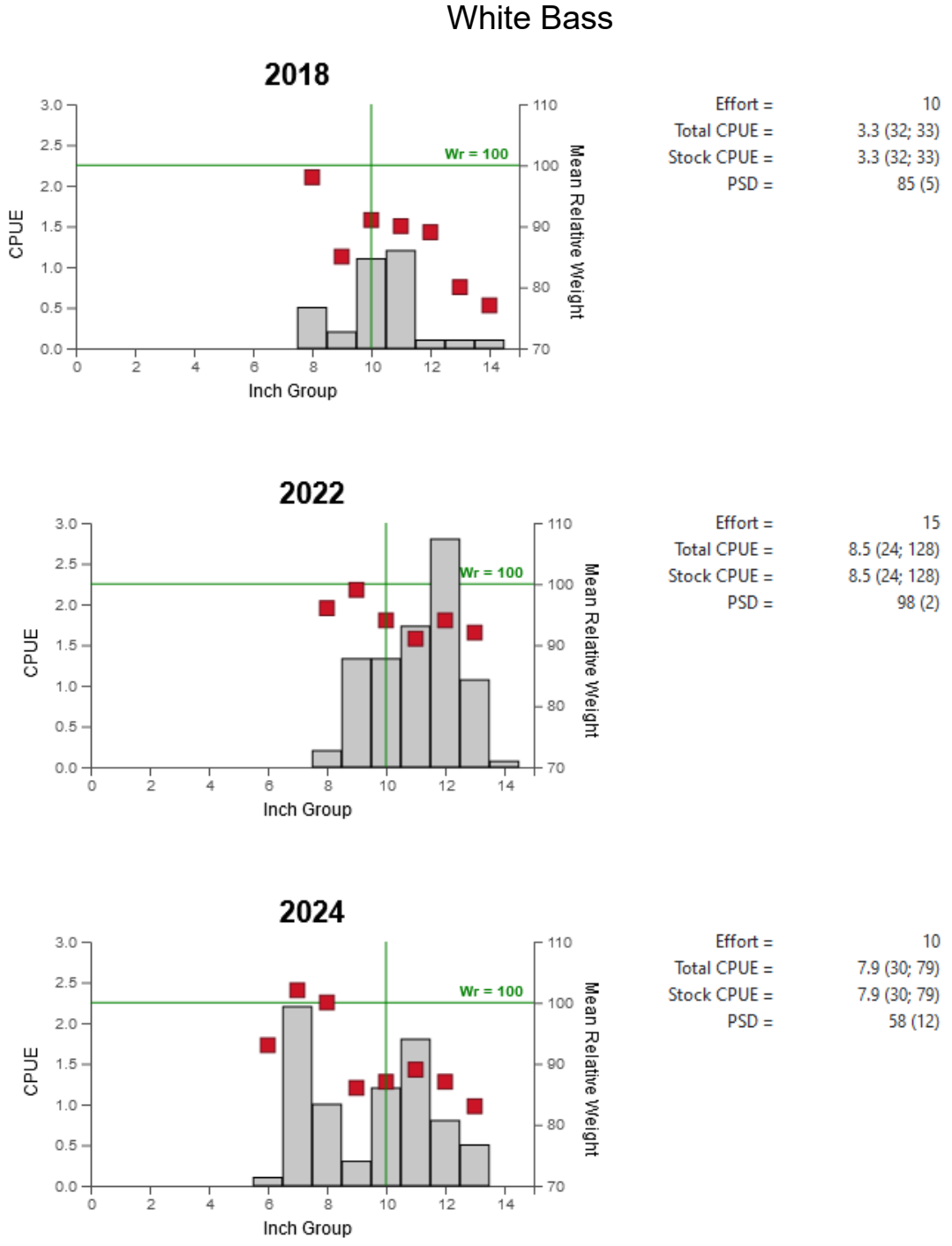


Figure 8. Number of White Bass caught per net night (CPUE, bars), mean relative weight (squares), and population indices (RSE and N for CPUE and SE for size structure in parentheses) for spring gill netting surveys, Waco Reservoir, Texas, 2018, 2022, and 2024. The minimum length limit (vertical line) for White Bass was 10-inches for all three survey periods.

