PERFORMANCE REPORT

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FEDERAL AID IN SPORT FISH RESTORATION ACT

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FEDERAL AID PROJECT F-30-R-33

STATEWIDE FRESHWATER FISHERIES MONITORING AND MANAGEMENT PROGRAM

2007 Survey Report

Waco Reservoir

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TABLE OF CONTENTS

SURVEY AND MANAGEMENT SUMMARY

Fish populations in Waco Reservoir were surveyed in 2007 using electrofishing and trap nets and in 2008 using gill nets. Anglers were surveyed from June 2007 to May 2008 with a creel. 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 supplied by the North, Middle, and South Bosque Rivers within the Brazos River Basin, McLennan County. Water levels decreased steadily from 2005 through 2006, then peaked 25 feet above conservation pool in the first half of 2007. Shoreline fish habitat was dominated by standing timber, rocky shoreline, inundated stumps, and riprap. Bank and boat access (10 ramps) on the reservoir is good, but there are currently no handicap-specific facilities available.

- **Management history:** Important sport fish include largemouth bass, white bass, white crappie, and catfish. The management plan from the 2004 survey report included an evaluation of pre and post pool rise fishery and economic creel data, and plans to work with the U.S. Army Corps of Engineers on constructing a fishing pier for handicap and bank anglers.

- **Fish Community**
  - **Prey species:** The abundance of forage species such as threadfin shad, gizzard shad, bluegill, and redear sunfish was near or exceeding record catch rates for the reservoir. Many good sized sunfishes were collected.

  - **Catfishes:** The blue catfish population continues to grow with many fish in the quality and preferred size classes. Channel catfish are also holding strong with good body conditions. Almost 25% of all anglers at Waco Reservoir fished for some species of catfish.

  - **White bass:** White bass were present in the reservoir in low numbers. White bass accounted for 11.5% of the fishing effort in the reservoir.

  - **Largemouth bass:** Largemouth bass were collected at higher rates than ever before, and body condition was excellent. Over 40% of all anglers at Waco Reservoir fished for largemouth bass, making it the most popular species to fish for in the reservoir.

  - **White crappie:** White crappie were collected at higher rates than ever before, and body condition was excellent. Crappie accounted for 12.1% of the fishing effort in the reservoir.

- **Management Strategies:** Continue managing Waco Reservoir with statewide regulations. Conduct general monitoring with electrofisher and trap nets in 2011 and gill nets in 2012. Also, perform a new littoral habitat survey prior to the 2012 report.

INTRODUCTION

This document is a summary of fisheries data collected from Waco Reservoir in 2007-2008. The purpose of the document is to provide fisheries information and make management recommendations to protect and improve the sport fishery. While information on other species of fishes was collected, this report deals primarily with major sport fishes and important prey species. Historical data are presented with the 2007-2008 data for comparison.

Reservoir Description

Waco Reservoir is a 8,465-acre impoundment supplied by 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 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. The current conservation pool is 462 feet above mean sea level, and water levels were at or near this during the time of sampling (Figure 1). Shoreline fish habitat was dominated by standing timber, rocky shoreline, inundated stumps, and riprap; other descriptive characteristics for Waco Reservoir are in Table 1. Hydrilla, a non-native, was first documented in the reservoir in 2003, but has not been observed since the high water levels of 2007. Bank and boat access (10 ramps) on the reservoir is good, but there are currently no handicap-specific facilities. More information about Waco Reservoir and its facilities can be obtained by visiting the Texas Parks and Wildlife Department's web site at www.tpwd.state.tx.us and navigating within the fishing link.

Management History

Previous management strategies and actions: Management strategies and actions from the previous survey report (Tibbs and Baird 2004) included:

1. Evaluating pre and post pool rise fishery and economic creel data.
   Action: Fishery and economic creel surveys were conducted to establish baseline data for Waco Reservoir prior to the permanent 7-ft rise in conservation pool. Post-rise fishery and economic creel data were collected in 2007and 2008. This report will evaluate effects on the fishery, results of angler opinion, as well as any economic benefit(s) to the surrounding community.
2. Working with the U.S. Army Corps of Engineers on constructing a fishing pier for handicap and bank anglers.
   Action: A survey was performed in 2005 to identify optimal locations for the construction of fishing piers which handicapped and bank anglers could access. These locations were discussed with the U.S. Army Corps of Engineers, and construction began on two of the three identified sites in 2006. The piers were only partially constructed when reservoir levels reached 25 feet above conservation pool in 2007, and damage from the high water left the piers structurally unsafe. Plans to rebuild one or both piers are currently in the works.

Harvest regulation history: Sportfishes in Waco Reservoir are currently managed with statewide regulations (Table 2).

Stocking history: Waco Reservoir was stocked with 131,621 blue catfish and 143,249 Florida largemouth bass in 2004. No additional stockings have taken place to date. The complete stocking history is in Table 3.

Vegetation/habitat history: Historical vegetation surveys reported only a few species of native vegetation including American lotus, Black Willow, Buttonbush, Cattail, Spatterdock, and Water Willow. In 1998, TPWD and the Lewisville Aquatic Ecosystem Research Facility (LAERF) began an aquatic habitat

enhancement initiative to establish native species of vegetation throughout the reservoir. Founder colonies of native species were initially planted in protected coves, and began spreading beyond their enclosures by 2001. In 2003, more than 75 acres of *new* native species were reported. In the fall of 2003 several small areas of hydrilla (*Hydrilla verticillata*) were also observed by TPWD; however the late season discovery prevented any controlling action.

The seven-foot pool rise slated to begin in October 2003 was complete almost immediately after it began. By the end of the month the new conservation pool was surpassed due to heavy rains within the drainage. No Hydrilla was observed during 2004 following the pool rise and native vegetation was once-again reduced to remnant populations of water willow, several floating-leaved species, and wild celery.

Native vegetation had recovered some by the end of 2005, and consisted mainly of southern naiad. The small areas of Hydrilla discovered in 2003 expanded to approximately nine acres in 2005 and 73 acres in 2006. The main areas of infestation included Twin Bridges Park, Speegleville Park, Airport Park, and Reynolds Creek. Hydrilla in the Speegleville Park and Twin Bridges Park areas was treated with *Nautique* on two occasions during the summer of 2006 by City of Waco officials, however high densities of hydrilla remained until the end of the year when colder weather and cool water temperatures stifled growth. High water levels in 2007 eliminated all visible signs of hydrilla to date, but undoubtedly it will return at some level within the year.

METHODS

Fishes were collected by electrofishing (1.5 hours at 18 5-min stations), gill netting (10 net nights at 10 stations), and trap netting (30 net nights at 30 stations). Catch per unit effort (CPUE) for electrofishing was recorded as the number of fish caught per hour (fish/h) of actual electrofishing and, for gill and trap nets, as the number of fish per net night (fish/nn). All survey sites were randomly selected and all surveys were conducted according to the Fishery Assessment Procedures (TPWD, Inland Fisheries Division, unpublished manual revised 2002). Additional sampling for day vs. night electrofishing comparisons as well as additional age information for largemouth bass was completed as described in Appendix D. Additional electrofishing for white bass was completed in the North and South Bosque Rivers during spawning season to collect additional age information, since gill net catch rates were too low to accomplish that goal.

