Belton Reservoir
2018 Fisheries Management Survey Report

PERFORMANCE REPORT

As Required by

FEDERAL AID IN SPORT FISH RESTORATION ACT

TEXAS

FEDERAL AID PROJECT F-221-M-3

INLAND FISHERIES DIVISION MONITORING AND MANAGEMENT PROGRAM

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July 31, 2019

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Survey and Management Summary

Fish populations in Belton Reservoir were surveyed in 2014 with electrofishing, in 2018 using trap netting and in 2019 using gill netting. Electrofishing was not completed in 2018 due to high water during the sampling period. Historical data are presented with the 2018-2019 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: Belton Reservoir is a 12,385-acre impoundment located in Bell County, Texas. Water levels fluctuated from 5 feet below conservation pool (594 feet above mean sea level) to a record high 25 feet over conservation pool between July 2015 and April 2019. Mean and maximum water depths are 37 and 124 feet respectively and the reservoir is classified as mesotrophic with water clarity averaging around six feet. Habitat features consisted mainly of bluffs, rocky shoreline, sandy beaches, and some standing timber.

Management History: Important sport fish include Largemouth and Smallmouth Bass, White Bass, Hybrid Striped Bass, White Crappie, and catfishes. Blue Catfish and Florida Largemouth Bass were stocked most recently in 2008 and 2016 respectively. Belton currently contains two Hybrid Striped Bass strains. Palmetto Bass have been stocked nearly annually since the 70s, and Sunshine Bass were stocked in 2014 and 2016. Habitat improvement projects began in 2012 when Water Willow was planted at three shoreline sites with the help of Student Conservation Association volunteers. Monitoring of these sites over the next few years confirmed plantings failed due to drought conditions. Despite a robust public relations campaign and associated efforts, Zebra Mussels were confirmed in Belton Reservoir in August 2013, and the reservoir is now infested. Management efforts have since included a comprehensive public relations campaign to further educate Belton user groups about Zebra Mussels, how to inspect and clean, drain and dry their watercraft, and the new statewide water draining laws meant to prevent the spread of Zebra Mussels to other Texas waters. Recent management efforts have focused on fry density stocking evaluations for Hybrid Striped Bass, an evaluation of stocking effects on Smallmouth Bass recruitment and maintaining Zebra Mussel signage at access points around the reservoir and continuing to educate boaters and marina owners about the states' clean, drain, and dry campaign to prevent the spread of AIS into additional Texas reservoirs.

Fish Community

- **Prey species:** Threadfin Shad were present in the reservoir in 2014. Electrofishing catch of Gizzard Shad was very low, and few Gizzard Shad were available as prey. Electrofishing catch of Bluegill and Longear Sunfish was very good.
- **Catfishes:** Channel Catfish were present in low numbers similar to previous years. Blue Catfish catch greatly increased, providing excellent angling opportunities. Flathead Catfish were present in the reservoir.
- **Temperate basses:** White Bass and Hybrid Striped Bass abundance declined from previous years, but an excellent population is present.
- **Black Basses:** Largemouth Bass electrofishing catch was low in 2014 and few legal-size fish were available to anglers. Smallmouth Bass continued to be an important sport fish with documented natural recruitment
- **White Crappie:** White Crappie were present with legal-size fish available to anglers.

Management Strategies: Continue stocking Hybrid Striped Bass fry at 50 and 100/acre in alternate years. Conduct additional standard night electrofishing in Fall 2020. Collect category 3 age samples on Hybrid Striped Bass and Smallmouth Bass in 2023. Continue Zebra Mussel awareness efforts.

Introduction

This document is a summary of fisheries data collected from Belton Reservoir in 2014-2019. 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 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

Belton Reservoir is located on the Leon River in Bell County, Texas. The reservoir was constructed in 1954 by the United States Army Corps of Engineers (USACE) to serve as a source of municipal water and for flood control and is managed by the same agency (Table 1). The conservation pool is 594 feet above mean sea level, and the reservoir has a maximum and average depth of 124 and 37 feet respectively (Figure 1). The 12,385-acre impoundment has a drainage area of 3,531 square miles, a storage capacity of 457,600 acre-feet, and a shoreline length of 136 miles. Water level was above conservation pool (594) for most of the period from July 2015 to July 2017. Water level remained below conservation pool from July 2017 until late fall 2018 before increasing to approximately 15' above conservation pool. A few weeks later, water levels peaked again, and the reservoir level is still high as of late May 2019. Fish habitat at time of sampling consisted primarily of natural and rocky shorelines, with limited standing timber and trace amounts of aquatic vegetation (Table 6).

Angler Access

Bank fishing and boat access is excellent with numerous parks and seventeen public boat ramps. All ramps were closed from October 16 to November 28, 2018 due to high water. Additional boat ramp characteristics are in Table 2.

Management History

Previous management strategies and actions: Management strategies and actions from the previous survey report (Tibbs and Baird 2014) included:

1. Complete additional native vegetation plantings and monitor success.

   Action: Three sites were planted with approximately 100 Water Willow plants each with the help of Student Conservation Association (SCA) volunteers. The sites were planted during late summer 2012 and monitored once during late summer 2013. However, Belton Reservoir's water level following the planting continued to decrease through 2014 until heavy rains increased water levels to 15' over conservation pool as of late spring, 2015. Continued swings in water levels have eliminated the original plantings and made additional plantings impractical.

2. Cooperate 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. During summer 2015, TPWD continued public awareness efforts at boat ramps with the help of interns. Additional efforts included on-site media events, public awareness efforts during summer holidays in 2016 and 2017, and social media.

3. Discontinue Palmetto Bass fingerling stockings, stock Hybrid Striped Bass fry at 50 or 100/acre, work with other districts to evaluate fry stockings in other reservoirs, collect category 3 age sample.

Action: Hybrid Striped Bass were stocked annually at 50 or 100 fry per acre since 2015. The district collected and provided data on fry stockings for a statewide evaluation that was completed and presented by another biologist at the Southern Division of the American Fisheries Society Meeting in 2019. A category 3 age sample was collected in 2019.

4. Request Smallmouth Bass annually, collect a category 3 age sample in 2018, collect broodfish for hatcheries as requested, update the public on the Smallmouth Bass population.

   Action: Smallmouth Bass were requested annually and stocked in 2015 and 2018. Broodfish were collected and several social media posts were made about Smallmouth Bass in Belton. A category 3 age sample was collected in February 2019.

5. Stock Florida Largemouth Bass in 2016, discuss best weigh-in practices with the USACE, present best weigh-in practices to interested bass clubs, request tournament permit data from USACE.

   Action: Florida Largemouth Bass were stocked in 2016. Concerns regarding tournament weigh-in procedures were shared with the USACE. Although a permit is required to hold a tournament on Belton Reservoir, not all tournaments obtain one. No presentations on best weigh-in practices were presented. Tournament permit data were obtained from the USACE.

Harvest regulation history: Sport fishes in Belton Reservoir have always been managed with statewide regulations (Table 3).

Stocking history: Smallmouth and Palmetto Bass stockings have been requested every year. Historical stockings of Palmettos have been consistent since the 70s, with few exceptions. Blue Catfish were last stocked in 2008. Sunshine Bass fingerlings were stocked to supplement Palmetto Bass in 2014 and Sunshine Bass fry were stocked in 2016. Smallmouth Bass were stocked in 2015 and 2018. Florida Largemouth Bass fingerlings were stocked in 2016. The complete stocking history is in Table 4.

Vegetation/habitat management history: Belton Reservoir supports very little aquatic vegetation. There have been reports of hydrilla in the past, but none confirmed by TPWD surveys. A grass roots initiative began in 2006 by Centex Bass Hunters, in conjunction with Bass Anglers Sportsman's Society (BASS), Texas Parks and Wildlife Department (TPWD), and the USACE aquatic research laboratory in Lewisville, to establish native aquatic vegetation in Belton Reservoir. Funding contributions from that effort fell short of expectations, yet the interest and need to try and improve fish habitat in Belton remained. A second effort to introduce native vegetation into Belton Reservoir was initiated by TPWD in 2012, and three sites were planted with approximately 100 Water Willow plants each later that year. Monitoring of these sites over the next few years confirmed failed plantings due to drought conditions. Currently, no noxious vegetation is known to exist in the reservoir.

Water transfer: There are three raw water intake stations on Belton reservoir which transfer water offsite to water treatment facilities. The first is operated by the Water Control Improvement District #1(WCID#1), the second is Bluebonnet Water Supply and the third is for the City of Gatesville. They pump treated water to their destinations for use as municipal water. Since the date of the last report a pumping station was approved to pump untreated water directly to Stillhouse Hollow Reservoir from Belton Reservoir, but construction has not yet been completed.

Reservoir capacity: Belton was impounded in 1954. Original plans calculated the reservoir's capacity at conservation pool (594 feet above mean sea level) to be 457,600 acre-feet with a surface area of 12,300 acres. Two volumetric surveys were completed by the Texas Water Development Board (TWDB) on Belton since impoundment; one in 1994 and one in 2003. The 1994 survey calculated a volume of 434,500 acre-feet and a surface area of 12,385 acres at conservation pool, whereas the 2003 survey calculated a volume of 435,225 acre-feet and surface area of 12,135 acres. According to the TWDB, the two surveys are within the margin of error and are essentially identical indicating that sedimentation is not an issue in the reservoir.

Zebra Mussels: Zebra Mussel monitoring began on Belton Reservoir in 2012. Signage was posted at the 17 public boat ramps to make boaters aware of the threat of AIS including Zebra Mussels, yet by the end of summer 2013, Zebra Mussels were found throughout the reservoir. Educational signage posted in 2013 was then replaced with warning signage and boat ramp stencils warning boaters that the reservoir was infested with Zebra Mussels. During the summer of 2014 and 2015, TPWD continued the public awareness campaign by hiring two interns each summer to educate boaters and other watercraft users about Zebra Mussels, the new water draining rules in Texas public waters, how to properly inspect a watercraft, and the importance of the campaign slogan “Clean Drain and Dry” in maintaining their watercraft. After 2015, these internships were transferred to Austin headquarters and no further funding for on-site invasive species education has been allocated to the district.

Methods

Surveys were conducted to achieve survey and sampling objectives in accordance with the objective-based sampling (OBS) plan for Belton Reservoir (Tibbs and Baird 2014). Primary components of the OBS plan are listed in Table 5. All standard survey sites were randomly selected, and all surveys were conducted according to the Fishery Assessment Procedures (TPWD, Inland Fisheries Division, unpublished manual revised 2018). All Smallmouth Bass and some Hybrid Striped Bass age data were collected with sites selected by biologists to optimize sample size. These data were not included in any other metrics.

Electrofishing –Smallmouth Bass were collected by electrofishing (4 hours and 45 minutes at 19, 15-min biologist-selected stations) in February for age data only. Standard electrofishing was not conducted in fall 2018 due to heavy rains and complete boat ramp closure from October 16 through November 28. Therefore, new data on forage species and Largemouth Bass are not in this report. Fall 2014 electrofishing data are the most recent available.

Gill netting – Hybrid Striped Bass, White Bass, catfishes and crappie were collected by gill netting (15 net nights at 15 random stations for catch-per-unit-effort (CPUE) and structural indices; 5 net nights at 5 biologist-selected stations for additional age data). Catch per unit effort for gill netting was recorded as the number of fish caught per net night (fish/nn).

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 and creel statistics. Age datasets were collected at a Category 3 precision level (TPWD, Inland Fisheries Division, unpublished manual revised 2018).

Habitat – A structural habitat survey was conducted in 2010. The 2018 vegetation survey was conducted using an adaptation of the point method (TPWD, Inland Fisheries Division, unpublished manual revised 2015). A total of 136 points were randomly generated on the shoreline. A transect was made from each point out to deep water, and all encountered vegetation on that transect was recorded.

Water level – Source for water level data was the United States Geological Survey (USGS 2019).

Results and Discussion

Habitat: A habitat survey was last conducted in 2010 (Tibbs and Baird 2010). Only trace amounts of a few aquatic vegetation species (e.g., Arrowhead, *Chara* and *Naiad*) were observed in 2018. No noxious vegetation exists.

Prey species: The Fall 2014 electrofishing catch rates of Threadfin and Gizzard Shad were 33.0/h and 30.5/h respectively and were well below those from the previous survey (Figure 3; Appendices A and B). Index of vulnerability (IOV) for Gizzard Shad was poor, and only 67% of Gizzard Shad were available to existing predators as forage. Bluegill catch rates remained good at 161.5/h, comparable to the historical average of 164.0/h (Figure 4; Appendices A and B). Other forage species collected were Longear Sunfish (85.5 /h) Green Sunfish (100.0/h), Redear Sunfish (2.5/h), and Warmouth (0.5/h) (Appendix B). Panfish seldom reach preferred size classes in Belton and few anglers actively seek them. However, Redear Sunfish in the preferred size class were observed during 2015 and 2019 gill netting. Thus, some large panfish are available for anglers in Belton Reservoir.

Catfishes: The objective-based sampling (OBS) plan for Blue and Channel Catfish included collecting a minimum of 50 stock length fish for each species to facilitate comparison of trend data and length-frequency histograms among years (Table 5). The Blue Catfish population expanded significantly in

2019. Blue Catfish catch rates were 3.1/nn (2013) 2.3/nn (2015), and 10.9/nn in 2019 (Figure 5; Appendices A and B). The 2019 catch rate equated to 136 stock-length fish, so the OBS plan target was met. Catch of larger catfish, expressed as CPUE-18, also increased in 2019 (Figure 5). The PSD value in 2019 also increased, reflecting the higher proportion of larger fish in the population. Body condition, expressed as relative weight (Wr), averaged around 80 during 2013, 85 during 2015 and 95 during 2019. All signs point to an expanding population in excellent condition.

Channel Catfish catch rates were 1.7/nn in 2019, which was similar to catch rates over the last 20 years (Figure 6; Appendices A and B). Most collected fish were of legal size. The 2019 catch rate equated to 22 stock-length fish, so the OBS target was not met. The PSD value decreased in 2019, illustrating the lower proportion of larger fish in the population. Body condition (Wr) remained very good, averaging about 90 for 2019.

The Flathead Catfish population is low density as only two were collected in 2019 gill netting (Appendix A).

Temperate bass: The OBS plan for Belton 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 2.2/nn in 2019 compared to 6.7/nn in both 2013 and 2015 (Figure 7; 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, and body condition (Wr) has averaged 85 during the same time period (Figure 7).