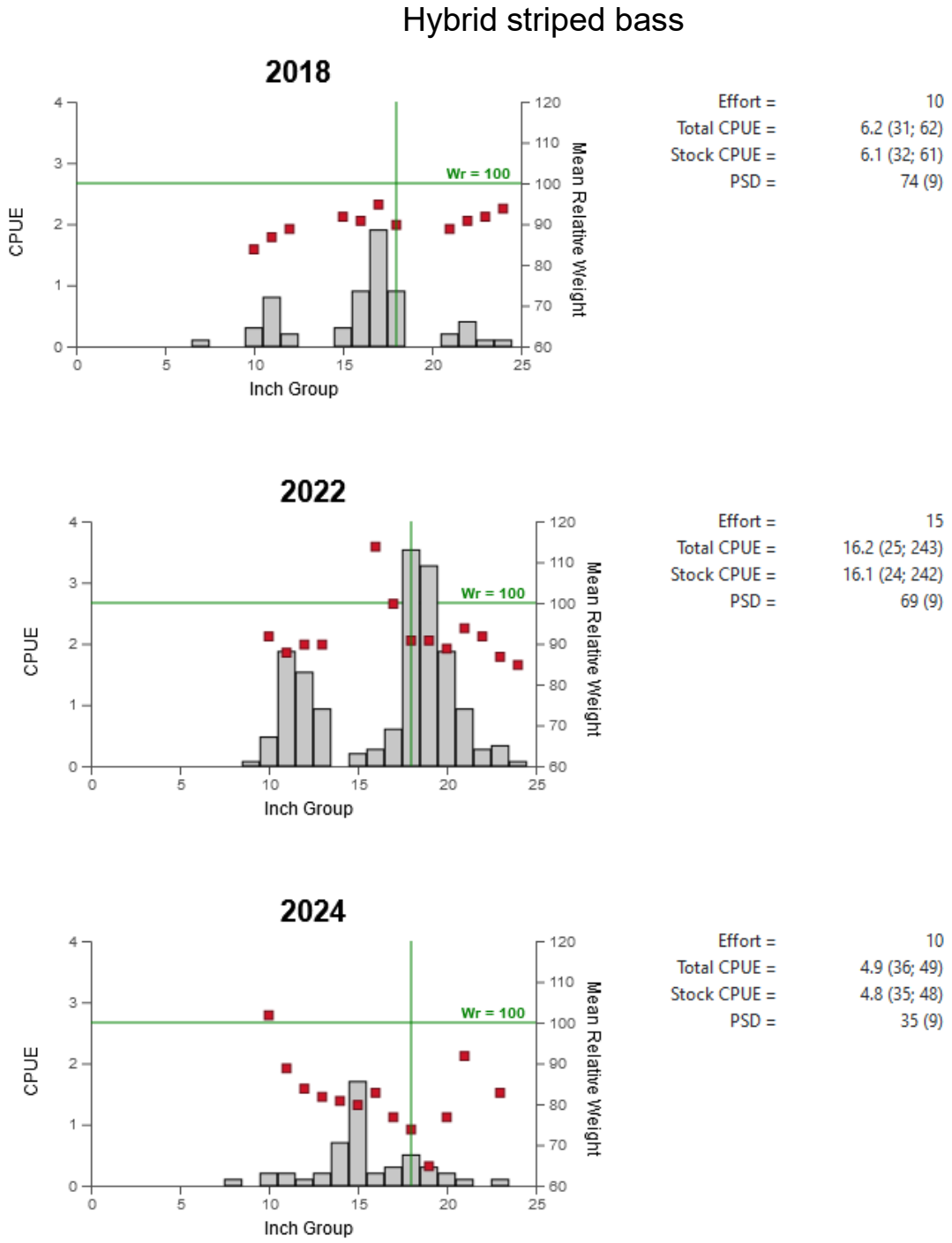


Figure 9. Number of HSB caught per net night (CPUE, bars), mean relative weight (squares), and population indices (RSE and N for CPUE and SE for size structure in parentheses) for spring gill netting surveys, Waco Reservoir, Texas, 2018, 2022, and 2024. The minimum length limit (vertical line) for HSB was 18-inches for all three survey periods.