Sampling statistics (CPUE for various length categories), structural indices [Proportional Stock Density (PSD), Relative Stock Density (RSD)], and condition indices [relative weight (Wr)] were calculated for target fishes according to Anderson and Neumann (1996). Index of vulnerability (IOV) was calculated for gizzard shad (DiCenzo et al. 1996). Relative standard error (RSE = 100 X SE of the estimate/estimate) was calculated for all CPUE statistics and for creel statistics and SE was calculated for structural indices and IOV. Ages were determined using otoliths from up to 10 fish per centimeter group for largemouth bass, white crappie, and white bass. Source for water level data was the United States Geological Survey (USGS) website.

RESULTS AND DISCUSSION

Habitat: Littoral zone habitat consisted primarily of standing timber, rocky shoreline, inundated stumps, and riprap (Table 4). A habitat survey was last conducted in 1997 (Mitchell 1997).

Creel: Directed fishing effort by anglers was highest for largemouth bass (41.3%), followed by anglers fishing for catfish spp., blue catfish, channel catfish, and flathead catfish combined (23.2%), crappie spp. and white crappie combined (12.1%) and white bass (11.5%, Table 5). Total fishing effort for all species at Waco Reservoir was 172,295 h from June 2007 to May 2008, which is much higher than the previous creel before the pool rise from June 2001 to May 2002, during which the total fishing effort was 70,847 hours. Bank anglers comprised 29% of the total fishing effort in ’07-’08 which was an increase over ’01-

’02 when bank anglers comprised 21.4% of the total fishng effort. Anglers spent an estimated $789,984 on direct expenditures in ’07-‘08, compared to $66,091 in ’01-’02. Of those expenditures, 15.9% was from bank anglers in ’07-’08, down from 20.2% in ’01-’02. This is likely attributable to the increased tournament activity on the lake which generates higher levels of revenue per angler than traditional anglers. None-the-less, fishing effort and expenditures by bank anglers is significant, and current levels of bank access should be maintained or increased.

Anglers were also questioned as to whether or not they thought an additional sportfish species not already present in the reservoir should be stocked, and if so, which one? Over the course of the survey, 55.6% (N= 340) wished to stock an additional sportfish species, whereas 44.4% (N = 271) were happy with the species present in the reservoir (Total N = 611). By far, the most requested sportfish species was hybrid striped bass, with 40.3% of “yes” respondents asking for this species (Table 7). Add to that the second most popular species, striped bass (17.4%), and fully 57.7% of the “yes” responses and 32.1% of all the responses were for a large Morone spp. Rounding out the top five species were smallmouth bass (16.5%), redfish (8.0%), and walleye (5.3%). It is important to note that a significant portion of the “no” respondents specifically commented that they did not wish to see striped bass and/or hybrid striped bass stocked in the reservoir. Unfortunately, this negative response was not quantified. This dichotomy of “pro-striper” and “anti-striper” anglers is a common theme echoed throughout Texas, and any efforts to stock hybrid striped bass or striped bass will likely be met with strong opinions from the public.

Prey species: The electrofishing catch rates of threadfin and gizzard shad were 174.0/h and 614.0/h, and far exceeded those from the previous two surveys (Figure 2). Index of vulnerability (IOV) for gizzard shad was excellent, and 91% of gizzard shad were available to existing predators as forage. Bluegill catch rates remained excellent at 314.0/h, similar to the 2005 (239.0/h) and 2003 (314.0/h) surveys (Figure 3). Bluegill populations had individuals in the 6 to 8-inch classes, thus providing good pan-fishing for anglers. Other forage species collected were longear sunfish (99.0/h), redear sunfish (23.0/h), warmouth (3.0/h), and green sunfish (2.0/h).

Catfishes: The blue catfish population continues to grow with catch rates of 5.3/nn in 2008. Proportional stock densities have increased over the past three surveys; 22 in 2004, 46 in 2006, and 58 in 2008 – indicating increasing numbers of quality-sized fish and larger in the population. Body conditions ranged from average to excellent (range 80 to 107, Figure 4). The channel catfish population was abundant with a catch rate of 7.5/nn in 2008. Recruitment and population size structure was excellent (PSD = 36) and body condition was good (range 87 to 105, Figure 6). No age and growth work was done on blue or channel catfish during this survey period. Directed fishing effort, catch per hour, and total catch for all catfish showed a thriving catfish fishery (Tables 5,8-10).

White bass: The gill net catch rate of white bass was 0.9/nn in 2008. Catch rates indicated that white bass continue to be present in the reservoir in low density (Figure 8). Sixty-seven percent of the population was 12-inches in length or greater. Growth of white bass was excellent with fish reaching 10 inches in the first year (Figure 10, Table 12) Directed fishing effort, catch per hour, and total harvest for white bass was 19,799 h, 1.88 fish/h, and 29,245 fish, respectively, from June 2007 through May 2008 (Table 11).

Largemouth bass: The electrofishing catch rate of largemouth bass was 420.7/h in 2007, the highest it’s ever been. Size structure was poor as the PSD was only 18, down from 32 and 34 in 2003 and 2005 respectively (Figure 11), although this difference is likely attributable to a strong year class in 2007. Growth of largemouth bass was good with fish reaching 14 inches in 2—3 years (Figure 12, Table 9). Body condition in 2007 was good (relative weight greater than 90) for all size classes of fish and was similar to body condition in previous surveys (Figure 11). Directed fishing effort, catch per hour, and total harvest for largemouth bass was 71,199 h, 1.54 fish/h, and 12,642 fish, respectively, from June 2007 through May 2008 (Table 13). Most legal largemouth bass were released, averaging 94.3% regardless of size. Florida largemouth bass influence has remained relatively constant as Florida alleles were estimated at 46.5% in 2006 (Table 15).

White crappie: The trap net catch rate of white crappie was 14.8/nn in 2007, also the highest they have ever been. The PSD was 55, similar to the PSD in 2005, and indicated a balanced population (Figure 14). Relative weights were good to excellent for all size classes (range 90 to 104, Figure 12). Many white crappie reached 10 inches in length by age 1, and nearly all were legal size by age 2 (Figure 16, Table 17) Crappie angling remains a popular and productive pastime on the reservoir, as evidenced by the data in Table 5.

Fisheries management plan for Waco Reservoir, Texas

Prepared – July 2008.

ISSUE 1: Although Hydrilla has not been observed in the reservoir since before the high water levels of 2007, there is a good chance it will return and continue to spread.

MANAGEMENT STRATEGIES

1. Continue monitoring the reservoir for noxious vegetation annually through 2011.
2. Work with the U.S. Army Corps of Engineers, the City of Waco, and private marinas on Waco Reservoir to manage exotic vegetation and complete an exotic vegetation management plan before the 2009 growing season.

ISSUE 2: There are currently no fishing piers available to handicap and bank anglers on Waco reservoir, despite the fact that bank anglers comprised 29% of the angling effort and contributed 15.9% of expenditures in the '07-'08 creel.

MANAGEMENT STRATEGIES

1. Continue working with the U.S. Army Corps of Engineers to facilitate the placement and design of one or two new fishing piers.
2. Organize the placement of new fish habitat around the pier(s) once built.

ISSUE 3: The blue catfish population has come on very strong since they were first collected in 2004. Although not detected in our angler survey, anecdotal evidence from anglers indicates heavy exploitation of large blue catfish by jugliners during winter months. Recent reservoir studies by the City of Waco point to a need to increase top predators in an attempt to improve water quality.

MANAGEMENT STRATEGY

1. Propose a 30" to 45" slot length limit with only one over 45" to protect large blue catfish.
2. If the regulation is implemented, survey other states with trophy blue catfish regulations to determine how best to evaluate success. Proceed with evaluation as needed.
3. Work with the City of Waco, Baylor University, and other stakeholders to quantify possible improvements in water quality that could be attributed to increased numbers of large blue catfish.