The OBS plan for Hybrid Striped Bass included collecting a category 3 age and growth sample (200 stock-sized fish) to compare recruitment between three stocking regimes: fingerlings at 10/acre, fry at 100/acre, and fry at 50/acre (Appendix D). This is a continuation of work begun in 2011. A total of 141 fish were collected and 103 were aged. A total of 15 randomly placed gill nets and 5 biologist-selected gill nets were required to collect the category 3 sample in 2019 (Figure 8, 9; Appendices A and B). Although the 2019 sample size is below the target mentioned in the OBS plan for this species, virtually all sampled size classes of Hybrid Striped Bass exceeded the 5 fish per cm threshold except for the very oldest fish. Thus, most fish collected in the last few nets were surplus to our sampling needs. The standard gill net catch rate for Hybrid Striped Bass was 4.5/nn in 2019 (N = 67), which compares to 8.9/nn in 2013 (N = 133) and 7.7/nn in 2015 (N = 126). Catch of legal-sized fish (18") declined for the third survey in a row to 1.2/nn. Almost all fish exceeded 18" by age-3 (mean =19.5") but growth slowed considerably after that, with the mean length at age-6 equaling 21.3" (Figure 9, Table 7). Relative weight (Wr) averaged about 90, which was an improvement over the previous two surveys where the average was 80 or less. High water appeared to negatively impact year-class strength in 2015 and 2016 (Appendix D), which could explain the reduced catches observed overall. These two years represented a 50-per-acre and a 100-per-acre fry stocking rate, respectively. It's possible that either low reservoir retention times resulted in emigration of stocked fry, or turbidity associated with high water events reduced forage availability for fry. It is also possible that the established zebra mussel population is negatively affecting primary productivity which would affect forage availability for fry. The PSD-12 value was 72 in 2019, much lower than the previous two sampling year. This indicates that Age-1 fish comprised a higher proportion of the population and confirms the findings from the age data. There is not enough evidence to suggest that altering our current stocking strategy of alternating 50- and 100-per-acre fry-only stockings is warranted. Further evaluation is recommended. Appendix D contains additional results and discussion.

Black basses: Largemouth Bass were collected by standard electrofishing at a rate of 127.5/h in 2010 and 41.0/h in 2014. These catch rates equate to 255 and 82 collected individuals (Figure 10 and Appendices A and B). Catch of legal-sized fish remained low. Body condition (Wr) in 2014 was good, and typically averaged around 90.

The number of bass tournament permits for each calendar year represented in this report was obtained from the USACE (Ronald L. Bruggman, pers. comm. 2019; Table 8). Not all tournaments were permitted, so the numbers should be viewed as an index of tournament pressure over time. The annual number of permitted tournaments was similar from 2012-2018 and averaged 39.1 (range 36-45).

The OBS plan for Belton Reservoir's Smallmouth Bass included collecting a category III age and growth sample for Smallmouth Bass to calculate length-at-age, year class strength, and mortality rates (Table 5). Smallmouth Bass were collected by electrofishing during February 2019 (Figure 12; Appendices A and B). A total of 267 were collected and 210 were aged. Unlike the 2014 collection, year-class strength varied indicating inconsistent recruitment (Appendix D). The 2016 year-class was much lower than expected and correlates to a high-water year with no supplemental stocking. Years with higher year-class strength included 2015, which was a high-water year with supplemental stocking, and 2017 which was a stable full-pool year with no stocking. These data would indicate that stocking can increase year-class strength during high water events, and that stable water levels result in consistent natural recruitment. Appendix D contains additional results and discussion.

White crappie: The OBS plan for Belton Reservoir's White Crappie included collecting a minimum of 50 stock length fish, in order calculate proportions (e.g., PSD, PSD-10) and allow comparison of trend data and length-frequency histograms among years, and to inform anglers about the White Crappie population (Table 5). Historical trap netting catch rates for White Crappie were low, and trap netting is no longer a standard sampling method for this species in Belton. Instead, gill netting is currently being used as a non-standard gear to collect data on this population. The gill net catch rate for White Crappie was 1.5/nn in 2019, 0.7/nn in 2015 and 2.7/nn in 2013 (Figure 13; Appendices A and B). The total catch in 2019 was 29 fish, so the OBS target was not met. Catch of legal-sized fish was low with CPUE-10 at 0.9/nn and a PSD-10 of 45..

Fisheries Management Plan for Belton Reservoir, Texas

Prepared – July 2019

ISSUE 1: Collectively, dominant year classes of Palmetto Bass were identified for 2004, 2007, 2010, 2013, and 2017, all years when fry were stocked (See Appendix D for results and discussion). However, fry stockings in 2015 and 2016 were poor year-classes and were correlated to high water events. It is possible that increased outflow from high water washed out most of the fry. It is also possible that turbidity associated with high water resulted in reduced forage availability. Regardless of the actual cause, the data indicate that high water events often result in reduced recruitment of Hybrid Striped Bass fry and may be the cause of reduced gill net catch rates in 2019.

MANAGEMENT STRATEGIES

1. Continue stocking Hybrid Striped Bass at 50 and 100 fry per-acre in alternate years.
2. If the reservoir is flooding at the time of scheduled fry stockings, consider stocking fingerlings later in the year if it is an option.
3. Collect a category III age sample in 2023 to assess stocking success and growth.

ISSUE 2: Electrofishing was not conducted in fall 2018 due to heavy rains and boat ramp closures, therefore, current data on forage species and Largemouth Bass were not available for this report.

MANAGEMENT STRATEGY

1. Complete an additional standard nighttime electrofishing survey in fall 2020.

ISSUE 3: The 2014 Smallmouth Bass evaluation indicated that stocking had little impact on the number of Smallmouth Bass recruiting to the population from 2009 to 2014. It was hypothesized that habitat during the first year of life was limiting, and that high water could positively impact availability. The 2019 evaluation indicated unequal year-class strength in 2015, 2016 and 2017. High year-class strength was observed in 2015, which was a high-water year when Smallmouth Bass were stocked, and 2017, a year with relatively stable water levels where none were stocked. Year-class strength was low in 2016, a high-water year when no Smallmouth Bass were stocked.

MANAGEMENT STRATEGIES

1. Collect a category III age sample in January or February 2023 to assess stocking effects and population parameters.
2. If the opportunity arises, stock Smallmouth Bass fingerlings at least once during a high-water year before 2022.
3. Based on several years of data indicating satisfactory recruitment in years with stable water levels near conservation pool, do not stock supplementary fingerlings during those years.

ISSUE 4: Despite preventative efforts, Zebra Mussels were found throughout Belton Reservoir in August 2013 and continue to be an issue.

MANAGEMENT STRATEGIES

1. Cooperate with the USACE to post and maintain appropriate signage at access points around the reservoir.
2. Contact and educate marina owners about invasive species, and provide them with posters, literature, etc… so that they can in turn educate their customers.
3. Educate the public about invasive species using media and the internet.
4. Make a speaking point about invasive species when presenting to constituent and user groups.
5. Keep track of (i.e., map) existing and future inter-basin water transfers to facilitate potential invasive species responses.

Objective-Based Sampling Plan and Schedule (2019–2023)

Important sport and forage fishes: Abundant and/or important sport fishes in Belton Reservoir include Largemouth and Smallmouth Bass, Hybrid Striped Bass, White Bass, White Crappie, Channel Catfish and Blue Catfish. Important forage fishes include Gizzard and Threadfin Shad, Bluegill, Green Sunfish, Redear and Longear Sunfish.

Sport fishes with low-density populations: Spotted Bass, Flathead Catfish, and Black Crappie occur in very low abundance in Belton Reservoir and are generally caught incidentally to other targeted species. We will still collect them with relevant sampling gear, length will be recorded in the FMF, and CPUE will be recorded in the management report.

Survey objectives, fisheries metrics, and sampling objectives

Fall Electrofishing: A minimum of 18 randomly selected 5-min electrofishing stations will be sampled at night in fall 2020 and 2022. This survey will be used to evaluate Largemouth and Smallmouth Bass and primary forage species (Gizzard and Threadfin Shad, Bluegill, Redear, Green Sunfish, and Longear Sunfish) by general monitoring (using CPUE, size structure and relative weight as metrics) to characterize Black Bass populations 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 distribution with 80% confidence. Genetics will also be collected on Largemouth Bass.

A Category 3 age sample (200 stock-size fish; up to 5 fish per cm group) for Smallmouth Bass will be collected in Winter, 2023. Daytime electrofishing at biologist-selected stations will continue until the target is reached, or it becomes obvious that the target can't be reached.

The forage species goals will also be general monitoring (using CPUE and size structure as metrics) to characterize Gizzard Shad, Threadfin Shad, Bluegill, Redear, Green Sunfish and Longear Sunfish populations and make comparisons with historical and future data. Catch per unit effort target precision will be an RSE < 25. Target sample size will be N ≥ 50 stock-sized fish to determine population size structure, allowing us to calculate proportional size distributions with 80% confidence. Index of vulnerability (IOV) will also be calculated for Gizzard Shad to assess the relative proportion of individuals in the population suitable as prey for sport fish.

Spring Gill Netting: A minimum of 15 randomly selected gill net stations will be sampled in spring, 2023. This survey will be used to evaluate Hybrid Striped Bass, White Bass, Blue Catfish, Channel Catfish and White Crappie. For all species, catch per unit effort target precision will be an RSE < 25. Target sample size will be N≥ 50 stock-sized fish to determine population size structure, allowing us to calculate proportional size distributions with 80% confidence.

A Category 3 age sample (200 stock-size fish; up to 5 fish per cm group) for Hybrid Striped Bass will be collected in Winter, 2023. If the goal of sampling is only Hybrid Striped Bass age data, stations will be selected to optimize numbers of fish collected. If continued sampling results in >75% of collected fish measurements falling into already completed cm groups, discontinuing sampling should be considered rather than continuing to collect fish that won't increase precision.

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Tables and Figures

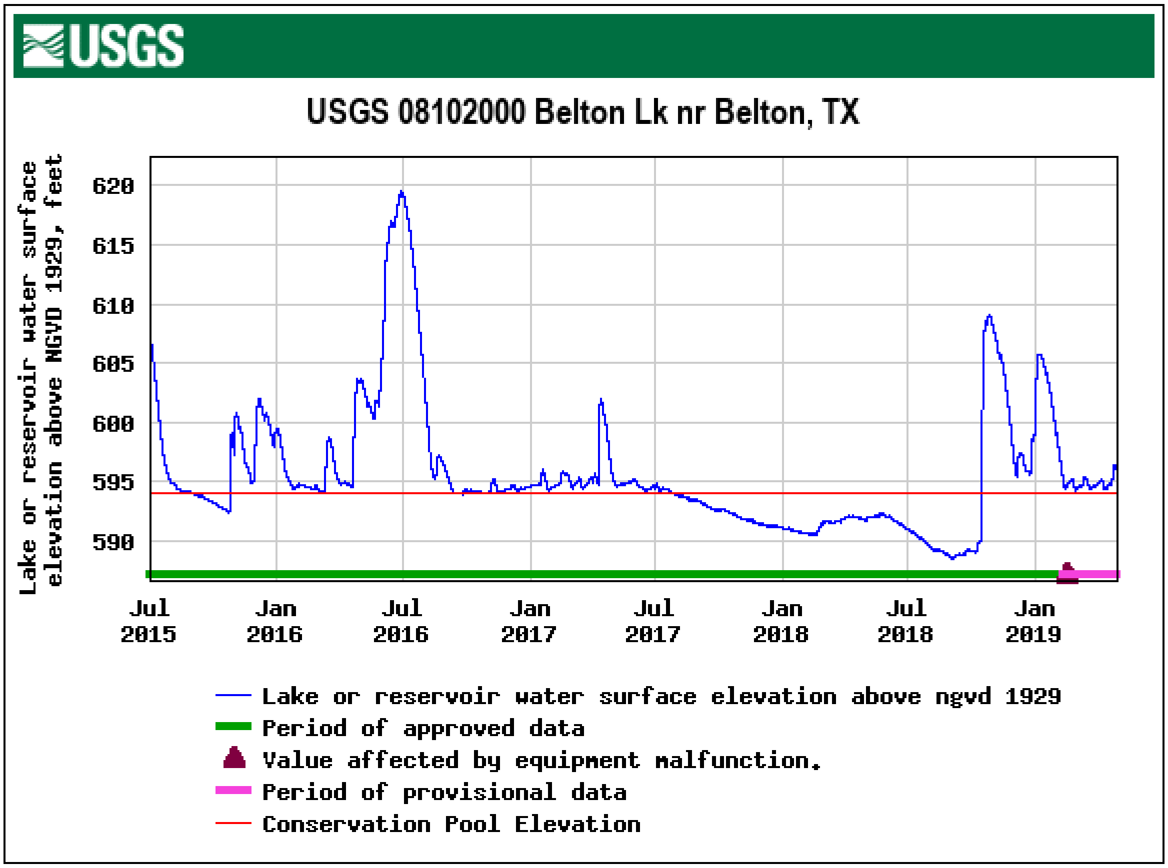


Figure 1. Daily mean water level elevations in feet above mean sea level recorded for Belton Reservoir, Texas, July 1, 2015 through May 1, 2019. Conservation pool (594) is denoted by a line.

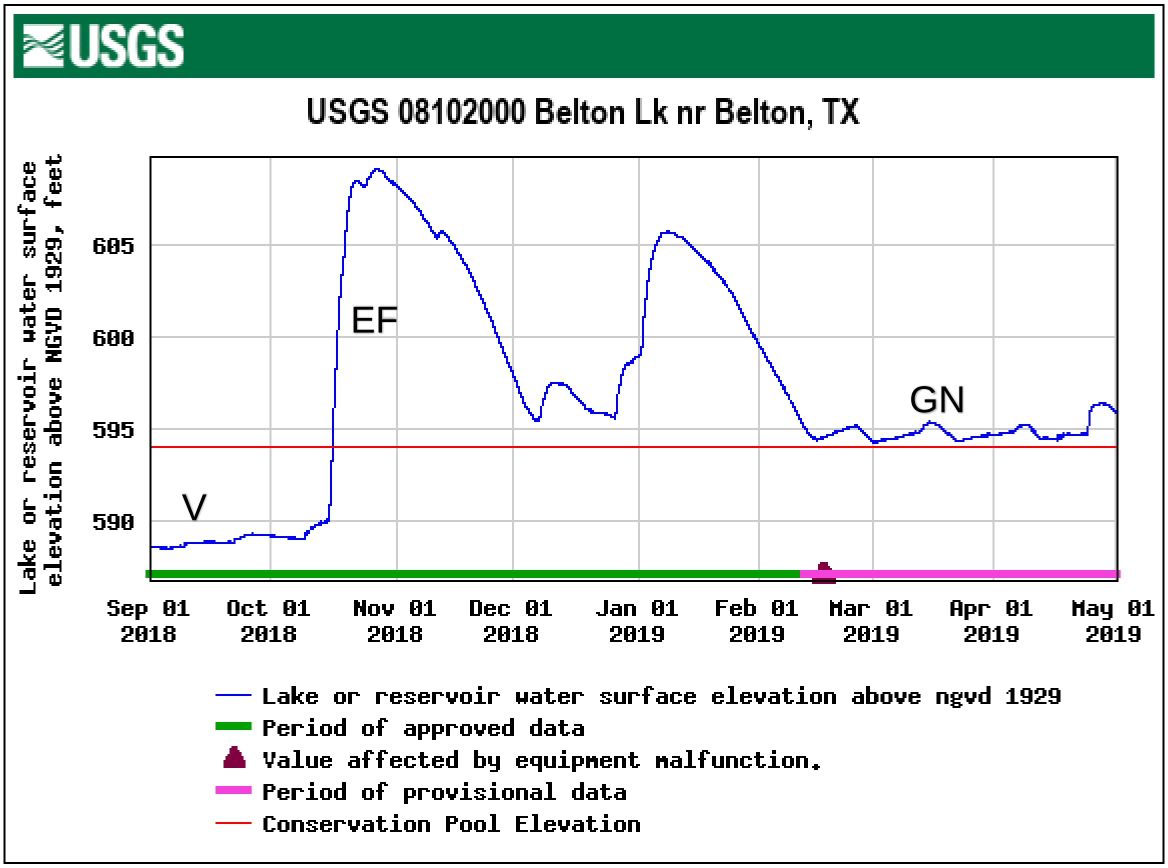


Figure 2. Daily mean water level elevations in feet above mean sea level (MSL) recorded for Belton Reservoir, Texas, September 1, 2018 through May 1, 2019. Conservation pool (594) is denoted by a line while scheduled surveys are denoted by V (vegetation), EF (electrofishing), and GN (gill netting).