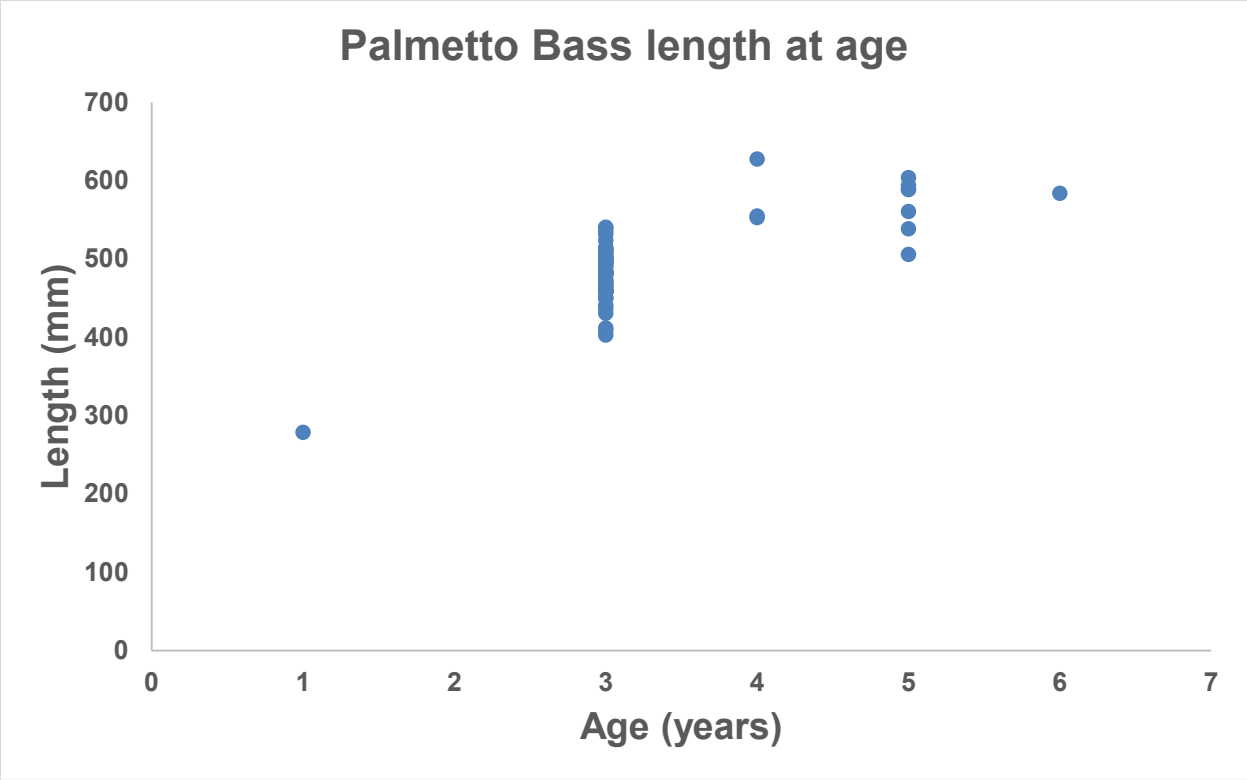


Figure 10. Length at age for palmetto bass (n = 70) collected by gill netting, Waco Reservoir, Texas, 2022. All individuals were genetically verified.