ISSUE 4: The most recent habitat survey on file for Waco reservoir is dated 1996.

MANAGEMENT STRATEGY

1. Conduct and map a thorough habitat/vegetation survey prior to 2012.

SAMPLING SCHEDULE JUSTIFICATION:

The proposed sampling schedule includes electrofisher and trap net sampling in 2011 and gill net sampling in 2012 (Table 18). This may be modified if the blue catfish regulation is approved.

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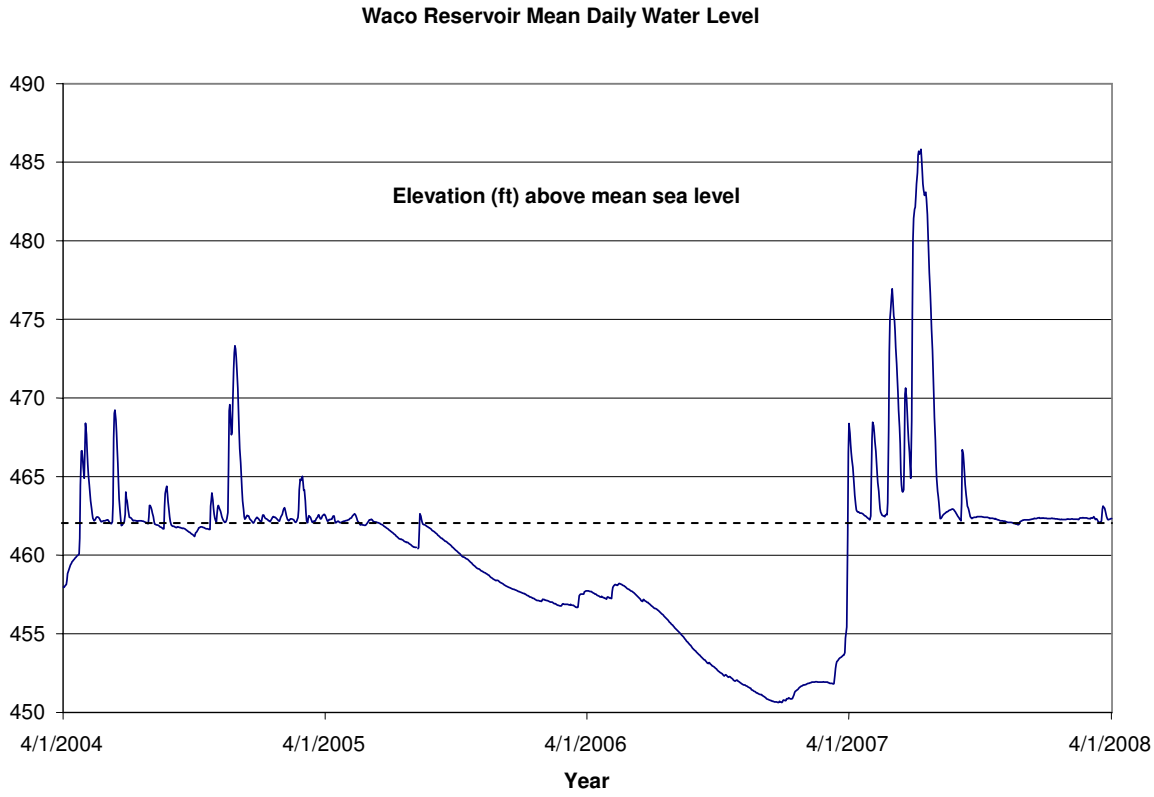


Figure 1. Quarterly water level elevations in feet above mean sea level (MSL) recorded for Waco Reservoir, Texas. Dashed line represents conservation pool.

Table 1. Characteristics of Waco Reservoir, Texas.

Characteristic	Description
Year Constructed	1965
Controlling authority	U.S. Army Corps of Engineers
County	McLennan
Reservoir type	Tributary of the Brazos River
Shoreline Development Index (SDI)	5.0
Conductivity	325 umhos/cm

Table 2. Harvest regulations for Waco Reservoir.

Species	Bag Limit	Minimum-Maximum Length (inches)
Catfish: channel and blue catfish, their hybrids and subspecies	25 (in any combination)	12 - No Limit
Catfish, flathead	5	18 - No Limit
Bass, white	25	10 - No Limit
Bass: largemouth	5	14 - No Limit
Bass: spotted*	5 (in any combination)	No Limit - No Limit
Crappie: white and black crappie, their hybrids and subspecies	25 (in any combination)	10 - No Limit

*On September 1, 2001 the minimum length limit changed from 12 inches to no minimum. The combined bag limit for largemouth and spotted bass is 5 fish per day.

Table 3. Stocking history of Waco, 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
	Total	543,496		
Largemouth bass	1971	400,000	FRY	0.7
	Total	400,000		
Palmetto bass (striped X white bass hybrid)	1975	72,233	UNK	UNK
	1977	73,121	UNK	UNK
	1979	65,700	UNK	UNK
	Total	211,054		
Striped bass	1983	72,300	UNK	UNK
	1995	116,260	FGL	1.3
	1996	80,768	FGL	1.3
	Total	269,328		
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

Species	Year	Number	Life Stage	Mean TL (in)
	Total	1,643,500		

Table 4. Survey of littoral zone and physical habitat types, Waco Reservoir, Texas, 1996. A linear shoreline distance (miles) was recorded for each habitat type found. Surface area (acres) and percent of reservoir surface area was determined for each type of aquatic vegetation found.

Shoreline habitat type	Shoreline distance	
	Miles	Percent of total
Riprap	4.0	6.7
Cut bank	1.0	1.7
Dead trees, stumps	12.0	20.0
Eroded bank	1.0	1.7
Featureless	2.0	3.3
Overhanging brush	5.0	8.3
Rock or gravel	35.0	58.3

Table 5. Percent directed angler effort, directed catch per hour, and total catch for all anglers by species for Waco Reservoir, Texas, June 1, 2001 – May. 31, 2002 and June 1, 2007 – May 31, 2008.

Species	Percent directed effort		Directed catch per hour		Total catch	
Year	2001-02	2007-08	2001-02	2007-08	2001-02	2007-08
Blue catfish	0.0	2.8	0.0	0.1	2,065	4,900
Channel catfish	6.7	0.9	0.4	0.4	6,386	11,556
Flathead catfish	0.7	0.2	0.5	0.0	246	0.0
Catfish spp.	18.0	19.3	1.1	0.5	0.0	19,720
White bass	7.1	11.5	13.0	1.9	12,714	29,245
Bluegill	0.0	0.1	0.0	3.0	277	1,961
Panfish spp.	0.0	1.3	0.0	4.0	0.0	10,379
Largemouth bass	30.9	41.3	1.5	1.5	4,453	12,642
White crappie	20.1	1.8	1.6	2.0	15,656	9,217
Crappie spp.	0.0	10.3	0.0	0.5	0.0	19,720
Anything	16.3	10.5	1.1	0.4	0.0	0.0

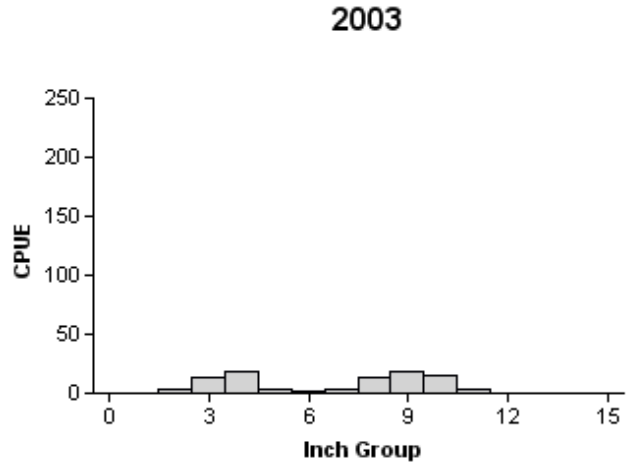
Table 6. Total fishing effort (h) for all species and total directed expenditures at Waco Reservoir, Texas, 2001- 2008.