Table 1. Characteristics of Belton Reservoir, Texas.

Characteristic	Description
Year Constructed	1954
Controlling authority	United States Army Corps of Engineers
County	Bell
Reservoir type	Mainstem
Shoreline Development Index (SDI)	8.8
Conductivity	370 uS/cm

Table 2. Boat ramp characteristics for Belton Reservoir, Texas, September 2018. Reservoir elevation at time of survey was approximately 589.0 feet above mean sea level (5’ below conservation pool).

Boat ramp	Latitude Longitude (dd)	Parking capacity (N)	Condition
Temples Lake Park (N)	31.13833/-97.49645	40	Good
Temples Lake Park (S)	31.12794/-97.49581	41	Good
Arrowhead Point	31.12317/-97.48866	30	Good
Live Oak Ridge	31.11661/-97.47684	24	Good
Lakeview Park	31.10460/-97.48495	68	Good
Westcliff Park	31.12094/-97.51823	41	Good
Sparta Valley Park	31.13461/-97.52651	19	Good
BLORA (E)	31.38483/-97.54581	50	Good
BLORA (W)	31.14826/-97.55858	16	Good
Rogers Park	31.16089/-97.48048	33	Good
Cedar Ridge Park (W)	31.16710/-97.45373	63	Good
Cedar Ridge Park (E)	31.16519/-97.44086	22	Good
McGregor Park	31.21159/-97.48188	12	Good
Leona Park	31.22018/-97.46734	32	Good
White Flint Park	31.22632/-97.47418	27	Good
Owl Creek Park	31.21750/-97.51383	30	Good
Iron Bridge Park	31.28071/-97.47229	18	Good

Table 3. Harvest regulations for Belton Reservoir, 2018-2019.

Species	Bag Limit	Length limit
Catfish: Channel, Blue, their hybrids and subspecies	25 (in any combination)	12-inch minimum
Catfish, Flathead	5	18-inch minimum
Bass, White	25	10-inch minimum
Bass: Palmetto and Sunshine	5 (in any combination)	18-inch minimum
Bass: Largemouth and Smallmouth	5	14-inch minimum
Bass: Spotted and Guadalupe	5[a]	None
Crappie: White, Black, their hybrids and subspecies	25 (in any combination)	10-inch minimum

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

Table 4. Stocking history for Belton (Bell County), Texas. Life stages are fry (FRY), fingerlings (FGL), advanced fingerlings (AFGL) 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	1998	308,987	FGL	2.2
	2008	312,748	FGL	2.1
	Total	621,735		
Channel Catfish	1971	44,000	AFGL	7.9
	Total	44,000		
Florida Largemouth Bass	1989	307,142	FRY	0.8
	1991	357,741	FGL	1.2
	1995	308,552	FGL	1.2
	2016	160,740	FGL	1.8
	Total	1,134,175		
Largemouth Bass	1967	4,600	UNK	0.0
	1969	350,000	FRY	0.7
	1970	100,000	UNK	0.0
	1972	225,000	UNK	0.0
	Total	679,600		
Palmetto Bass (striped X white bass hybrid)	1977	60,455	UNK	0.0
	1979	65,518	UNK	0.0
	1981	120,625	UNK	0.0
	1983	125,550	UNK	0.0
	1984	242,239	FGL	2.0
	1987	250,850	FRY	1.0
	1988	259,977	FRY	1.0
	1989	88,000	FGL	1.2
	1991	133,832	FGL	1.3
	1992	218,884	FGL	1.3
	1993	92,386	FGL	1.2
	1994	185,744	FGL	1.3
	1995	185,151	FGL	1.3
	1996	187,907	FGL	1.6
	1997	101,100	FGL	1.5
	1998	189,434	FGL	1.2
	1999	94,098	FGL	1.4
	2000	93,674	FGL	1.6
	2002	94,200	FGL	1.8
	2004	99,180	FGL	1.6
	2004	1,337,574	FRY	0.4

Table 4. Stocking history for Belton (Bell County), Texas. Life stages are fry (FRY), fingerlings (FGL), advanced fingerlings (AFGL) 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)
	2005	124,081	FGL	1.7
	2006	123,337	FGL	1.8
	2007	1,039,169	FRY	0.2
	2008	124,433	FGL	1.5
	2009	116,731	FGL	1.4
	2010	1,130,132	FRY	0.3
	2011	88,000	FGL	1.5
	2013	1,243,445	FRY	0.2
	2014	36,136	FGL	1.9
	2015	494,926	FRY	0.2
	2016	909,513	FRY	0.2
	2017	1,022,578	FRY	0.2
	2018	627,581	FRY	0.2
	Total	11,306,440		
Sauger	1985	54,113		1.5
	Total	54,113		
Smallmouth Bass	1978	99,850	UNK	0.0
	1979	100,000	UNK	0.0
	1980	101,320	UNK	0.0
	1995	28,450	FGL	1.5
	1997	302,150	FGL	1.1
	1998	184,500	FGL	1.2
	1999	189,258	FGL	1.4
	2000	130,000	FGL	1.5
	2007	4,373	ADL	8.4
	2007	12,500	FGL	3.0
	2008	87,250	FGL	1.4
	2010	289,719	FGL	1.3
	2012	20,225	FGL	2.1
	2014	171,381	FGL	1.4
	2015	54,573	FGL	1.9
	2018	5,945	FGL	1.8
	Total	1,781,494		
Sunshine Bass (white bass x striped bass hybrid)	2014	21,699	FGL	1.5
	2016	300,000	FRY	0.2
	Total	321,699		
Walleye	1973	493,000	FRY	0.2

Table 4. Stocking history for Belton (Bell County), Texas. Life stages are fry (FRY), fingerlings (FGL), advanced fingerlings (AFGL) 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)**
	1974	327,000	FRY	0.2
	Total	820,000		

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

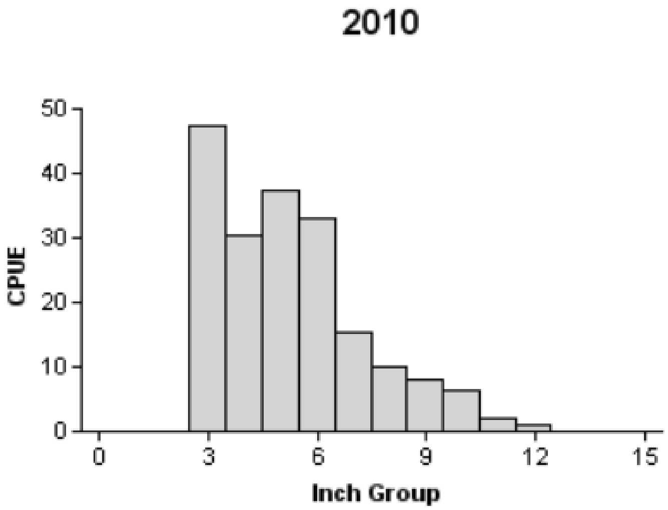
Gear/target species	Survey objective	Metrics	Sampling objective
Electrofishing			
Largemouth Bass	General Monitoring	CPUE, Size structure, Wr,	RSE-Stock ≤ 25; 10 per cm
	Genetics	%FLMB	N = 30, all sizes
Smallmouth Bass	General Monitoring	CPUE, Size structure, Wr, Age	N = 200 stock, 5 per cm
Bluegill [a]	General Monitoring	CPUE, Size structure	None
Longear [a]	General Monitoring	CPUE, Size structure	None
Gizzard Shad [a]	General Monitoring	CPUE, Size structure	None
Gill netting			
Hybrid Striped Bass	General Monitoring	CPUE, Size structure, Wr, Age	RSE-Stock ≤ 25; N = 200 stock, 5 per cm
White Bass	General Monitoring	CPUE, Size structure, Wr,	N ≥ 50 stock
White Crappie	General Monitoring	CPUE, Size structure	N ≥ 50 stock

[a] No additional effort will be expended to achieve an RSE ≤ 25 for CPUE of Bluegill and Gizzard Shad if not reached from designated Largemouth Bass sampling effort. Instead, Largemouth Bass body condition can provide information on forage abundance, vulnerability, or both relative to predator density.

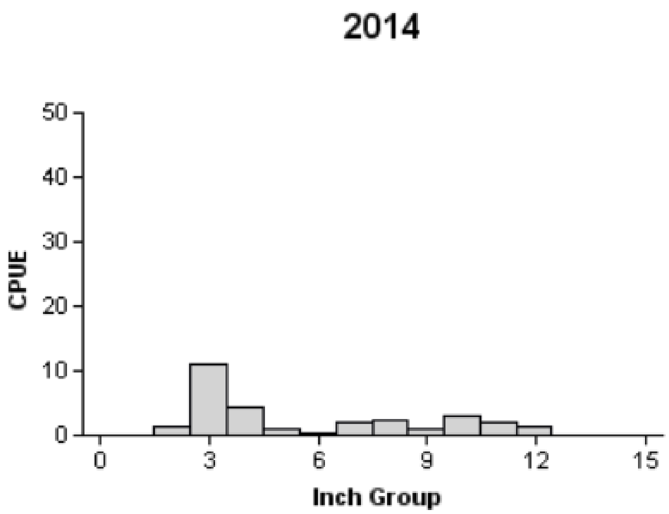
Table 6. Survey of structural habitat types, Belton Reservoir, Texas, 2010. Linear shoreline distance (miles) and percent of linear shoreline distance was recorded for each habitat type greater than one percent; otherwise noted as trace. Percent of total shoreline distance is blank for boat docks/piers because they were dually coded with adjacent habitat; counts are given instead. Survey was conducted using 2010 NAIP, 1-meter resolution satellite imagery.

Habitat type	Estimate (miles)	% of total
Natural/Rock shoreline	148.2	93.7
Rock Bluff	9.6	6.0
Piers and boat docks	N = 32	

Gizzard Shad



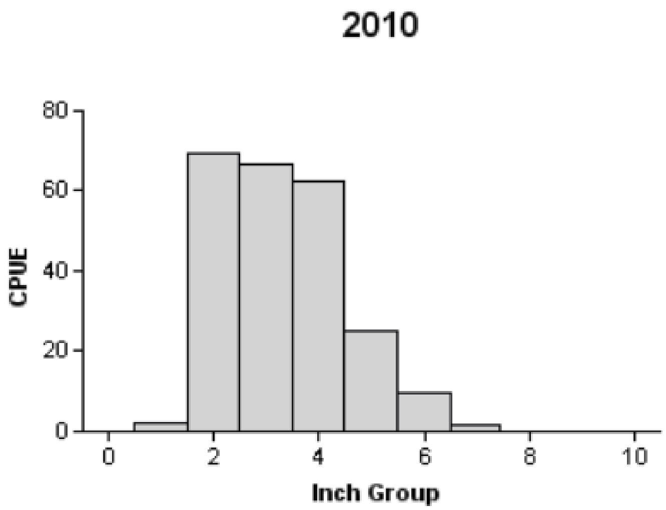
Effort = 2.0
Total CPUE = 191.5 (50; 383)
Stock CPUE = 43.0 (25; 86)
IOV = 86 (8)



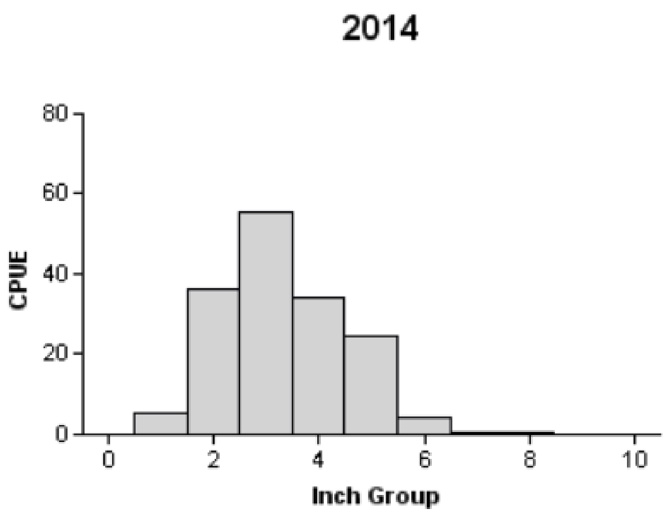
Effort = 2.0
Total CPUE = 30.5 (25; 61)
Stock CPUE = 12.0 (47; 24)
IOV = 67 (13)

Figure 3. 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, Belton Reservoir, Texas, 2010 and 2014.

Bluegill



Effort = 2.0
Total CPUE = 236.5 (19; 473)
Stock CPUE = 165.0 (15; 330)
PSD = 7 (2)



Effort = 2.0
Total CPUE = 161.5 (18; 323)
Stock CPUE = 119.5 (17; 239)
PSD = 5 (1)

Figure 4. 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, Belton Reservoir, Texas, 2010 and 2014.