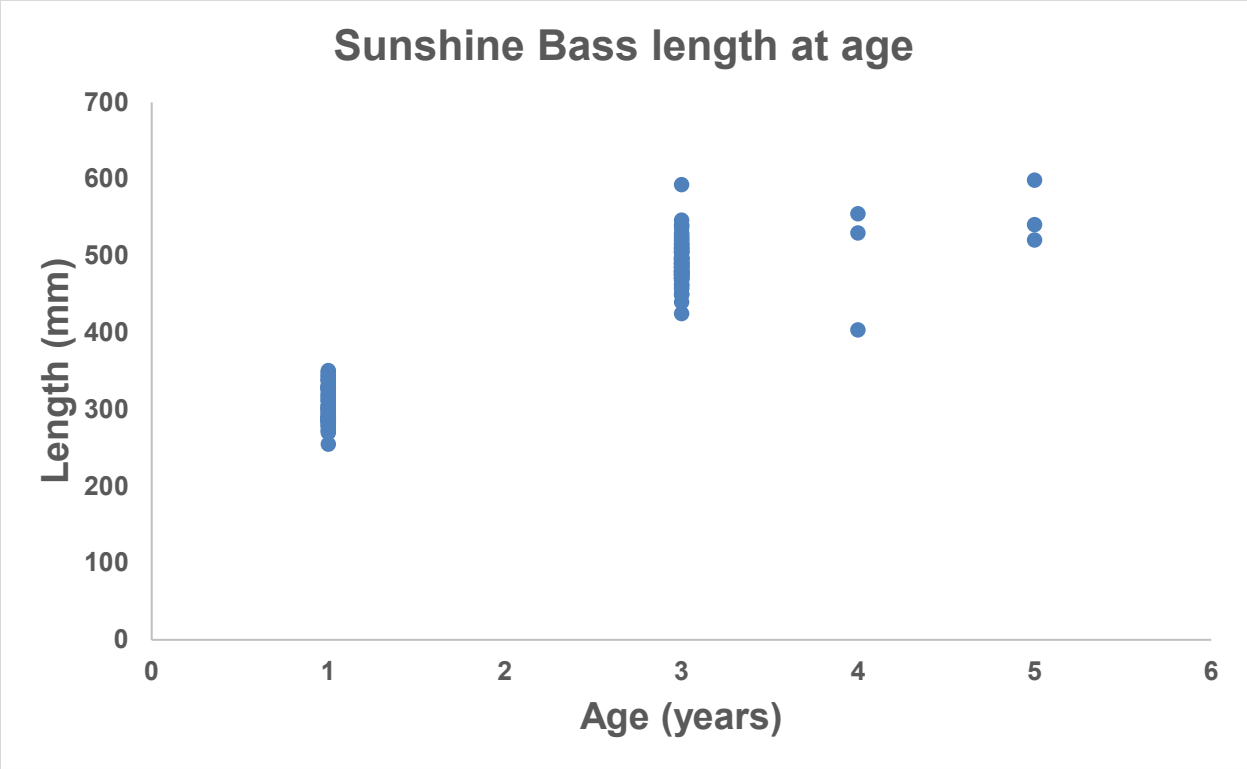


Figure 11. Length at age for sunshine bass (n = 153) collected by gill netting, Waco Reservoir, Texas, 2022. All individuals were genetically verified.