Creel Statistic	Year	
	2001-2002	2007-2008
Total fishing effort (hours)	70,847	172,294
Total directed expenditures	66,091	789,984

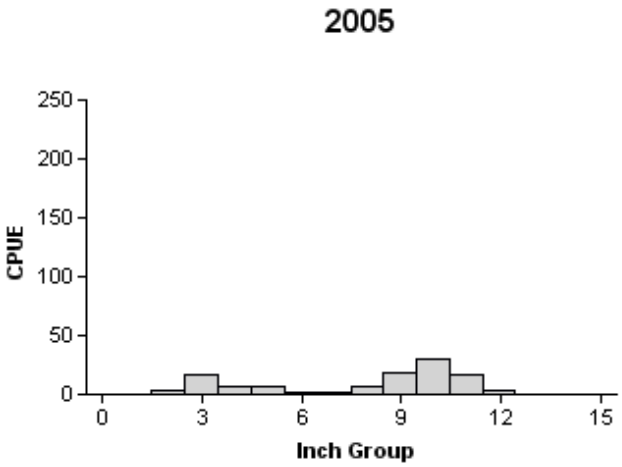
Table 7. Angler opinions on stocking an additional sportfish species not already present in Waco Reservoir, Texas, 2007-2008. Total number of anglers interviewed was 611, with 271, or 44.4% of anglers not wishing to stock an additional species and 340 or 55.6% of anglers requesting an additional species.

Species	Responses	Percent
Hybrid striped bass	137	40.3%
Striped bass	59	17.4%
Smallmouth bass	56	16.5%
Redfish	27	8.0%
No opinion	27	8.0%
Walleye	18	5.3%
Other	16	4.7%
Total	340	100%

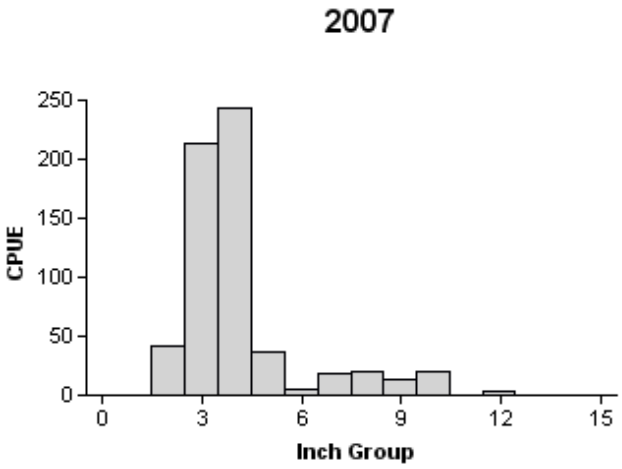
Gizzard Shad



Effort = 1.5
Total CPUE = 91.3 (26; 137)
Stock CPUE = 53.3 (25; 80)
IOV = 45.26 (10.2)



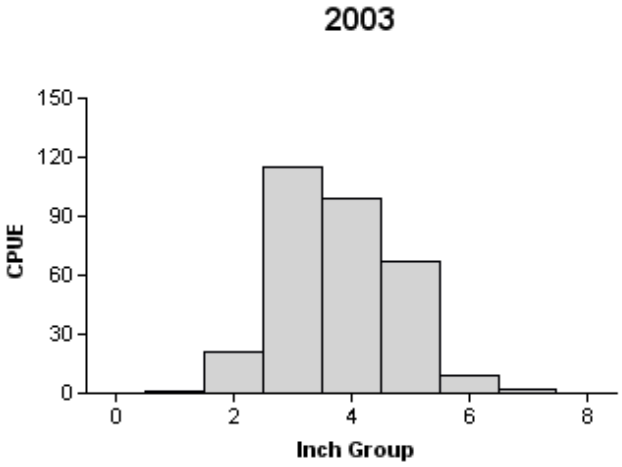
Effort = 1.5
Total CPUE = 110.0 (24; 165)
Stock CPUE = 75.3 (22; 113)
IOV = 33.33 (12.9)



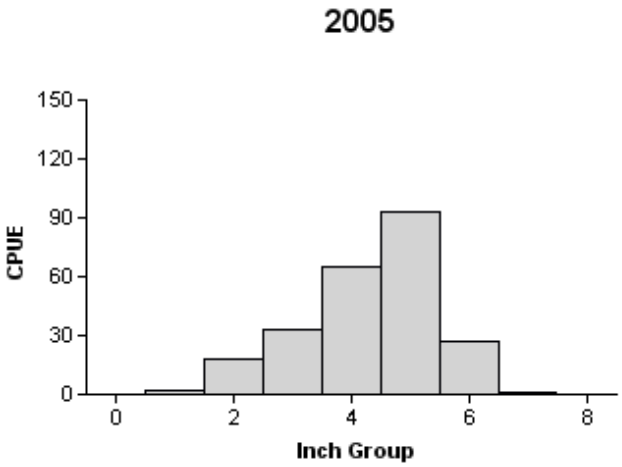
Effort = 1.5
Total CPUE = 614.0 (28; 921)
Stock CPUE = 74.0 (14; 111)
IOV = 90.99 (2.7)

Figure 2. Number of gizzard shad caught per hour (CPUE) and population indices (RSE and N for CPUE and SE for IOV are in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2003, 2005, and 2007.

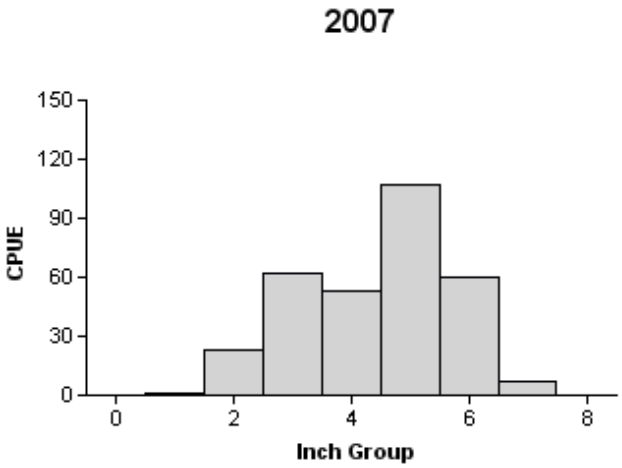
Bluegill



Effort = 1.5
Total CPUE = 314.7 (16; 472)
Stock CPUE = 292.7 (16; 439)
PSD = 4 (2.1)
RSD-P = 0 (0)