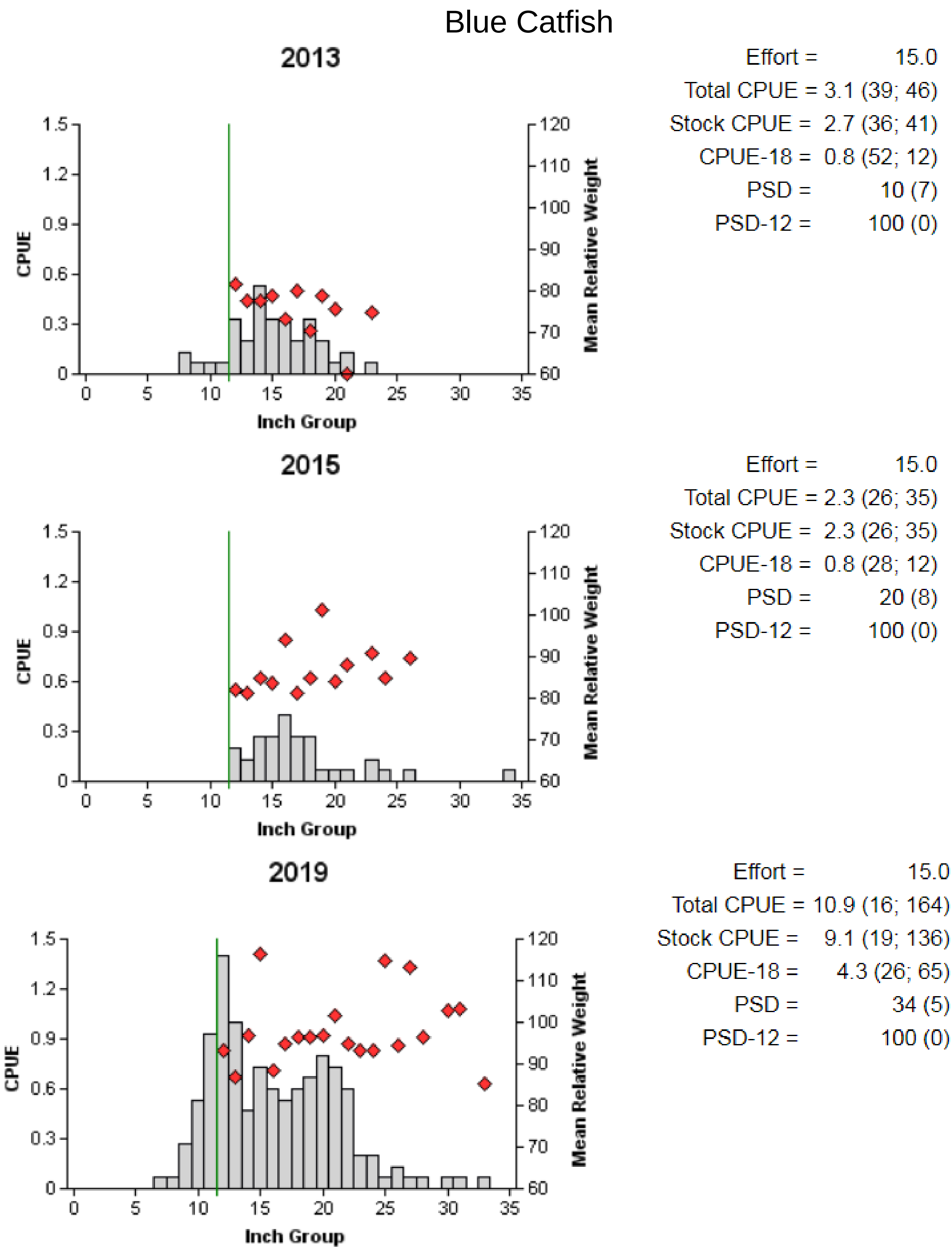
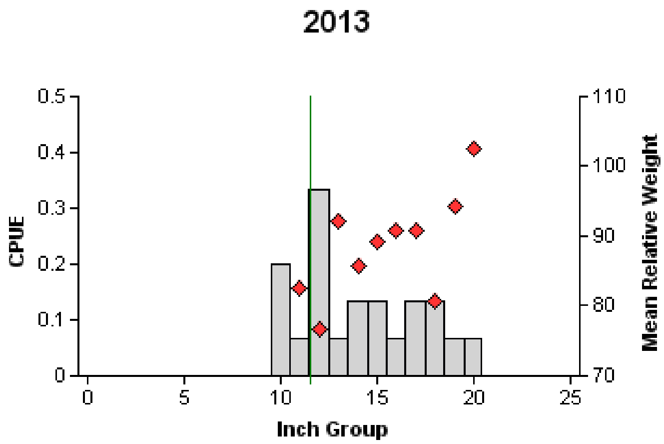
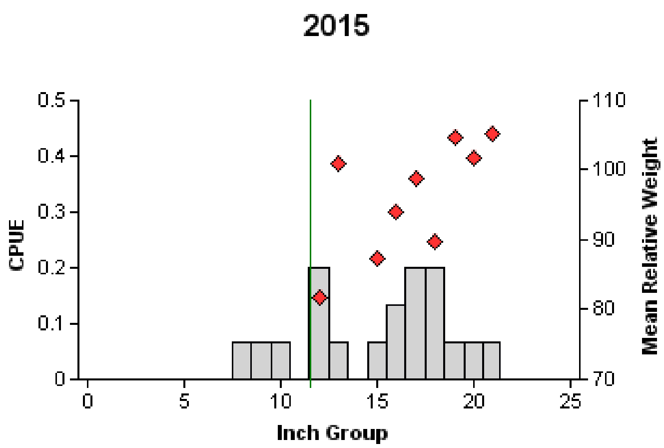


Figure 5. Number of Blue Catfish caught per net night (CPUE, bars), mean relative weight (diamonds), and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for spring gill netting surveys, Belton Reservoir, Texas, 2013, 2015, and 2019. Vertical line indicates minimum length limit.

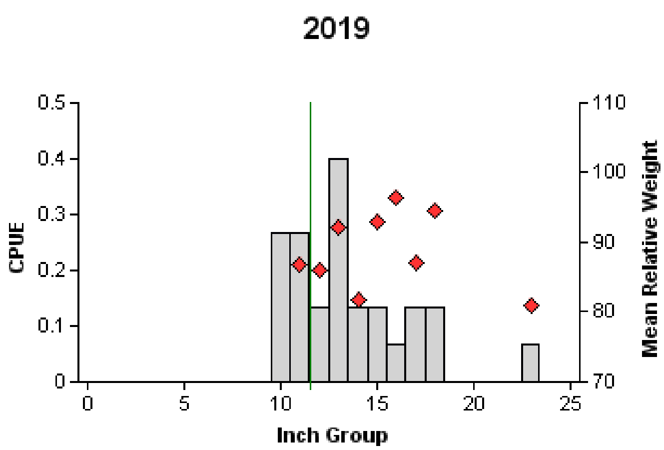
Channel Catfish



Effort = 15.0
Total CPUE = 1.4 (29; 21)
Stock CPUE = 1.2 (26; 18)
CPUE-12 = 1.1 (26; 17)
PSD = 39 (10)
PSD-12 = 94 (5)



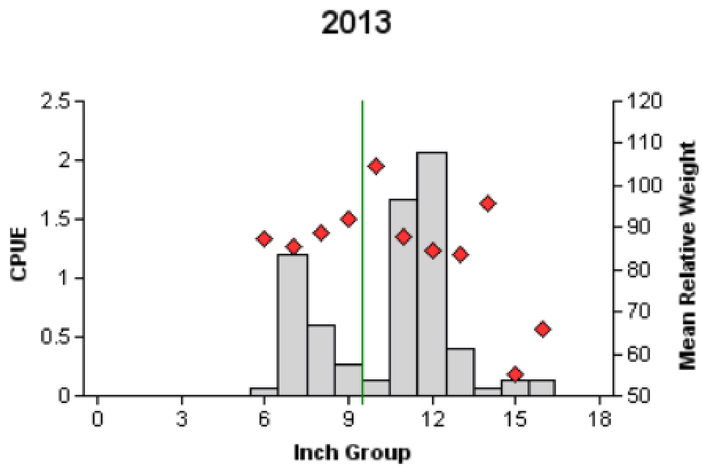
Effort = 15.0
Total CPUE = 1.3 (30; 19)
Stock CPUE = 1.1 (37; 16)
CPUE-12 = 1.1 (37; 16)
PSD = 69 (15)
PSD-12 = 100 (0)



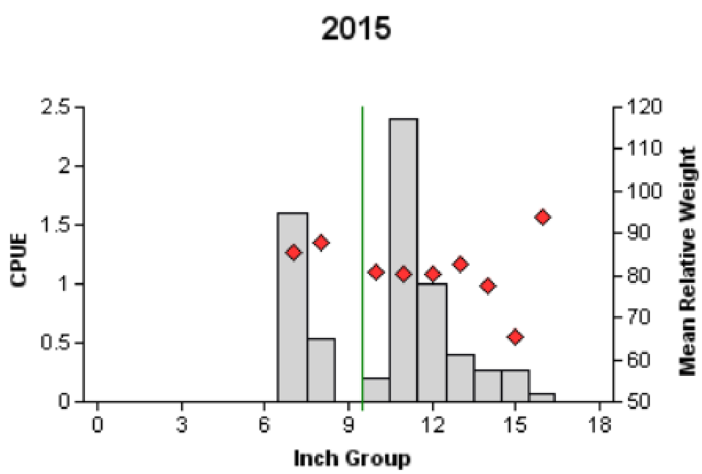
Effort = 15.0
Total CPUE = 1.7 (25; 26)
Stock CPUE = 1.5 (23; 22)
CPUE-12 = 1.2 (25; 18)
PSD = 27 (12)
PSD-12 = 82 (9)

Figure 6. Number of Channel Catfish caught per net night (CPUE, bars), mean relative weight (diamonds), and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for spring gill netting surveys, Belton Reservoir, Texas, 2013, 2015, and 2019. Vertical line indicates minimum length limit.

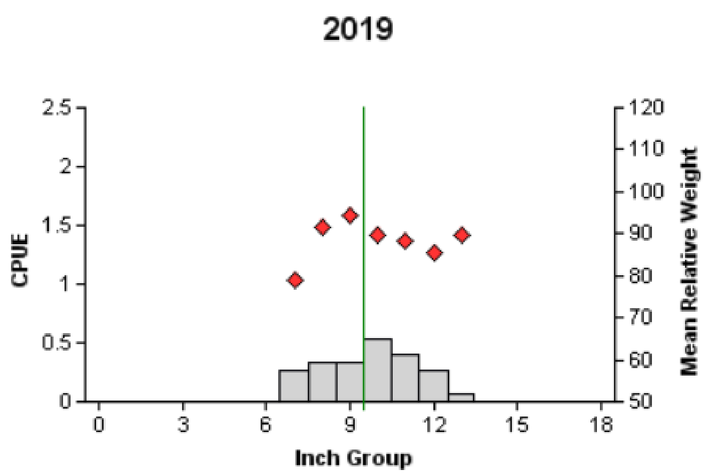
White Bass



Effort = 15.0
Total CPUE = 6.7 (27; 101)
Stock CPUE = 6.7 (27; 101)
CPUE-10 = 4.6 (32; 69)
PSD = 72 (7)
PSD-10 = 68 (8)



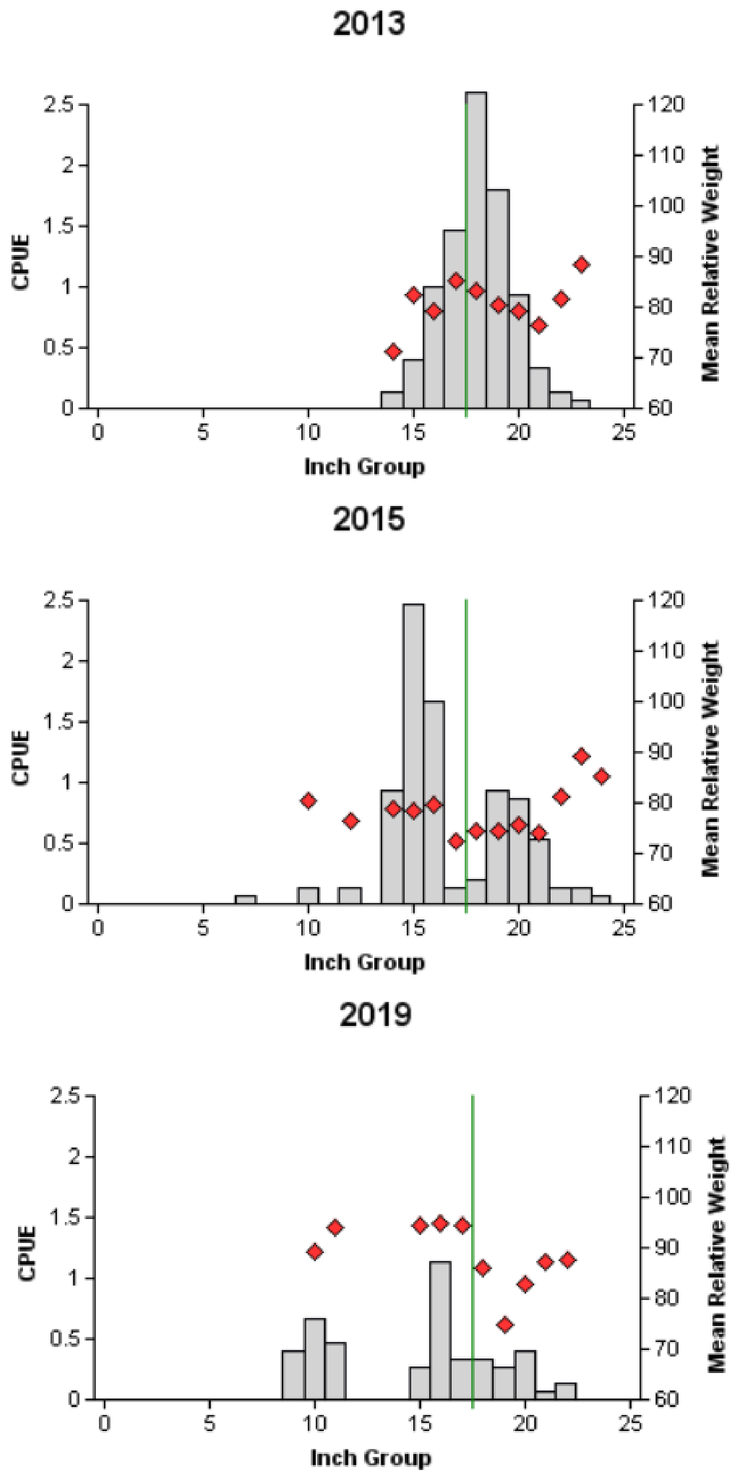
Effort = 15.0
Total CPUE = 6.7 (27; 101)
Stock CPUE = 6.7 (27; 101)
CPUE-10 = 4.6 (29; 69)
PSD = 68 (14)
PSD-10 = 68 (14)



Effort = 15.0
Total CPUE = 2.2 (28; 33)
Stock CPUE = 2.2 (28; 33)
CPUE-10 = 1.3 (31; 19)
PSD = 73 (6)
PSD-10 = 58 (8)

Figure 7. Number of White Bass caught per net night (CPUE, bars), mean relative weight (diamonds), and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for spring gill netting surveys, Belton Reservoir, Texas, 2013, 2015, and 2019. Vertical line indicates minimum length limit.

Hybrid Striped Bass



2013

Effort = 15.0
Total CPUE = 8.9 (20; 133)
Stock CPUE = 8.9 (20; 133)
CPUE-18 = 5.9 (19; 89)
PSD = 94 (2)
PSD-12 = 100 (0)

2015

Effort = 15.0
Total CPUE = 8.4 (33; 126)
Stock CPUE = 8.3 (33; 125)
CPUE-18 = 2.9 (35; 43)
PSD = 56 (7)
PSD-12 = 98 (1)

2019

Effort = 15.0
Total CPUE = 4.5 (41; 67)
Stock CPUE = 4.1 (38; 61)
CPUE-18 = 1.2 (37; 18)
PSD = 66 (11)
PSD-12 = 72 (9)

Figure 8. Number of Hybrid Striped Bass caught per net night (CPUE, bars), mean relative weight (diamonds), and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for spring gill netting surveys, Belton Reservoir, Texas, 2013, 2015, and 2019. Vertical line indicates minimum length limit.

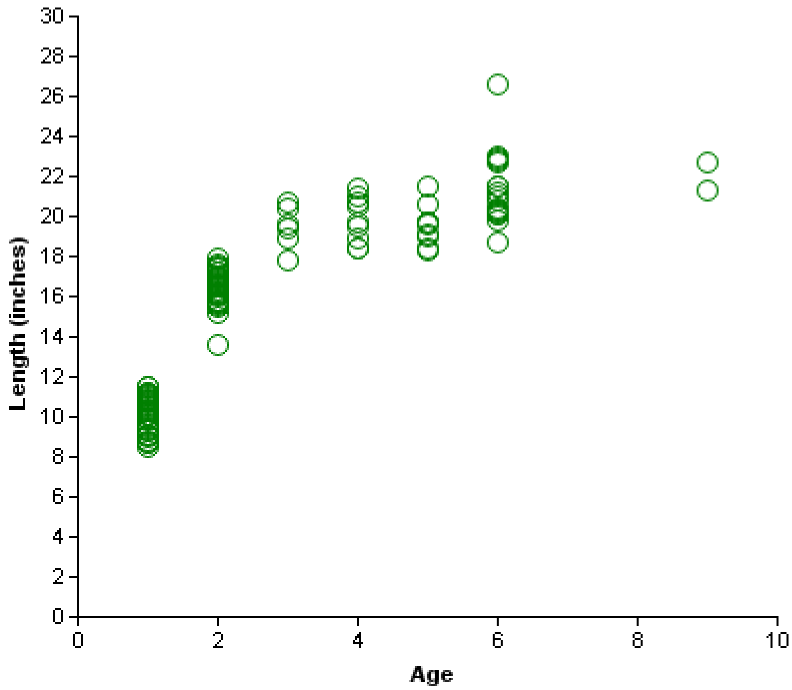


Figure 9. Length at age for Hybrid Striped Bass collected by gill netting, Belton Reservoir, Texas, 2019.