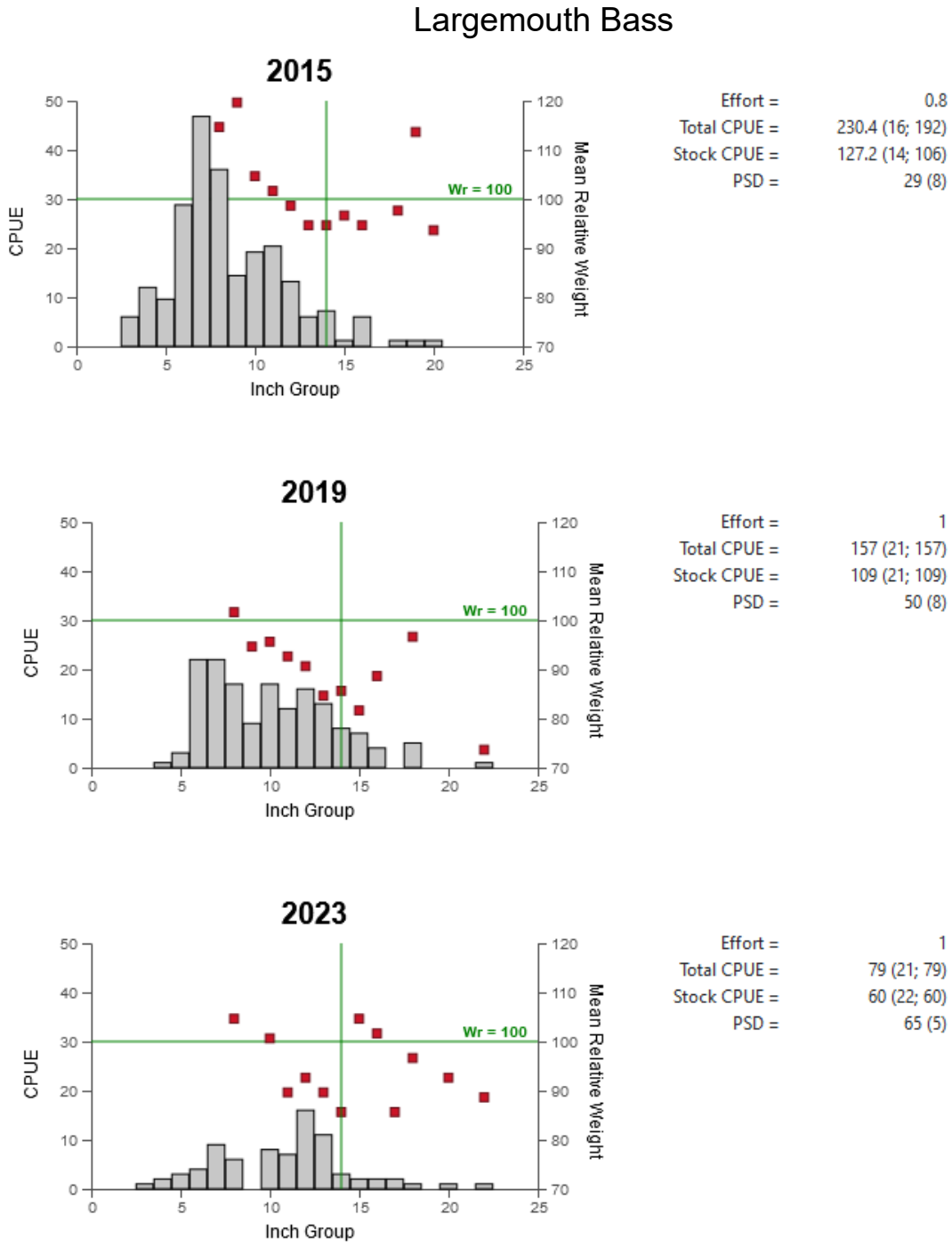


Figure 12. Number of Largemouth Bass caught per hour (CPUE, bars), mean relative weights (squares) and population indices (RSE and N for CPUE and SE for size structure in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2015, 2019, and 2023. The minimum length limit (vertical line) for Largemouth Bass was 14-inches for all three survey periods.

Table 7. Results of genetic analysis of Largemouth Bass collected by fall electrofishing, Waco Reservoir, Texas, 2005, 2011, 2015, 2019 and 2023. 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
2023	30	0	30	0	60	0