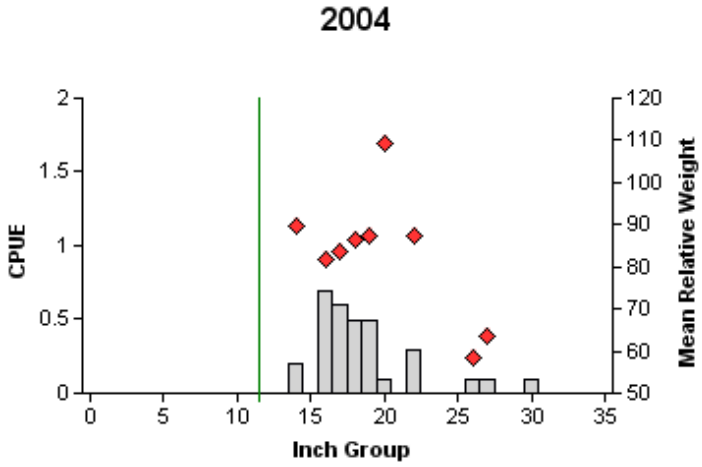
Effort = 1.5
Total CPUE = 238.7 (12; 358)
Stock CPUE = 218.7 (12; 328)
PSD = 13 (2.6)
RSD-P = 0 (0)



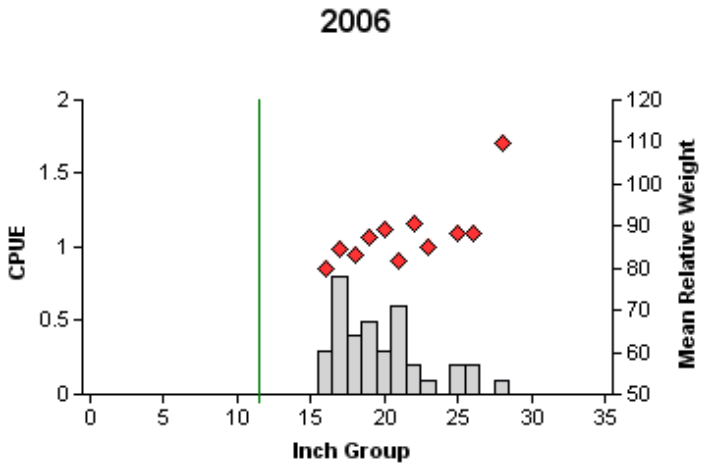
Effort = 1.5
Total CPUE = 314.0 (32; 471)
Stock CPUE = 290.0 (35; 435)
PSD = 23 (7.3)
RSD-P = 0 (0)

Figure 3. Number of bluegill caught per hour (CPUE) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2003, 2005, and 2007.

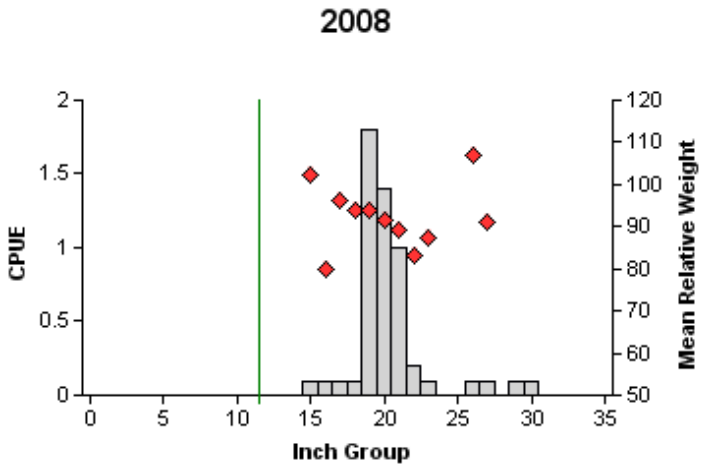
Blue Catfish



Effort = 10.0
Total CPUE = 3.2 (25; 32)
Stock CPUE = 3.2 (25; 32)
PSD = 22 (8.4)
RSD-P = 3 (3.1)



Effort = 10.0
Total CPUE = 3.7 (17; 37)
Stock CPUE = 3.7 (17; 37)
PSD = 46 (7.7)
RSD-P = 0 (0)



Effort = 10.0
Total CPUE = 5.3 (22; 53)
Stock CPUE = 5.3 (22; 53)
PSD = 58 (6.8)
RSD-P = 2 (1.7)

Figure 4. Number of blue catfish caught per net night (CPUE) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for spring gill net surveys, Waco Reservoir, Texas, 2004, 2006, and 2008.

Blue Catfish

Table 8. Creel survey statistics for blue catfish at Waco Reservoir from June 2007 through May 2008, where total catch per hour is for anglers targeting blue catfish and total harvest is the estimated number of blue catfish harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Directed effort (h)	4,806.00 (27)
Directed effort/acre	0.57
Total catch per hour	0.06 (95)
Total harvest	4,900.00
Harvest/acre	0.58

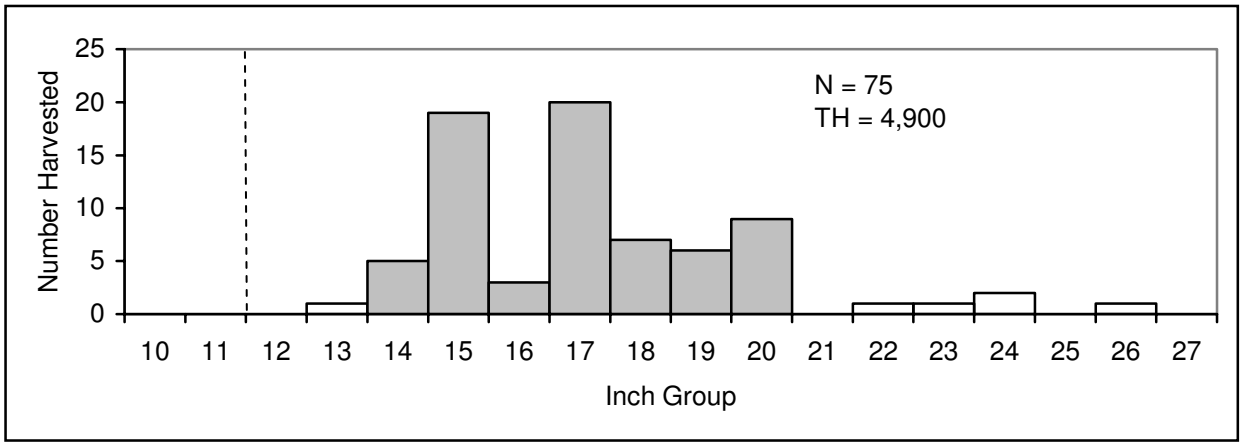
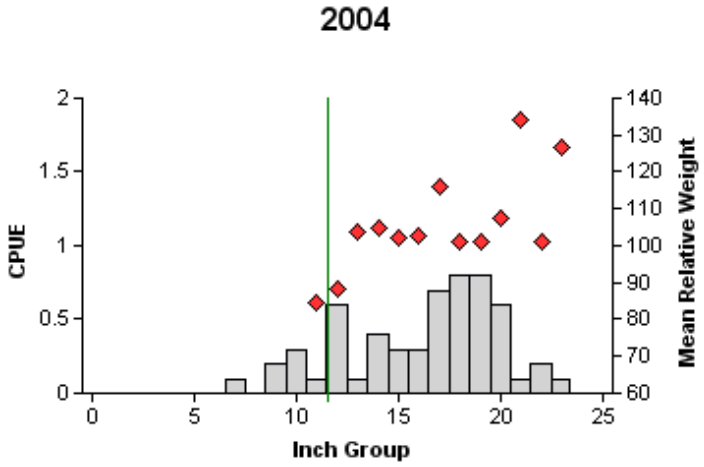
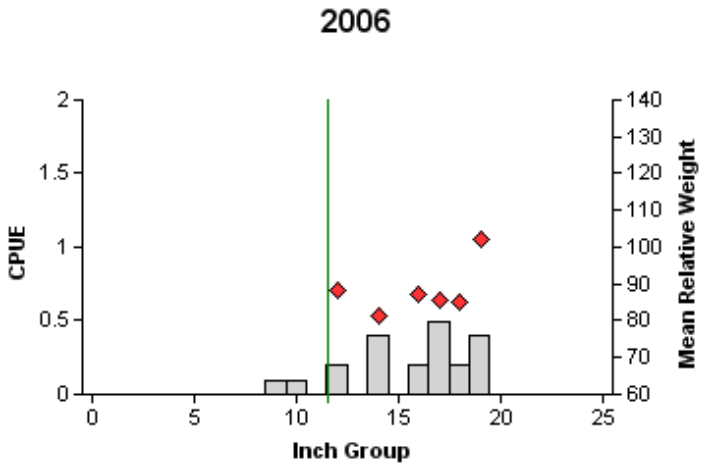