Table 7. Average length at capture for Hybrid Striped Bass (sexes combined) ages 1 – 9 collected in gill nets, Belton Reservoir, 2019. Lengths are followed by the sample size. Note that the age-1 data may not be representative of the actual size distribution because of gear bias against smaller fish.

Total Length	Survey Year	Age	Number of Fish
10.12	2019	1	33
16.47	2019	2	31
19.47	2019	3	6
19.83	2019	4	9
19.54	2019	5	9
21.32	2019	6	18
21.99	2019	9	2

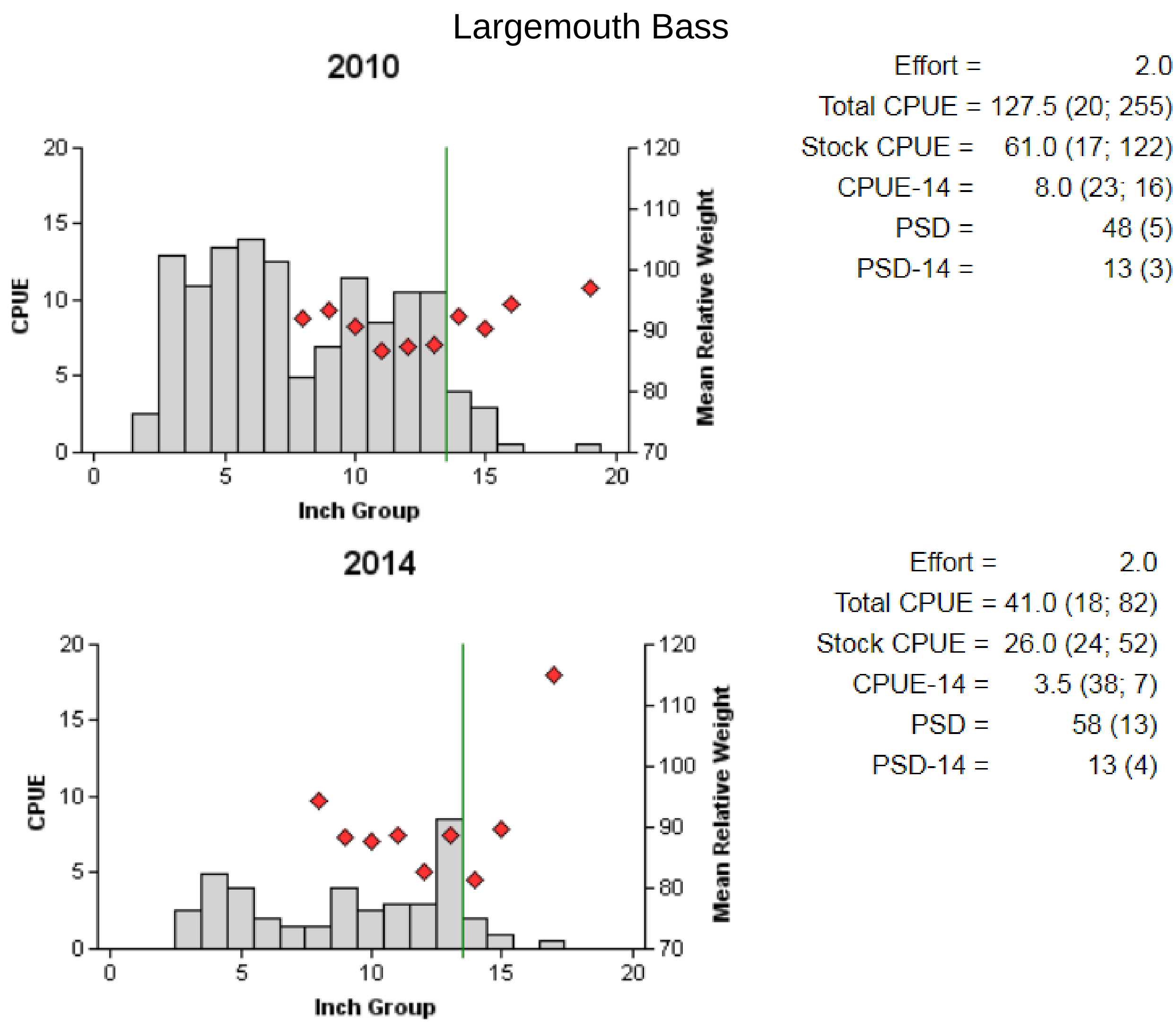
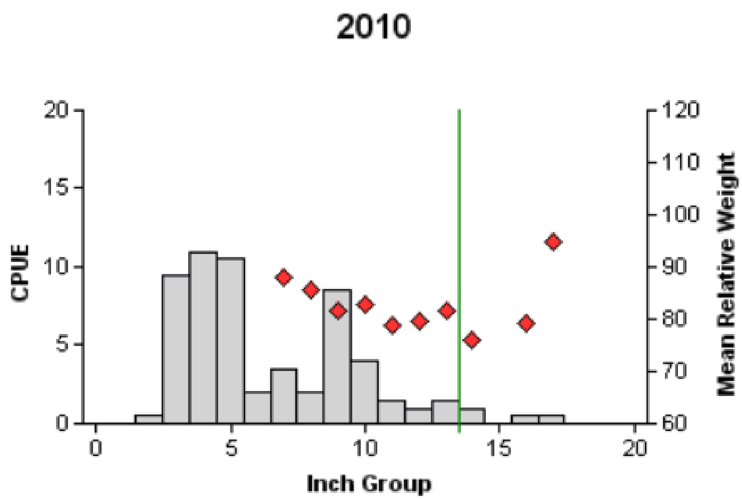


Figure 10. Number of Largemouth Bass caught per hour (CPUE, bars), mean relative weight (diamonds), and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for fall electrofishing surveys, Belton Reservoir, Texas, 2010 and 2014. Vertical line indicates minimum length limit.

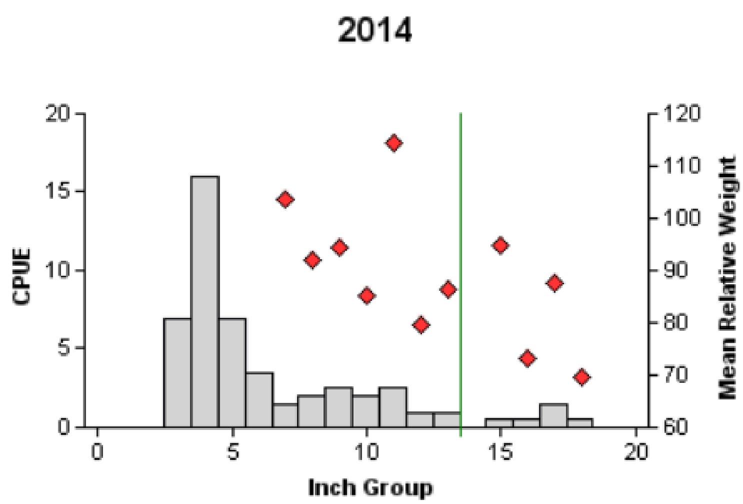
Table 8. Tournament permits issued by the United States Corps of Engineers at Belton Lake from 1999 through 2018 (Ronnie L. Bruggman, pers. comm. 2019). Although permitting is a requirement, not all tournaments were permitted. Thus, these numbers should be viewed as an index of tournament pressure.

Year	Number of Permits
1999	2
2000	2
2001	1
2002	4
2003	4
2004	5
2005	12
2006	20
2007	3
2008	12
2009	31
2010	55
2011	52
2012	41
2013	40
2014	36
2015	45
2016	37
2017	39
2018	36

Smallmouth Bass



Effort = 2.0
Total CPUE = 57.5 (36; 115)
Stock CPUE = 24.0 (42; 48)
CPUE-14 = 2.0 (47; 4)
PSD = 25 (7)
PSD-14 = 8 (5)



Effort = 2.0
Total CPUE = 49.0 (21; 98)
Stock CPUE = 15.5 (29; 31)
CPUE-14 = 3.0 (50; 6)
PSD = 48 (8)
PSD-14 = 19 (9)

Figure 11. Number of Smallmouth Bass caught per hour (CPUE, bars), mean relative weight (diamonds), and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for fall electrofishing surveys, Belton Reservoir, Texas, 2010 and 2014. Vertical line indicates minimum length limit.

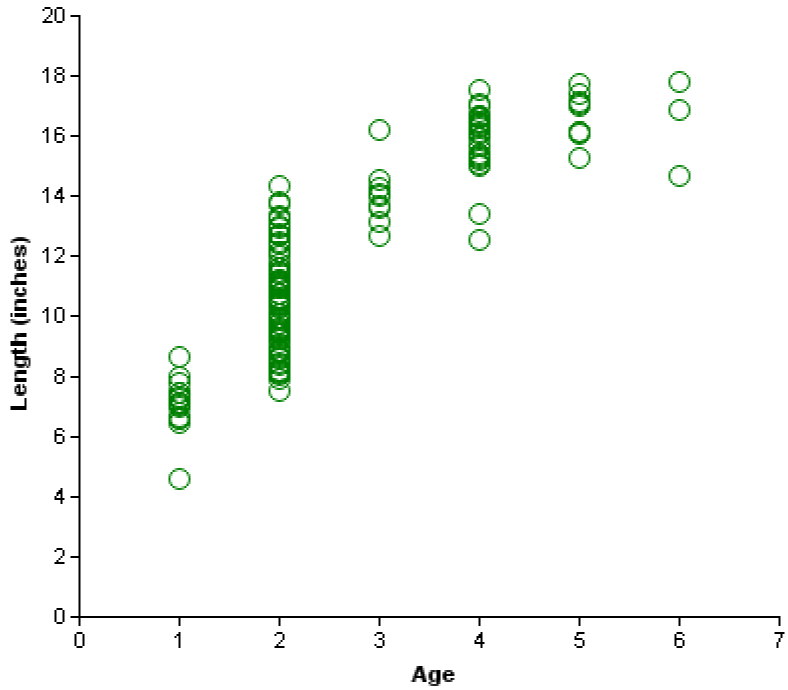


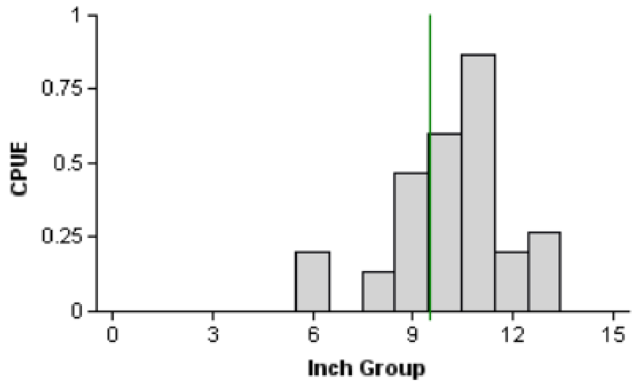
Figure 12. Length at age for Smallmouth Bass collected by spring electrofishing, Belton Reservoir, Texas, 2019.

Table 9. Average length at capture for Smallmouth Bass (sexes combined) ages 1 – 6 collected by electrofishing, Belton Reservoir, 2019. Note that these fish were collected in February, so the age is incremented up by one to reflect that as compared to a fall collection.

Total Length	Survey Year	Age	Number of Fish
5.40	2019	1	89
10.54	2019	2	75
14.02	2019	3	9
15.91	2019	4	25
16.67	2019	5	9
16.44	2019	6	3

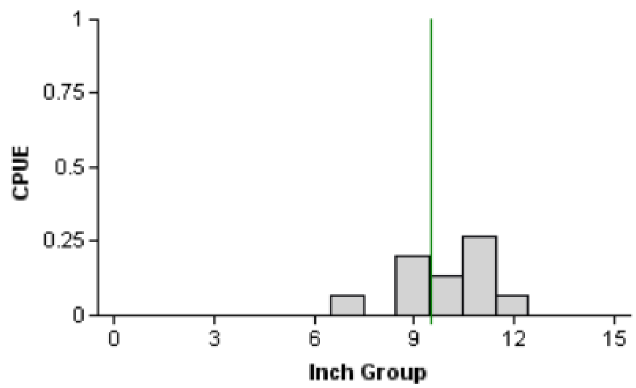
White Crappie

2013



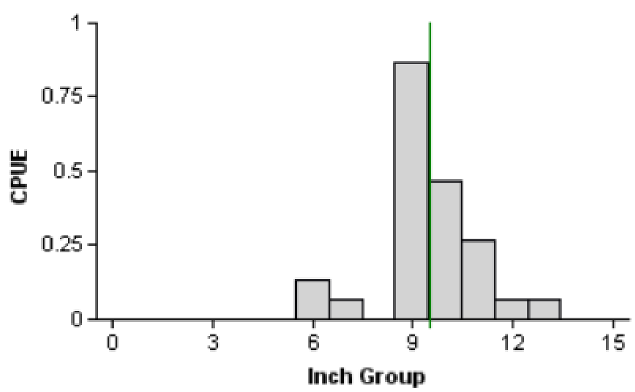
Effort = 15.0
Total CPUE = 2.7 (38; 41)
Stock CPUE = 2.7 (38; 41)
CPUE-10 = 1.9 (43; 29)
PSD = 93 (4)
PSD-10 = 71 (6)

2015



Effort = 15.0
Total CPUE = 0.7 (45; 11)
Stock CPUE = 0.7 (45; 11)
CPUE-10 = 0.5 (46; 7)
PSD = 91 (7)
PSD-10 = 64 (11)

2019



Effort = 15.0
Total CPUE = 1.9 (31; 29)
Stock CPUE = 1.9 (31; 29)
CPUE-10 = 0.9 (35; 13)
PSD = 90 (7)
PSD-10 = 45 (6)

Figure 13. Number of White Crappie caught per net night (CPUE, bars) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for spring gill netting surveys, Belton Reservoir, Texas, 2013, 2015, and 2019. Vertical line indicates minimum length limit.

Proposed Sampling Schedule

Table 10. Proposed sampling schedule for Belton Reservoir, Texas. Survey period is June through May. Gill netting surveys are conducted in the spring, while electrofishing surveys are conducted in the fall. Standard survey denoted by S and additional survey denoted by A.

	Survey year			
	2019-2020	2020-2021	2021-2022	2022-2023
Angler Access				S
Vegetation				S
Electrofishing – Fall		A		S
Electrofishing – Winter				A
Gill netting				S
Report				S

APPENDIX A – Catch rates for all species from gill nets

Number (N) and catch rate (CPUE) (RSE in parentheses) of all target species collected from gill nets in Belton Reservoir, Texas, 2019. Sampling effort was 15 net nights for gill netting.