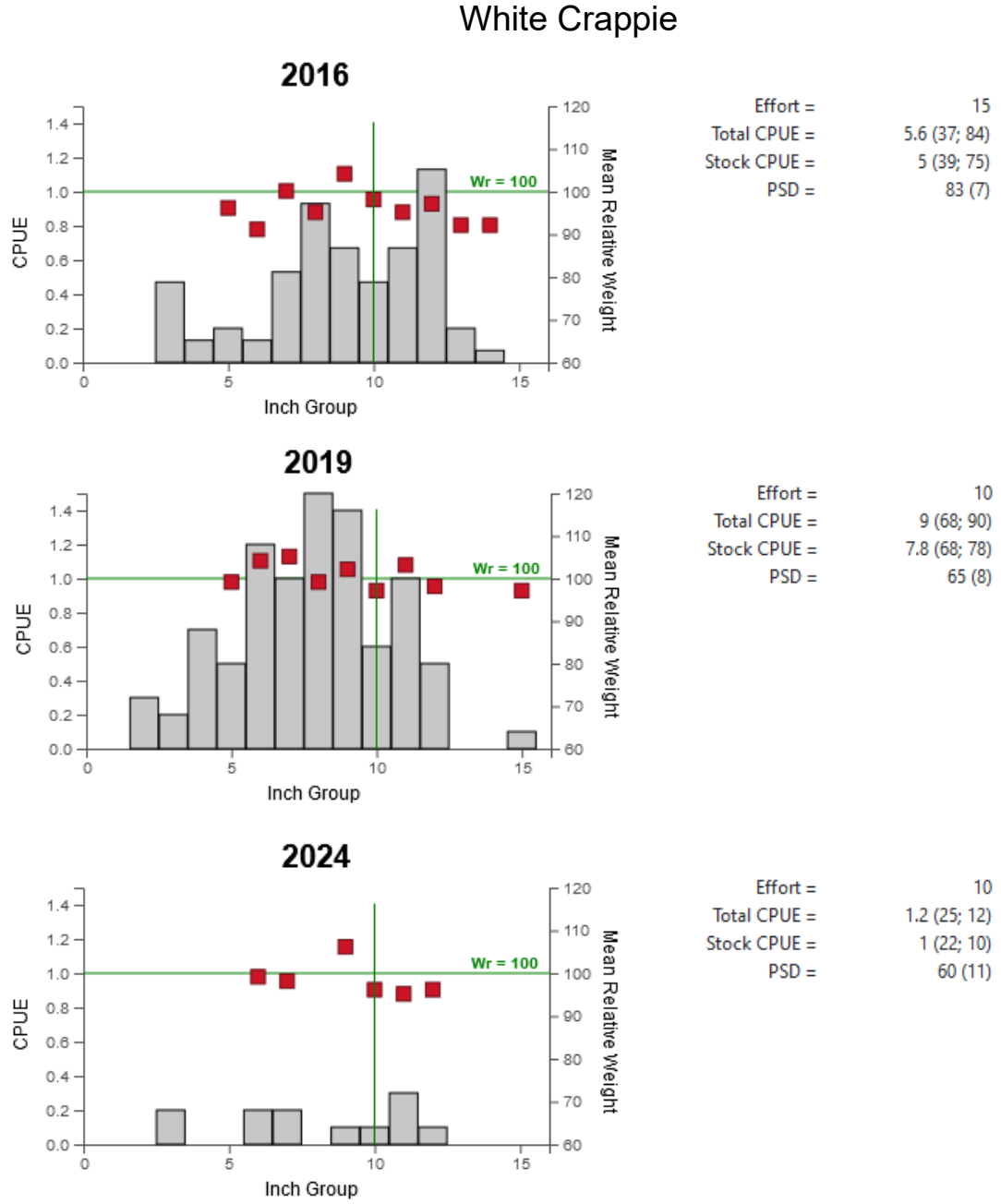


Figure 13. Number of White Crappie caught per net night (CPUE, bars), mean relative weight (squares), and population indices (RSE and N for CPUE and SE for size structure in parentheses) in late winter (January 2016), early winter (November 2019), and late winter (February 2024) trap netting surveys, Waco Reservoir, Texas. The minimum length limit (vertical line) for White Crappie was 10-inches for all three survey periods.