Figure 5. Length frequency of harvested blue catfish observed during creel surveys at Waco Reservoir, Texas, June 2007 through May 2008, all anglers combined. N is the number of harvested blue catfish observed during creel surveys, and TH is the total estimated harvest for the creel period. Dashed line indicates minimum length limit.

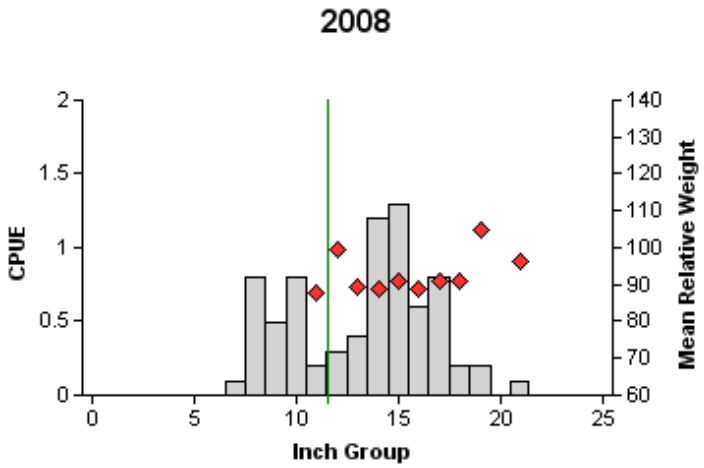
Channel Catfish



Effort = 10.0
Total CPUE = 5.7 (21; 57)
Stock CPUE = 5.1 (23; 51)
PSD = 71 (5.2)
RSD-P = 0 (0)



Effort = 10.0
Total CPUE = 2.1 (39; 21)
Stock CPUE = 1.9 (35; 19)
PSD = 68 (16.5)
RSD-P = 0 (0)



Effort = 10.0
Total CPUE = 7.5 (31; 75)
Stock CPUE = 5.3 (30; 53)
PSD = 36 (11.8)
RSD-P = 0 (0)

Figure 6. Number of channel catfish caught per net night (CPUE) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for spring gill net surveys, Waco Reservoir, Texas, 2004, 2006, and 2008.

Channel Catfish

Table 9. Creel survey statistics for channel catfish at Waco Reservoir from June 2007 through May 2008, where total catch per hour is for anglers targeting channel catfish and total harvest is the estimated number of channel catfish harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Directed effort (h)	1,504.00 (45)
Directed effort/acre	0.18
Total catch per hour	0.43 (45)
Total harvest	11,556.00
Harvest/acre	1.37

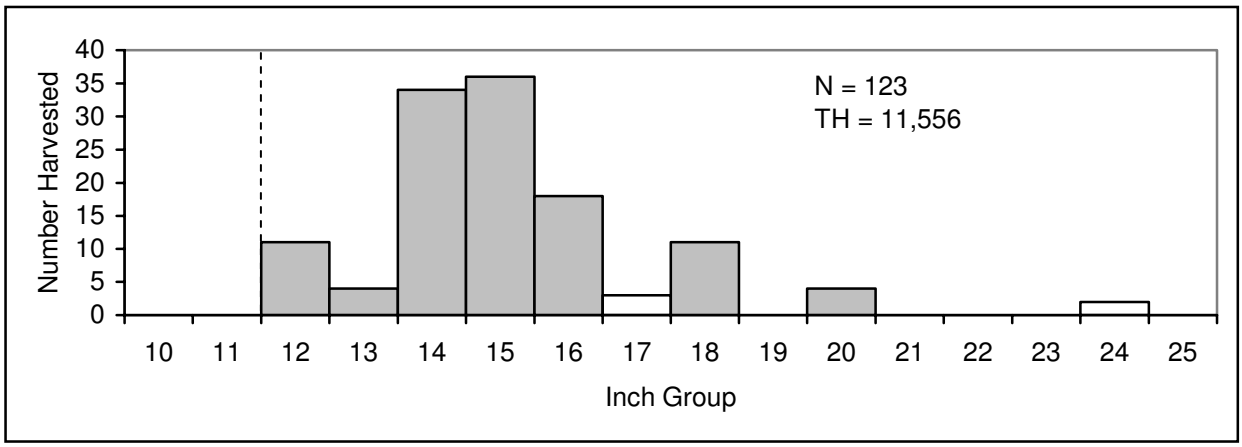
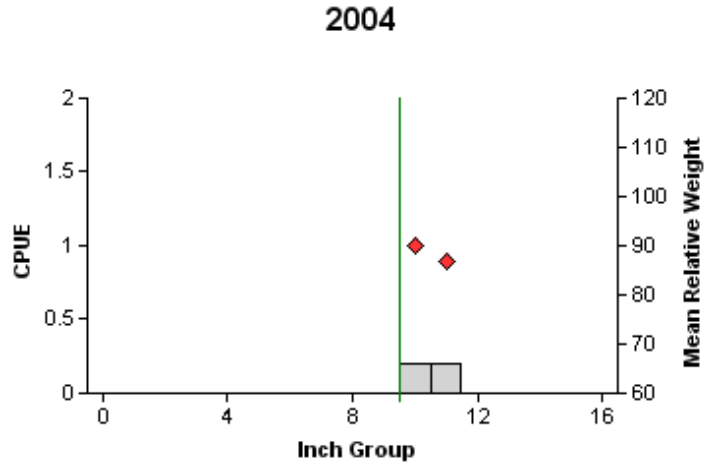


Figure 7. Length frequency of harvested channel catfish observed during creel surveys at Waco Reservoir, Texas, June 2007 through May 2008, all anglers combined. N is the number of harvested channel catfish observed during creel surveys, and TH is the total estimated harvest for the creel period. Dashed line indicates minimum length limit.

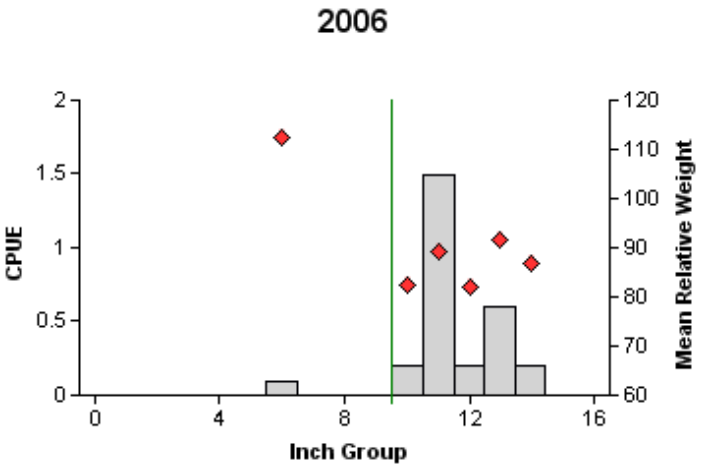
Table 10. Creel survey statistics for catfish spp. at Waco Reservoir from June 2007 through May 2008, where total catch per hour is for anglers targeting catfish spp. Relative standard errors (RSE) are in parentheses.