Species	Gill Netting	
	N	CPUE
Blue Catfish	164	10.9 (16)
Channel Catfish	26	1.7 (25)
Flathead Catfish	2	0.1 (68)
White Bass	33	2.2 (28)
Hybrid Striped Bass	67	4.5 (41)
White Crappie	29	1.9 (31)

APPENDIX B – Historical catch rates for targeted species

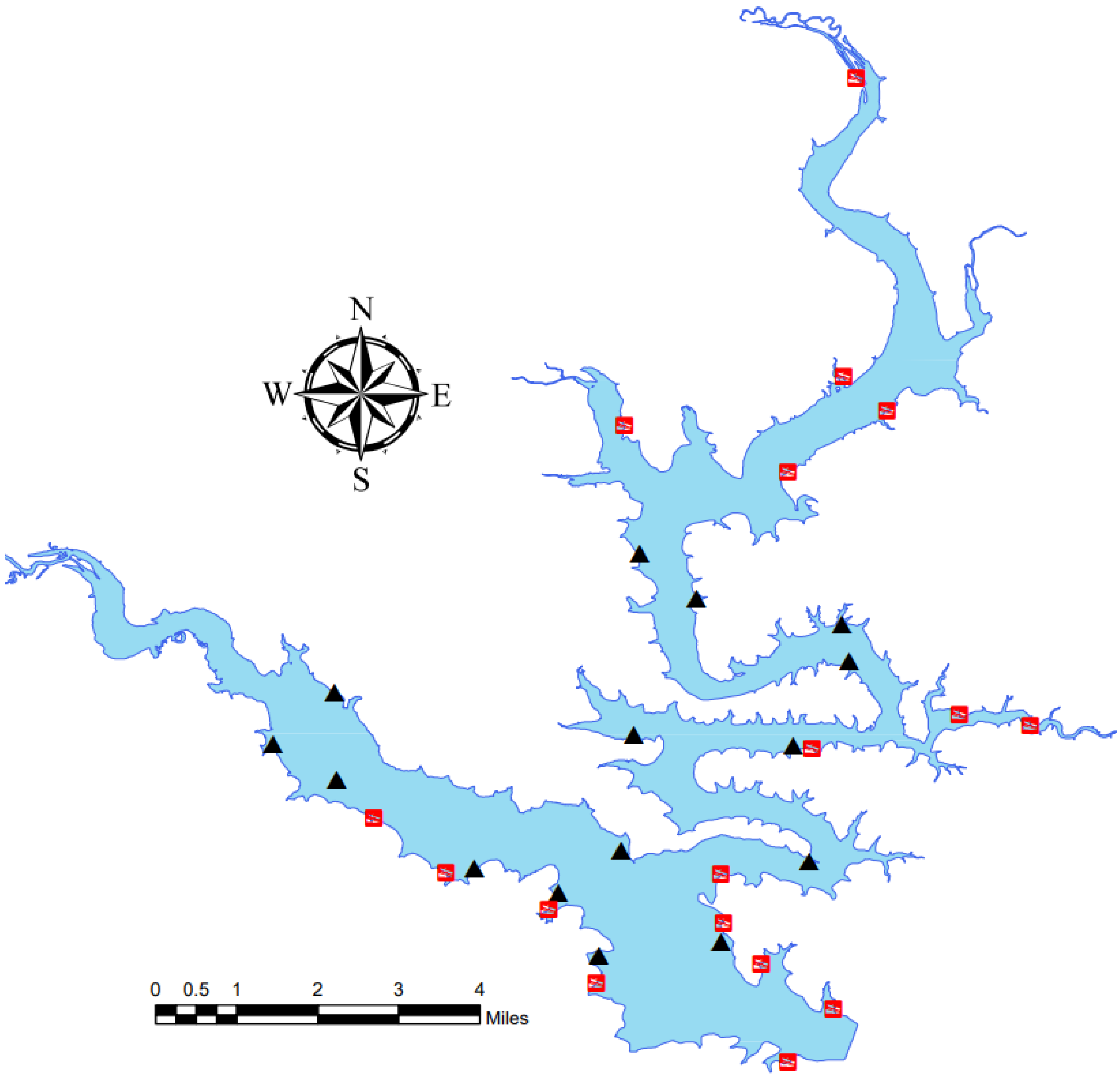
Catch rates (CPUE) of targeted species collected with electrofishing, trap netting and gill netting surveys on Belton Reservoir, Texas, 2002 (*1991 for White Crappie*) to present. Electrofishing stations were sampled with a 5.0 Smith-Root GPP (Gas Powered Pulsator) until 2010 and a 7.5 Smith-Root GPP thereafter. No electrofishing was conducted in fall 2018. Trap netting became an optional gear in 2009 and was no longer used on Belton Reservoir. Dashes represent no data available. Species averages are in bold.

	Electrofishing						
	2002	2006	2008	2010	2014	2018	Average
Gizzard Shad	221.5	56.5	29.5	191.5	30.5	--	**88.3**
Threadfin Shad	11.0	24.5	48.5	61.0	33.0	--	**29.7**
Bluegill	147.5	196.5	347.5	236.5	161.5	--	**181.6**
Redear	11.5	13.0	18.0	12.0	2.5	--	**9.5**
Longear	69.0	39.0	37.5	67.5	85.5	--	**49.8**
Green	79.0	23.5	30.0	110.0	100.0	--	**57.1**
Warmouth	1.0	1.5	1.0	2.5	0.5	--	**1.1**
Largemouth Bass	139.5	64.0	126.0	127.5	41.0	--	**83.0**
Smallmouth Bass	8.0	11.0	13.0	57.5	49.0	--	**23.1**
Spotted Bass	1.5	0.0	0.0	2.0	0.0	--	**0.6**

	Trap netting						
	1991	1993	1996	1999	2002	2006	
White Crappie	9.7	4.4	9.2	0.4	0.9	1.4	**4.3**

	Gill netting							
	2003	2007	2009	2011	2013	2015	2019	
Blue Catfish	1.1	1.7	3.6	3.1	3.1	2.3	10.9	**3.7**
Channel Catfish	1.9	2.9	2.1	3.9	1.4	1.3	1.7	**2.2**
Flathead Catfish	0.1	0.5	0.1	0.1	0.2	0.3	0.1	**0.2**
White Bass	2.8	4.2	0.7	4.3	6.7	6.7	2.2	**3.9**
Palmetto Bass	2.4	7.1	4.6	5.5	9.6	8.4	4.5	**6.0**
White Crappie	--	--	--	1.8	3.0	0.7	1.9	**1.2**

APPENDIX C – Map of sampling locations



Location of sampling sites, Belton Reservoir, Texas, 2018-2019. Gill netting stations are indicated by a triangle. Water level was approximately 15' above conservation pool during the scheduled electrofishing survey period and the reservoir was closed. Water level was 2' above conservation pool at time of gill netting.

APPENDIX D

Results from FAST modeling

Introduction
Recruitment, growth, total mortality, and maximum size are all important population statistics to have when managing a reservoir. We calculated these statistics from data collected during management surveys in 2010 (Largemouth Bass) 2014 and 2019 (Smallmouth Bass) and 2011, 2013, 2015 and 2019 (Hybrid Striped Bass) using Fishery Analysis and Simulation Tools (FAST, Slipke and Maceina, 2000).

Methods
Hybrid Striped Bass and Smallmouth Bass otoliths were collected using a stratified random approach in which up to five fish per centimeter group were selected for otolith removal from a pool of 141 and 268 fish respectively. Additional fish within each centimeter group were assigned ages using a length-age key. Hybrid Striped Bass were initially collected during standardized sampling. Additional Hybrid Striped Bass and all Smallmouth Bass were collected with supplementary sampling at non-random locations selected to maximize catch rates. Otoliths were collected and processed according to the Texas Parks and Wildlife Department Inland Fisheries Assessment Procedures (unpublished, revised manual 2009).

Total annual mortality, theoretical maximum age, L-infinity (theoretical maximum length), and residuals (year class strength) were calculated using FAST. Unweighted catch-curve regression was used to estimate total annual mortality, theoretical maximum age, and assess year class strength. For the purposes of this discussion, a strong year class was defined as having a residual $\geq$ .500 with that cohort represented by at least 5 fish in at least one sample. In addition, if the cohort was sampled in two or more years, it was considered a strong year class only if all the associated residuals were $\geq$ .500. The Von Bertalanffy growth function was used to determine L-infinity. In 2019, only data from age-1 through age-4 were used for Smallmouth Bass to calculate total annual mortality and theoretical maximum age because of possible gear bias for older fish described in the Texas Parks and Wildlife Department Inland Fisheries Assessment Procedures (unpublished, revised manual 2009). While this appears to differ from the 2014 collection that used Age-0 through Age-3, the 2019 fish were collected in February as opposed to the Fall in 2014, making them a year older but with little additional growth over the winter. Theoretical maximum length was not calculated for Smallmouth Bass because fish over 470 mm were released (N=6), the largest being 540 mm which was used as a surrogate for theoretical maximum length. Not including all fish data results in a very different and much lower estimate of theoretical maximum length. Only data from age-2 through age-9 were used for Hybrid Striped Bass because it was clear from the data that age-1 fish were not fully recruited to the sampling gear. Fish were not segregated by sex during the analyses. Creel data were collected according to the Texas Parks and Wildlife Department Inland Fisheries Assessment Procedures (unpublished, revised manual 2009). Estimates of harvest were determined from this information.

Results and Discussion
For reference, summary results for all age samples collected since 2010 are shown in Table A. This discussion focuses only on Smallmouth Bass and Hybrid Striped Bass for which there is new data.

The initial Smallmouth Bass age sample was collected in 2014 and exhibited a 48.8% mortality, with a maximum predicted size of 18.8” and age of 7.4 (Table A). The hypothesis of consistent recruitment was supported by un-weighted catch-curve regression ($p \leq 0.0002$), leading us to conclude that stocking did not affect year-class strength. When the number of Smallmouth Bass for each cohort were graphed against the number predicted and compared to stocking years and densities, this statistical finding was also visually observable (Figure A). The hypothesis was that this could reflect finite rearing habitat for Age-0 fish, possibly due to prolonged drought. Another sample was collected in 2019, which exhibited a 35.8% mortality rate, an observed maximum size of 21.25”, and an age of 10.0. The hypothesis of consistent recruitment was not supported by un-weighted catch-curve regression ($p \leq 0.39$), leading us to conclude that stocking, habitat, or some combination was affecting year-class strength. This statistical finding was also visually observable in Figure B where 2015 had a strong year-class whereas 2016 did not. These were both high-water years and the only difference was stocking in 2015. Stable water levels in 2017 resulted in a very strong year class despite no stocking. Table B contains additional information relevant to Figure A.

The results for Hybrid Striped Bass were very interesting. Total mortality calculated in the 2011, 2013, 2015 and 2019 gill net surveys ranged from 36.0% to 52.2% (Table A). Maximum size slowly declined over the four surveys, from 22.5” to 21.2”. Maximum age ranged from 7.1 to 9.7 years. The hypothesis of consistent recruitment was not supported by un-weighted catch-curve regression in the first three surveys (2011, $p \leq 0.15$; 2013, $p \leq 0.14$; 2015, $p \leq 0.21$), indicating that in those years stocking did influence year-class strength. However, in 2019, the hypothesis was supported ($p \leq 0.03$) suggesting that interactions between stocking and habitat were driving year-class strength. Two stocking regimes were tested from 2005 - 2014. Fingerlings at 10/acre and fry at 100/acre (Table 4 earlier in report). From 2015 – 2019 stocking was refined to a fry-only approach with 50 and 100/acre tested. Figure C graphically illustrates year-class strength using residuals calculated from the catch-curve regression. Compared to fingerling stockings, recruitment was higher for fry stockings in all years but 2015 and 2016. These two years were characterized by extremely high water and it was hypothesized that either low reservoir retention times resulted in emigration of stocked fry, or turbidity associated with high water events reduced forage availability for fry. Figures D, E, F and G and Tables E, F, G and H contain information from each gill-net survey.

Table A: Population parameters of Largemouth Bass, Smallmouth Bass, and Hybrid Striped Bass in Belton Reservoir, 2010-2019. Estimates were obtained using the Fast Modeling Program.

Species	N aged	Total Mortality	Harvest rate	Maximum size (L-infinity)	Maximum age	Sample year
Largemouth Bass	425	29.3%	3.48/acre	23.4”	14.6	2010
Smallmouth Bass	287	48.8%	0.37/acre	18.8”	7.4	2014
Smallmouth Bass	210	35.8%	n.a.	21.25”[1]	10.0	2019
Palmetto Bass	232	45.1%	1.48/acre	22.5”	9.5	2011
Palmetto Bass	133	52.2%	n.a.	22.5”	7.1	2013
Palmetto Bass	163	36.4%	0.65/acre	22.2”	9.2	2015
Hybrid Striped Bass*	103	36.0%	n.a.	21.2”	9.7	2019

[1] All Smallmouth Bass >18” were released (N=6). This number represents the largest individual caught.
[2] Comprised mostly of Palmetto Bass, but some Sunshine Bass were stocked in 2014 and 2016.

Figure A: Number of Smallmouth Bass collected by age in 2014. Diamonds represent actual numbers of fish collected by age, and the line represents the number of fish expected to be collected if recruitment remained constant across years. Squares represent numbers of Smallmouth Bass fingerlings stocked by year and reference the secondary vertical axis on the right.

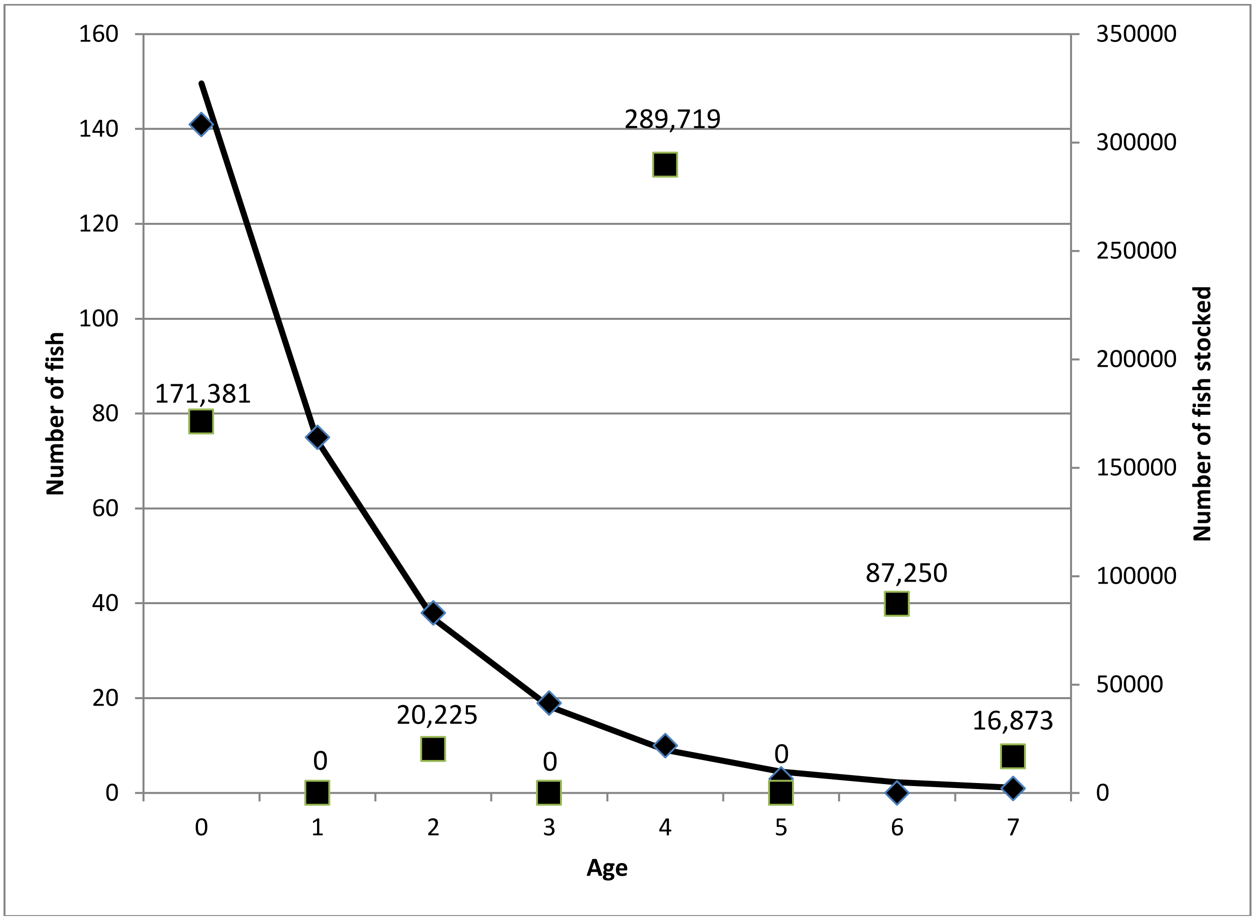


Table B: Number of Smallmouth Bass collected by age in 2014 with residuals calculated from linear regression (Fishery Analysis and Simulation Tools (FAST), Slipke and Maceina, 2000). A positive residual indicates a stronger than expected cohort, whereas a negative residual indicates a weaker than expected cohort, assuming equal recruitment across years.