White Crappie

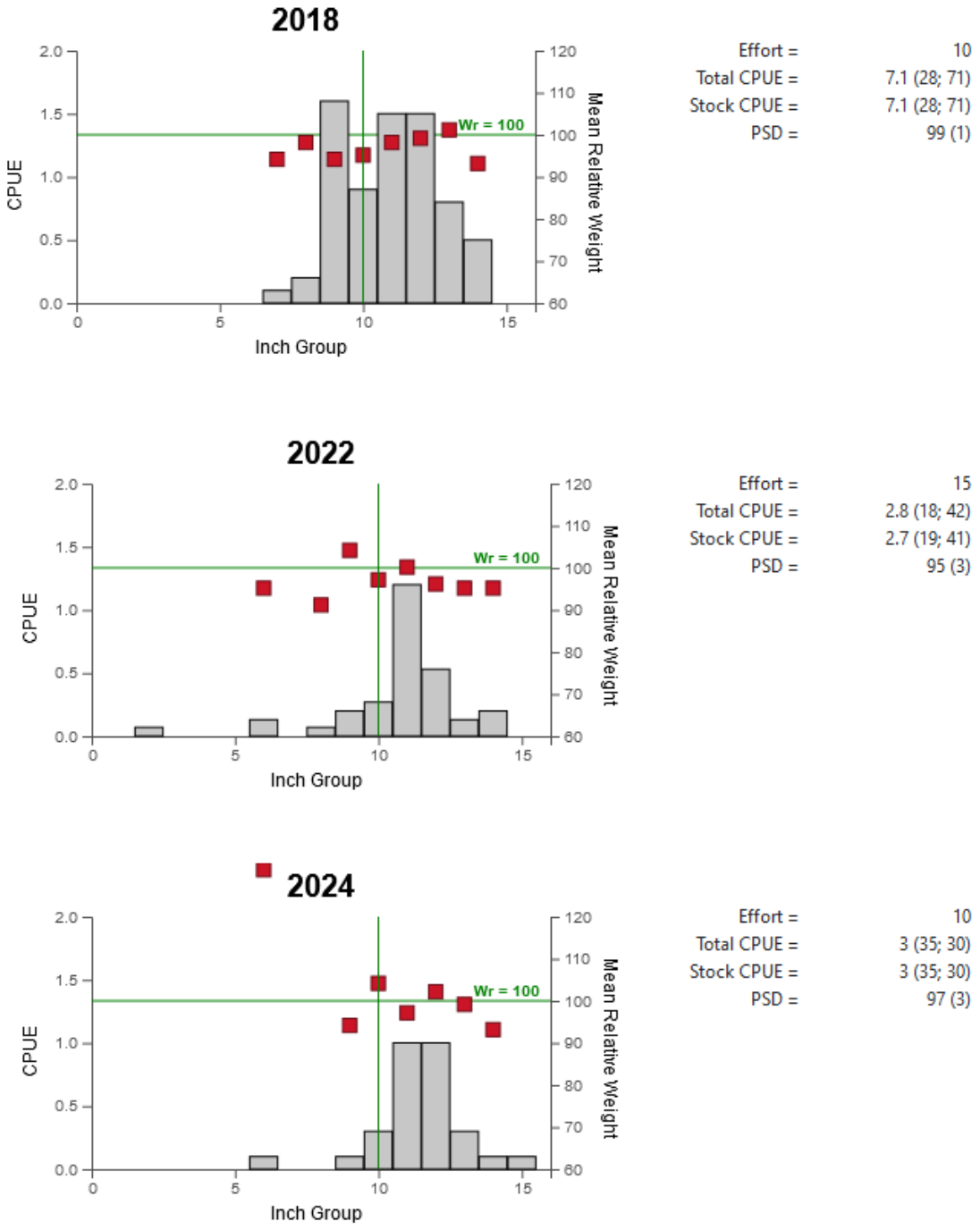


Figure 14. Number of White Crappie caught per net night (CPUE, bars), mean relative weight (squares), and population indices (RSE and N for CPUE and SE for size structure in parentheses) for spring gill netting surveys, Waco Reservoir, Texas, 2018, 2022, and 2024. The minimum length limit for White Crappie was 10-inches for all three survey periods.

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 electrofishing and trap netting surveys are conducted in the fall and late winter respectively. Scheduled surveys are denoted by X.

	Survey year			
	2024-2025	2025-2026	2026-2027	2027-2028
Angler Access				X
Vegetation				X
Electrofishing – Fall		X		X
Trap netting				X
Gill netting				X
Report				X

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, 2023-2024. Sampling effort was 10 net nights for gill netting, 10 net nights for trap netting, and 1 h for electrofishing.

Species	Gill Netting		Trap Netting		Electrofishing	
	N/RSE	CPUE	N/RSE	CPUE	N/RSE	CPUE
Gizzard Shad					381/37	381.0
Threadfin Shad					271/53	271.0
Blue Catfish	60/25	6.0				
Channel Catfish	31/26	3.1				
White Bass	79/30	7.9				
Hybrid Striped Bass	49/36	4.9				
Bluegill					253/27	253.0
Longear Sunfish					24/36	24.0
Redear Sunfish					6/39	6.0
Hybrid Spotted Bass					9/55	9.0
Largemouth Bass					79/21	79.0
White Crappie	30/35	3.0	12/25	1.2		
Black Crappie	1/100	0.1	2/100	0.2		

APPENDIX B – Historical catch rates for targeted species

Catch rates (CPUE) of targeted species collected with electrofishing, trap netting and gill netting surveys on Waco Reservoir, Texas, 1999 to present. Electrofishing stations were sampled with a 5.0 Smith-Root GPP (Gas Powered Pulsator) until 2010, a 7.5 Smith-Root GPP from 2010 to 2019, and a Smith-Root Apex unit thereafter. Species averages are in bold. Dashes represent no data available. Beginning in 2024, trap netting surveys were conducted in late winter instead of late fall.

Electrofishing

	1999	2003	2007	2011	2015	2019	2023	Average
Gizzard Shad	34.7	91.3	614.0	110.7	219.6	127.0	381.0	**225.5**
Threadfin Shad	0.7	3.3	174.0	108.0	289.2	86.0	271.0	**133.2**
Bluegill	92.7	314.7	314.0	388.7	373.2	285.0	253.0	**288.8**
Longear	12.0	130.7	99.3	114.0	201.6	48.0	24.0	**89.9**
Redear	5.3	22.7	22.7	32.7	26.4	4.0	6.0	**17.4**
Warmouth	2.7	7.3	2.7	2.0	7.2	3.0	0.0	**3.6**
Green	0.0	6.0	2.0	6.0	10.8	7.0	0.0	**4.5**
Largemouth Bass	176.7	194.0	420.4	189.3	230.4	157.0	79.0	**206.7**