Directed effort (h)	33,254.00 (13)
Directed effort/acre	3.93
Total catch per hour	0.54 (63)

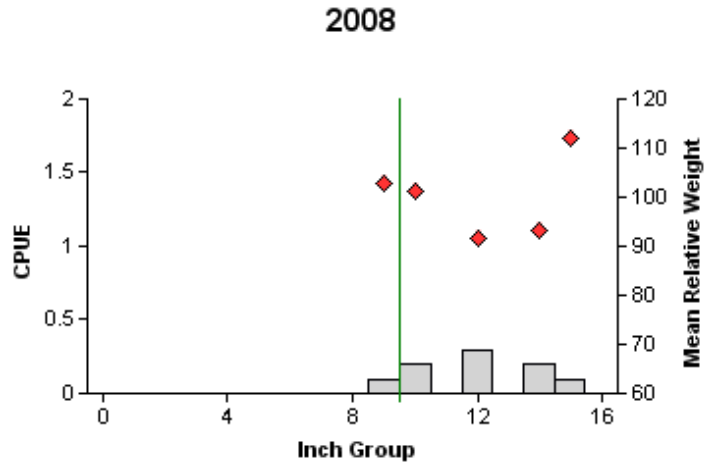
White Bass



Effort = 10.0
Total CPUE = 0.4 (55; 4)
Stock CPUE = 0.4 (55; 4)
PSD = 100 (0)
RSD-P = 0 (0)



Effort = 10.0
Total CPUE = 2.8 (39; 28)
Stock CPUE = 2.8 (39; 28)
PSD = 96 (4.2)
RSD-P = 36 (15.8)



Effort = 10.0
Total CPUE = 0.9 (35; 9)
Stock CPUE = 0.9 (35; 9)
PSD = 100 (0)
RSD-P = 67 (14.6)

Figure 8. Number of white bass caught per net night (CPUE) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for spring gill net surveys, Waco Reservoir, Texas, 2004, 2006, and 2008.

White Bass

Table 11. Creel survey statistics for white bass at Waco Reservoir from June 2007 through May 2008, where total catch per hour is for anglers targeting white bass and total harvest is the estimated number of white bass harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Directed effort (h)	19,799.00 (32)
Directed effort/acre	2.34
Total catch per hour	1.88 (20)
Total harvest	29,245.00
Harvest/acre	3.45

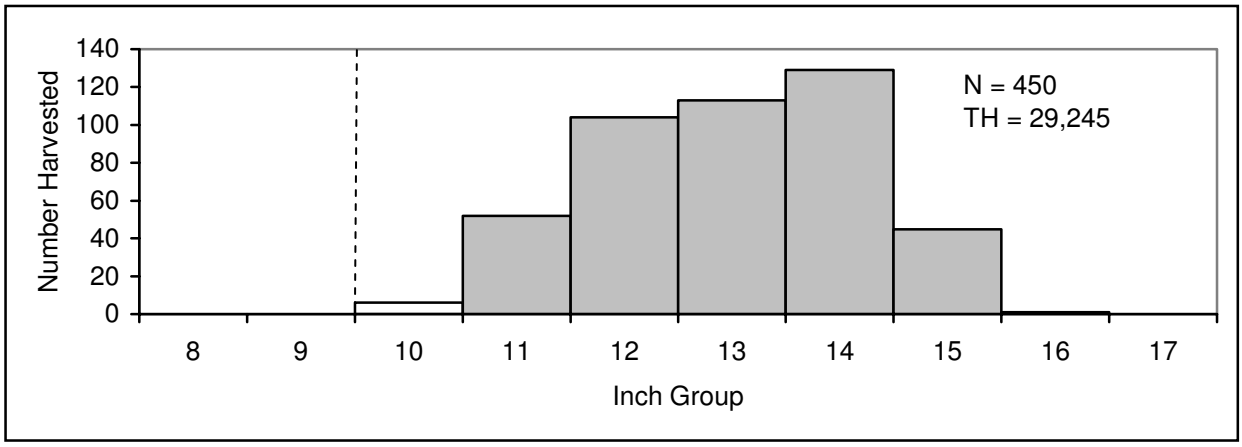


Figure 9. Length frequency of harvested white bass observed during creel surveys at Waco Reservoir, Texas, June 2007 through May 2008, all anglers combined. N is the number of harvested white bass observed during creel surveys, and TH is the total estimated harvest for the creel period. Dashed line indicates minimum length limit.

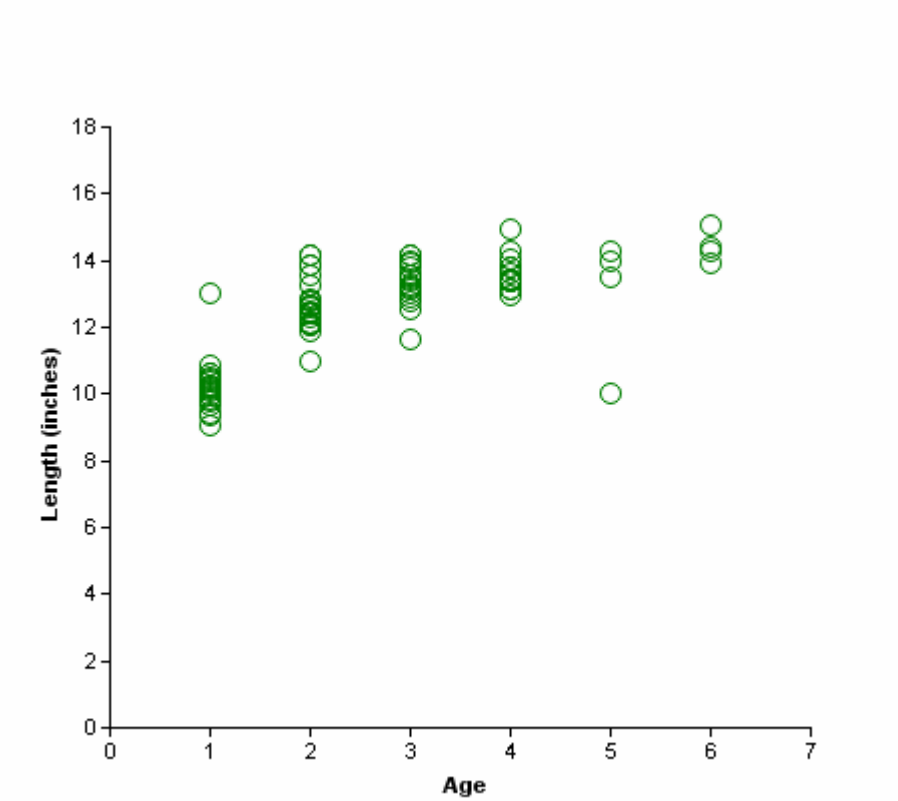


Figure 10. Length at age for white bass collected by electrofishing at Waco Reservoir, Texas, Spring, 2008.

Table 12. Average length at capture for white bass (sexes combined) ages 0 – 6 collected in electrofishing surveys, Waco Reservoir, spring 2008. Lengths are followed by the sample size. Note that the age-0 data may not be representative of the actual size distribution because of gear bias against smaller fish.