Age	Number	Ln(Number)	Predicted Number	Predicted Ln(Number)	Residual
0	141	4.956	149.603	5.008	-0.052
1	75	4.331	74.183	4.307	0.024
2	38	3.664	36.785	3.605	0.058
3	19	2.996	18.24	2.904	0.092
4	10	2.398	9.045	2.202	0.196
5	3	1.386	4.485	1.501	-0.114
6	0	0	2.224	0.799	-0.799
7	1	0.693	1.103	0.098	0.595

Figure B: Number of Smallmouth Bass collected by age in 2019. Diamonds represent actual numbers of fish collected by age, and the line represents the number of fish expected to be collected if recruitment remained constant across years. Squares represent numbers of Smallmouth Bass fingerlings stocked by year and reference the secondary vertical axis on the right.

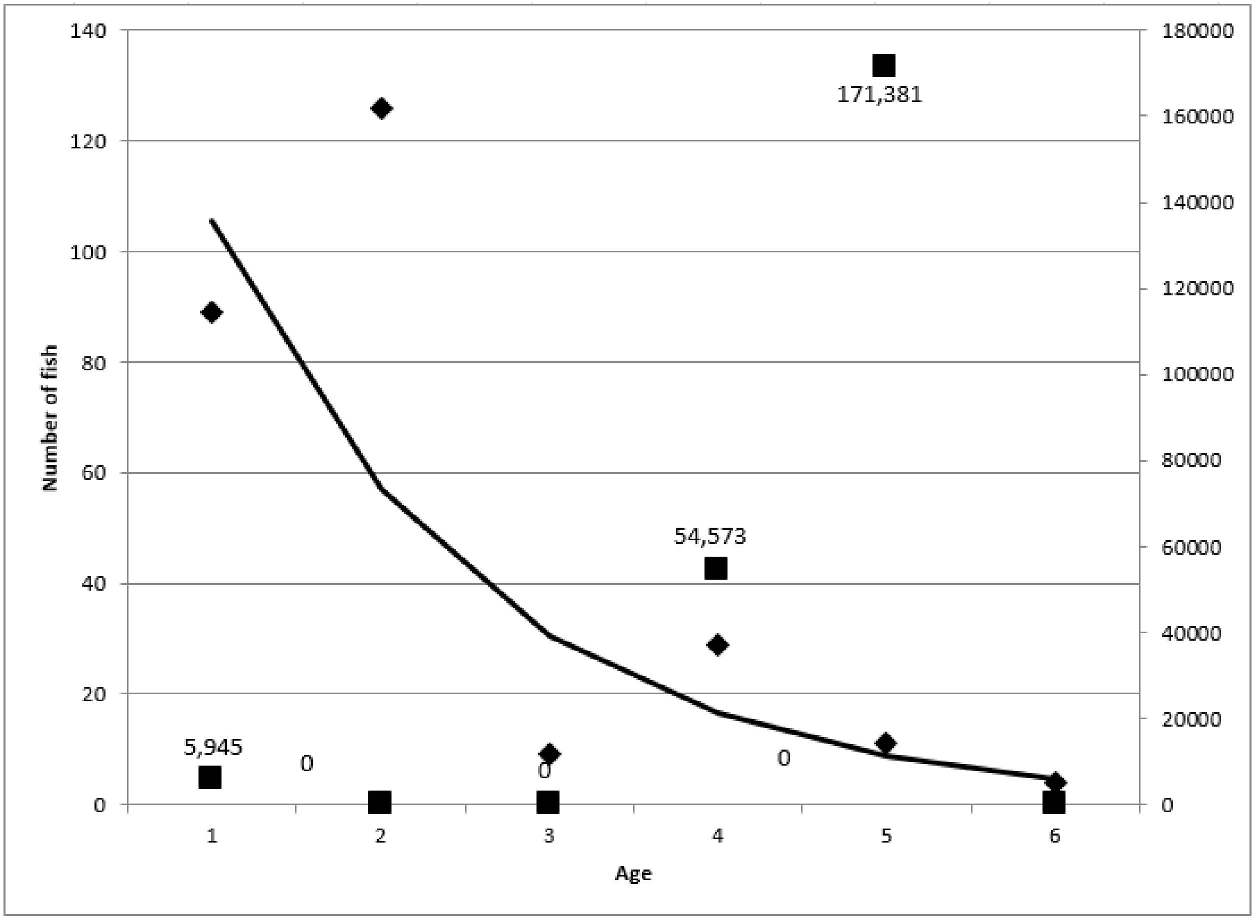


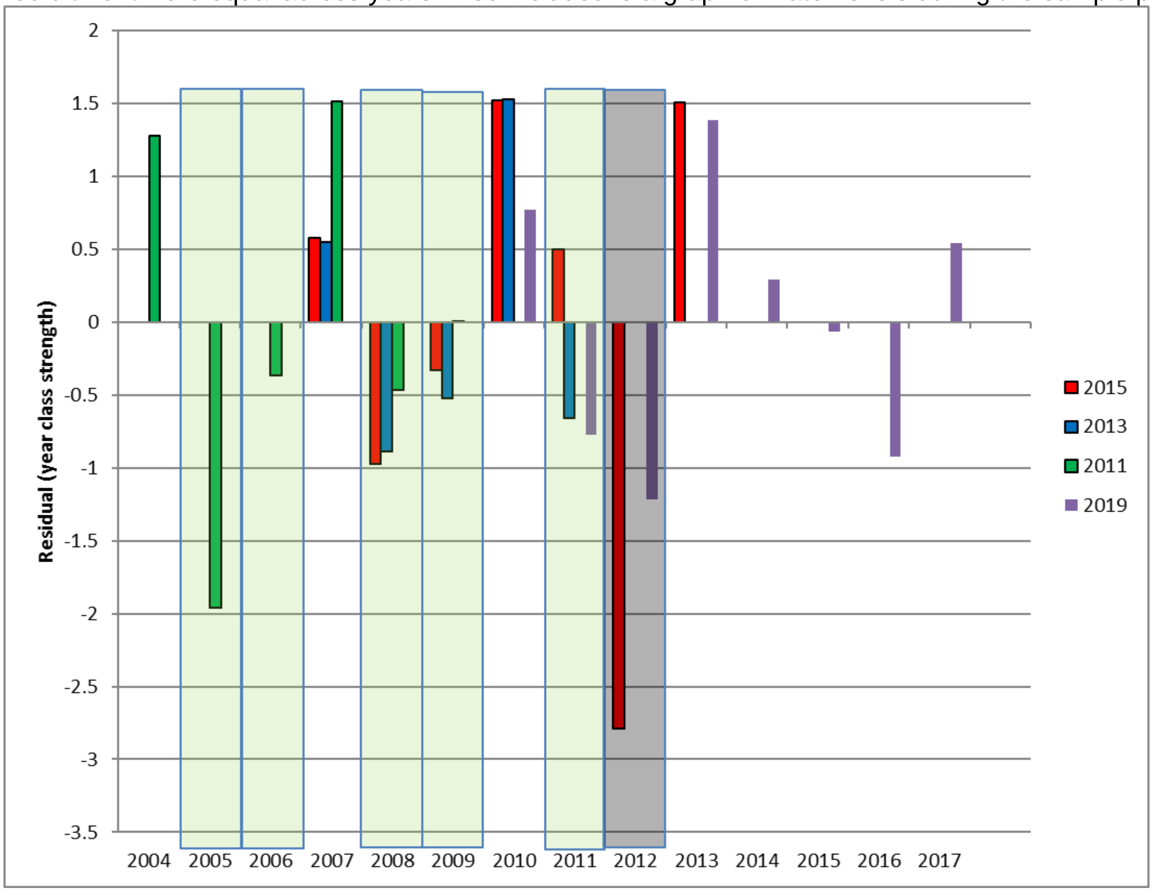
Table C: Number of Smallmouth Bass collected by age in 2019 with residuals calculated from linear regression (Fishery Analysis and Simulation Tools (FAST), Slipke and Maceina, 2000). A positive residual indicates a stronger than expected cohort, whereas a negative residual indicates a weaker than expected cohort, assuming equal recruitment across years.

Age	Number	Ln(Number)	Pred Number	Pred Ln(Number)	Residual
1	89	4.489	105.55	4.659	-0.171
2	126	4.836	56.85	4.04	0.796
3	9	2.197	30.62	3.422	-1.224
4	29	3.367	16.492	2.803	0.564
5	11	2.398	8.883	2.184	0.214
6	4	1.386	4.784	1.565	-0.179

Table D. Number of Smallmouth Bass caught per inch group, Belton Reservoir, Texas, 2019. This collection was designed to collect aging structures, so effort was not quantified.

Inch Class	Number of Fish
4	25
5	28
6	26
7	10
8	19
9	34
10	37
11	21
12	10
13	10
14	6
15	10
16	18
17	8
18	3
19	2
20	0
21	1

Figure C: Residuals from four Hybrid Striped Bass gill netting surveys (vertical bars) plotted on years when each cohort was produced. Green shaded areas indicate years where only fingerlings were stocked. Grey shaded areas indicate a year where none were stocked. Unshaded areas represent when fry were stocked. Bars of different colors are from different surveys (green = 2011, blue = 2013, red = 2015, purple = 2019). Positive residuals indicate stronger year classes than would be expected if recruitment were equal across years. Also included is a graph of water levels during the sample period.



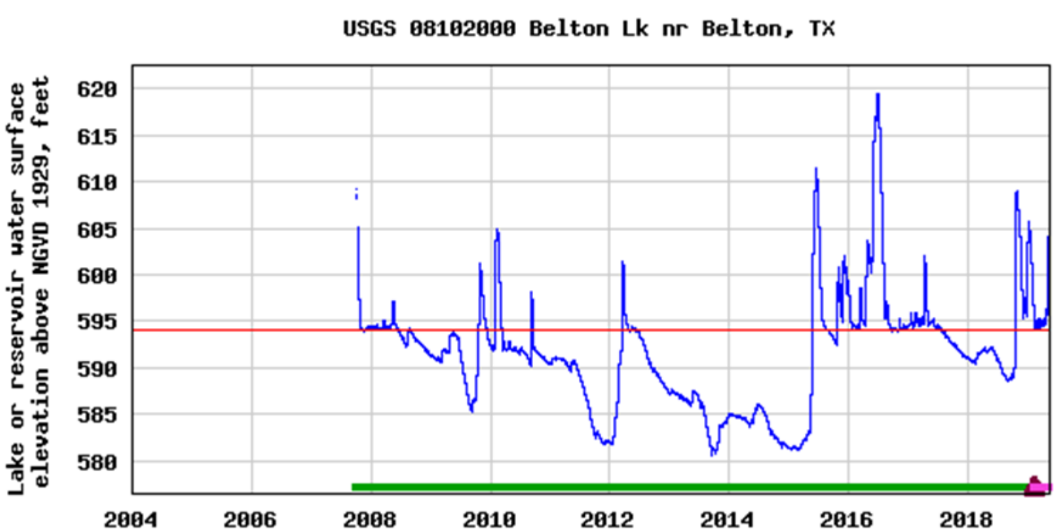


Figure D: Number of Palmetto Bass collected by age in 2011. Diamonds represent actual numbers of fish collected by age, and the line represents the number of fish expected to be collected if recruitment remained constant across years. Fry = fry stocking; Fgl = fingerling stocking; Fry/Fgl = both fry and fingerling stocked.

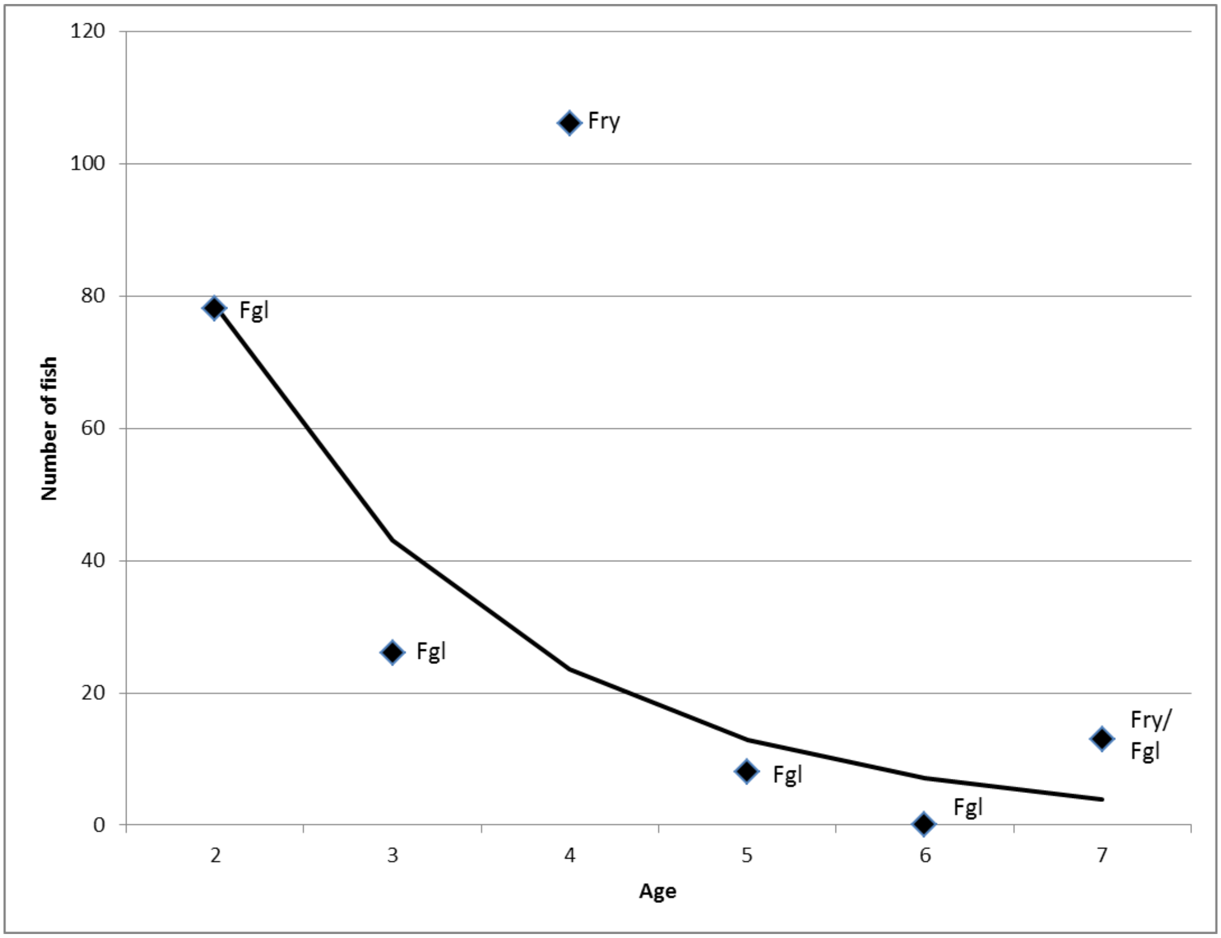


Table E: Number of Palmetto Bass collected by age in 2011 with residuals calculated from linear regression (Fishery Analysis and Simulation Tools (FAST), Slipke and Maceina, 2000). A positive residual indicates a stronger than expected cohort, whereas a negative residual indicates a weaker than expected cohort, assuming equal recruitment across years.