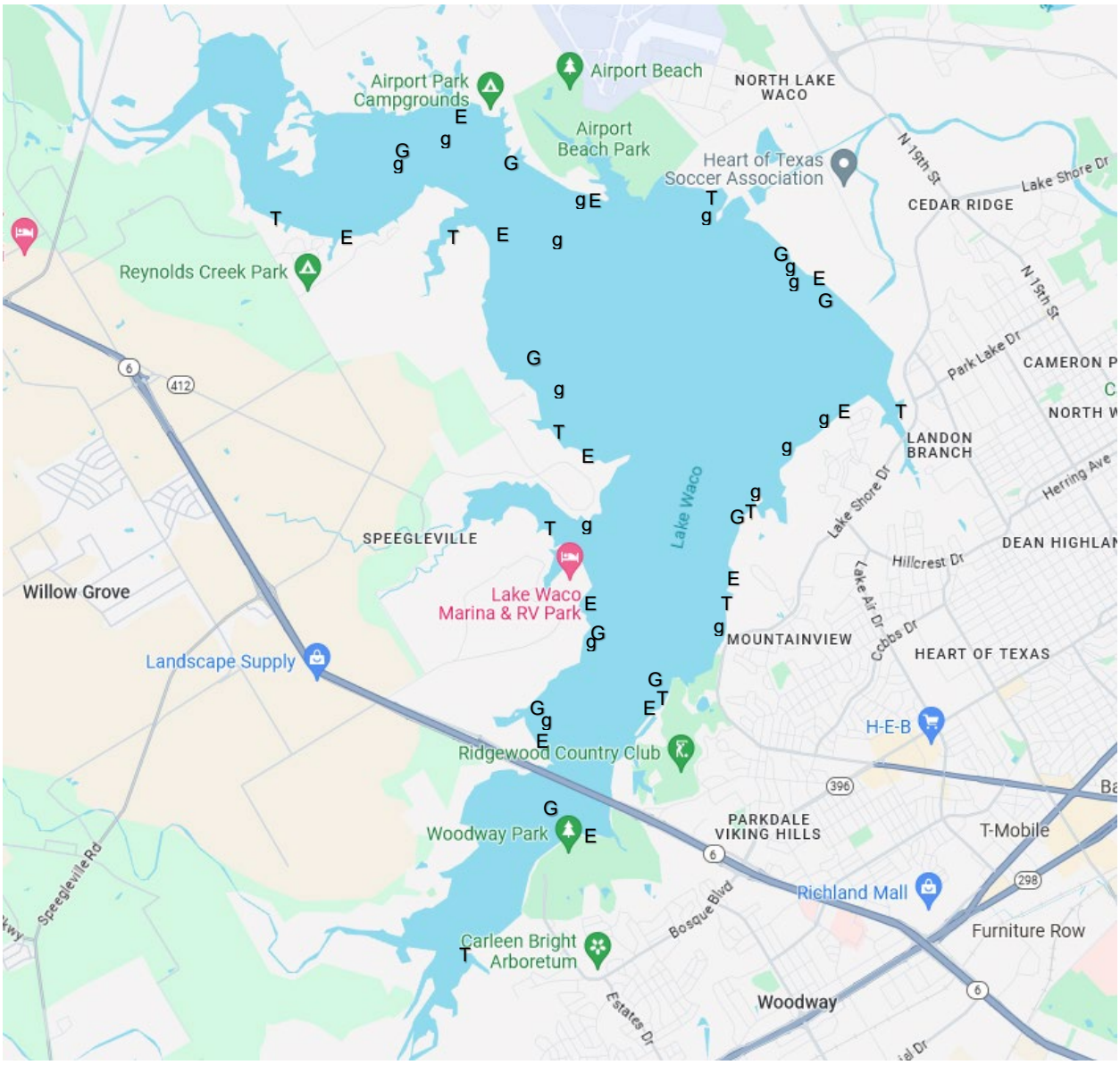
Trap netting

	1999	2003	2007	2011	2016	2019	2024	Average
White Crappie	9.0	5.2	14.8	2.1	5.6	9.0	1.2	**6.7**
Black Crappie	0.0	0.0	0.4	0.0	0.7	0.3	0.2	**0.2**

Gill netting

	1999	2004	2008	2012	2016	2022	2024	Average
Blue Catfish	0.1	3.2	5.3	2.8	2.0	4.9	6.0	**3.5**
Channel Catfish	7.2	5.7	7.5	7.0	5.4	4.5	3.1	**5.8**
Flathead Catfish	0.6	0.1	0.1	0.1	0.0	0.0	0.0	**0.1**
Hybrid Striped Bass	---	---	---	1.4	4.7	16.2	4.9	**6.8**
White Bass	1.8	0.4	0.9	4.3	4.2	8.5	7.9	**4.0**
White Crappie	---	---	---	---	5.6	2.8	3.0	**9.4**
Black Crappie	---	---	---	---	0.7	0.5	0.1	**1.2**

APPENDIX C – Map of sampling locations



Location of sampling sites, Waco Reservoir, Texas, 2022-2024. Electrofishing, trap netting, 2024 gill netting, and 2022 gill netting stations are indicated by E, T, G and g respectively. Water level was 3.8' low during the spring 2022 gill net survey, 11.6' low during the fall 2023 electrofishing survey, 1.9' above conservation pool during the late winter trap net survey, and 0.5' above conservation pool during the spring 2024 gill net survey.

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