Age	Number	Ln(Number)	Predicted Number	Predicted Ln(Number)	Residual
2	78	4.369	78.53	4.363	0.006
3	26	3.296	43.079	3.763	-0.467
4	106	4.673	23.632	3.163	1.51
5	8	2.197	12.964	2.562	-0.365
6	0	0	7.112	1.962	-1.962
7	13	2.639	3.901	1.361	1.278

Figure E: Number of Palmetto Bass collected by age in 2013. Diamonds represent actual numbers of fish collected by age, and the line represents the number of fish expected to be collected if recruitment remained constant across years. Fry = fry stocking; Fgl = fingerling stocking.

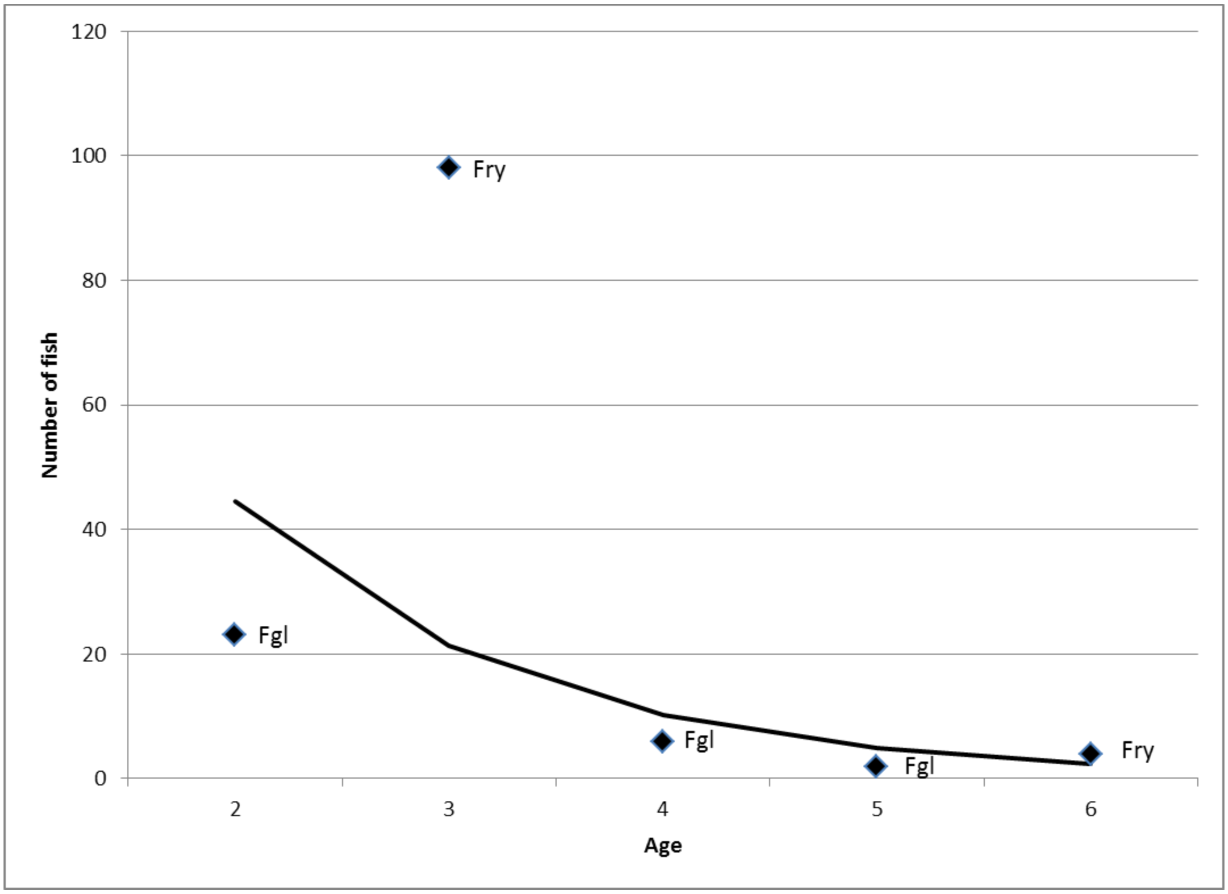


Table F: Number of Palmetto Bass collected by age in 2013 with residuals calculated from linear regression (Fishery Analysis and Simulation Tools (FAST), Slipke and Maceina, 2000). A positive residual indicates a stronger than expected cohort, whereas a negative residual indicates a weaker than expected cohort, assuming equal recruitment across years.

Age	Number	Ln(Number)	Predicted Number	Predicted Ln(Number)	Residual
2	23	3.135	44.54	3.796	-0.661
3	98	4.585	21.271	3.057	1.528
4	6	1.792	10.159	2.318	-0.527
5	2	0.693	4.852	1.579	-0.886
6	4	1.386	2.317	0.84	0.546

Figure F: Number of Palmetto Bass collected by age in 2015. Diamonds represent actual numbers of fish collected by age, and the line represents the number of fish expected to be collected if recruitment remained constant across years. Fry = fry stocking; Fgl = fingerling stocking; No stk = no stocking.

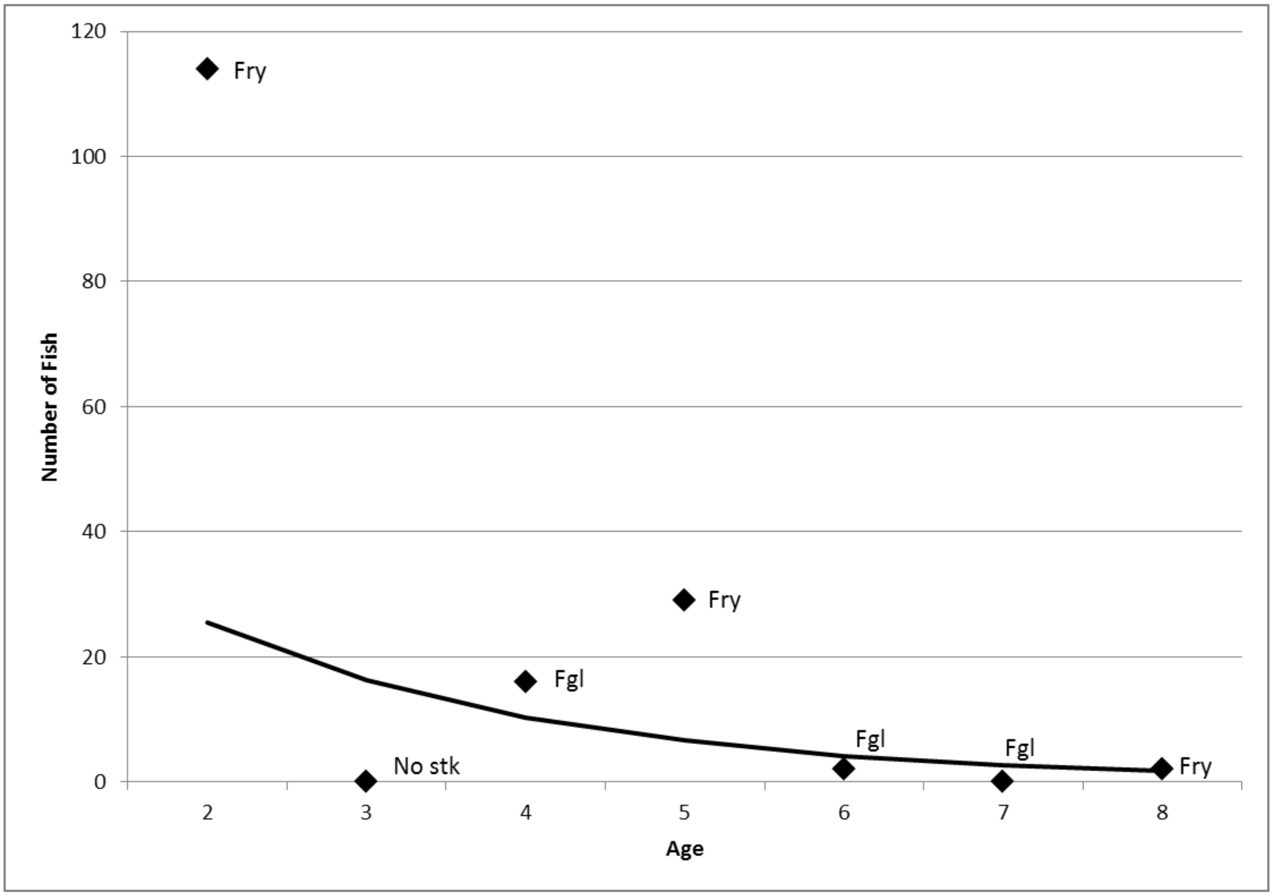


Table G: Number of Palmetto Bass collected by age in 2015 with residuals calculated from linear regression (Fishery Analysis and Simulation Tools (FAST), Slipke and Maceina, 2000). A positive residual indicates a stronger than expected cohort, whereas a negative residual indicates a weaker than expected cohort, assuming equal recruitment across years.

Age	Number	Ln(Number)	Predicted Number	Predicted Ln(Number)	Residual
2	114	4.745	25.54	3.24	1.505
3	0	0	16.242	2.788	-2.788
4	16	2.833	10.329	2.335	0.498
5	29	3.401	6.569	1.882	1.519
6	2	1.099	4.178	1.43	-0.331
7	0	0	2.657	0.977	-0.977
8	2	1.099	1.69	0.524	0.574

Figure G: Number of Hybrid Striped Bass collected by age in 2019. Diamonds represent actual numbers of fish collected by age, and the line represents the number of fish expected to be collected if recruitment remained constant across years. Fry = fry stocking; Fgl = fingerling stocking; No stk = no stocking.

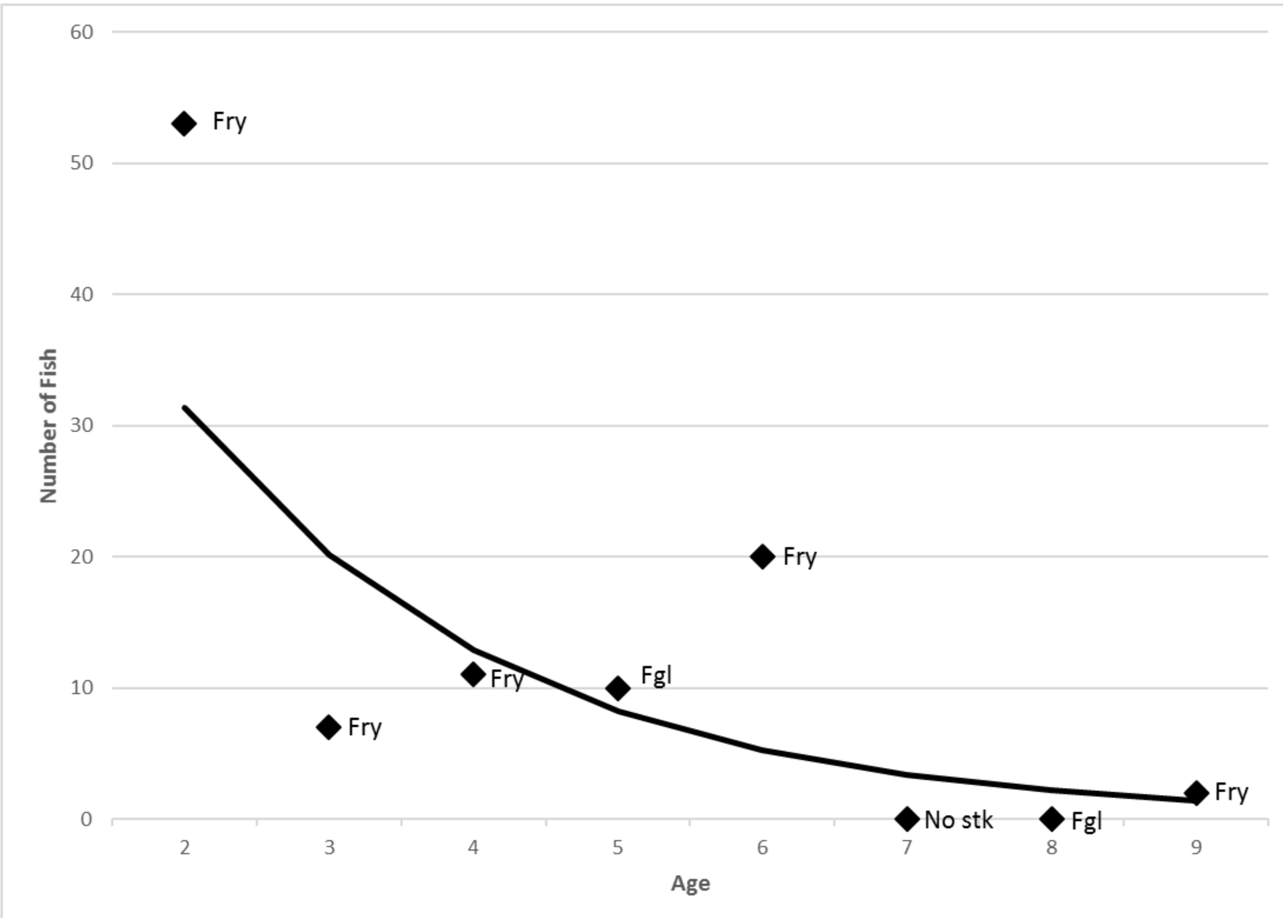


Table H: Number of Hybrid Striped Bass collected by age in 2019 with residuals calculated from linear regression (Fishery Analysis and Simulation Tools (FAST), Slipke and Maceina, 2000). A positive residual indicates a stronger than expected cohort, whereas a negative residual indicates a weaker than expected cohort, assuming equal recruitment across years.

Age	Number	Ln(Number)	Predicted Number	Predicted Ln(Number)	Residual
2	53	3.989	31.397	3.447	0.542
3	7	2.079	20.106	3.001	-0.922
4	11	2.485	12.876	2.555	-0.07
5	10	2.398	8.245	2.11	0.288
6	20	3.045	5.28	1.664	1.381
7	0	0	3.381	1.218	-1.218
8	0	0	2.165	0.773	-0.773
9	2	1.099	1.387	0.327	0.772