	Growth	
Age	Total Length	Number of fish
1	10.2	19
2	12.7	25
3	13.3	16
4	13.6	14
5	12.9	4
6	14.4	4

Largemouth Bass

Effort = 1.5
Total CPUE = 194.0 (11; 291)
Stock CPUE = 103.3 (17; 155)
PSD = 32 (3.9)
RSD-P = 8 (2.6)

Effort = 1.5
Total CPUE = 154.7 (15; 232)
Stock CPUE = 102.7 (18; 154)
PSD = 34 (4.4)
RSD-P = 9 (2.5)

Effort = 1.5
Total CPUE = 420.7 (22; 631)
Stock CPUE = 134.0 (34; 201)
PSD = 18 (4.3)
RSD-P = 4 (1.9)

Figure 11. Number of largemouth bass caught per hour (CPUE) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for fall electrofishing surveys, Waco Reservoir, Texas, 2003, 2005, and 2007.

Largemouth Bass

Table 13. Creel survey statistics for largemouth bass at Waco Reservoir from June 2007 through May 2008, where total catch per hour is for anglers targeting largemouth bass and total harvest is the estimated number of largemouth bass harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Directed effort (h)	71,199 (12)
Directed effort/acre	8.41
Total catch per hour	1.54 (31)
Total harvest	12,642.00
Harvest/acre	1.49

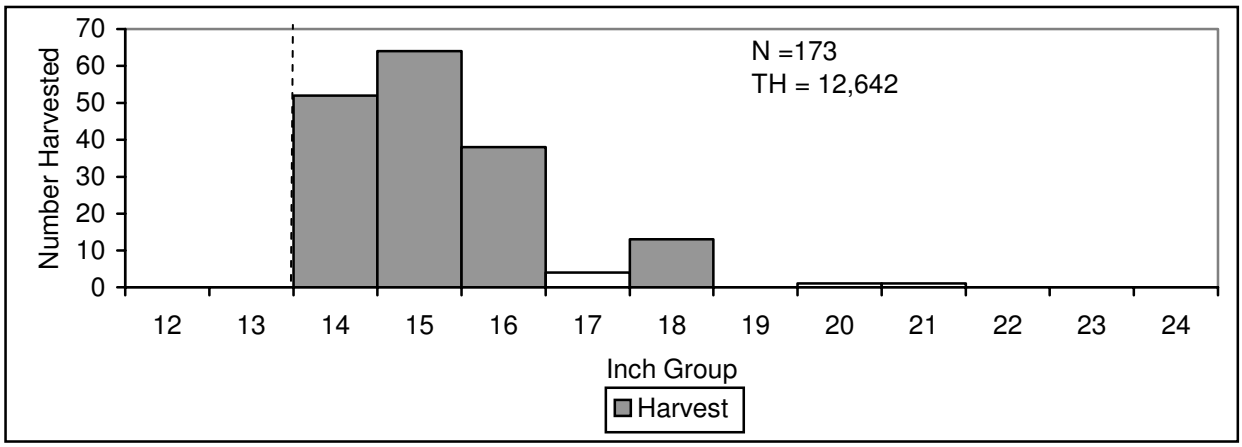


Figure 12. Length frequency of harvested largemouth bass observed during creel surveys at Waco Reservoir, Texas, June 2007 through May 2008, all anglers combined. N is the number of harvested largemouth bass observed during creel surveys, and TH is the total estimated harvest for the creel period. Dashed line indicates minimum length limit.

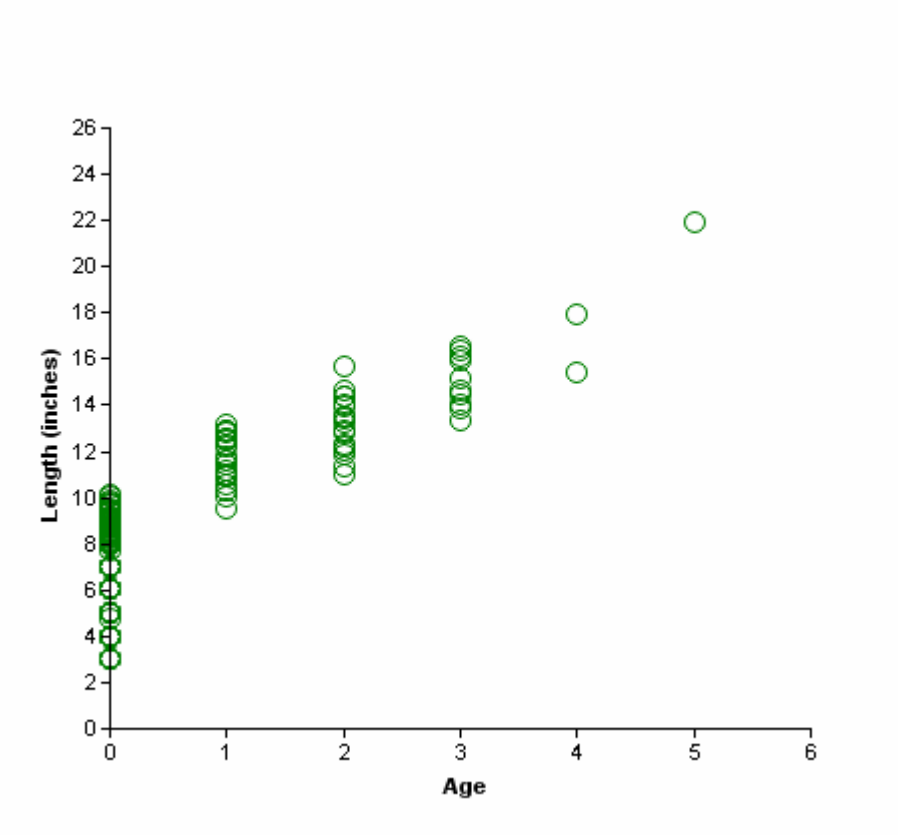


Figure 13. Length at age for largemouth bass collected by electrofishing at Waco Reservoir, Texas, Fall, 2007.

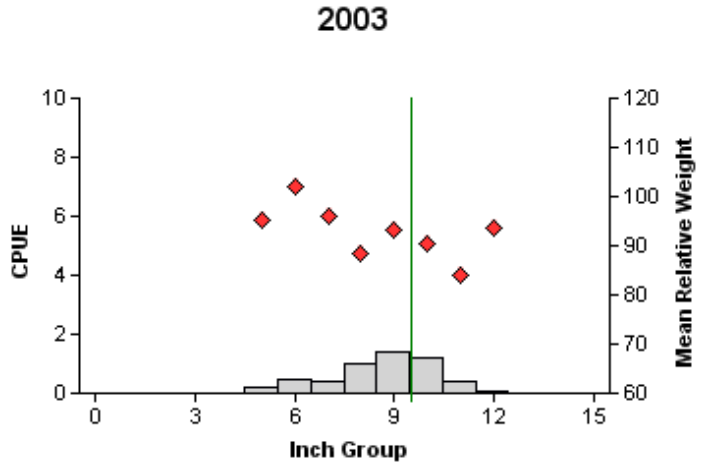
Table 14. Average length at capture for largemouth bass (sexes combined) ages 0 – 5 collected in electrofishing surveys, Waco Reservoir, fall 2007. Lengths are followed by the sample size. Note that the age-0 data may not be representative of the actual size distribution because of gear bias against smaller fish.

	Growth	
Age	Total Length	Number of fish
0	6.3	156
1	11.6	22
2	13.2	18
3	15.1	10
4	16.7	2
5	22.0	1

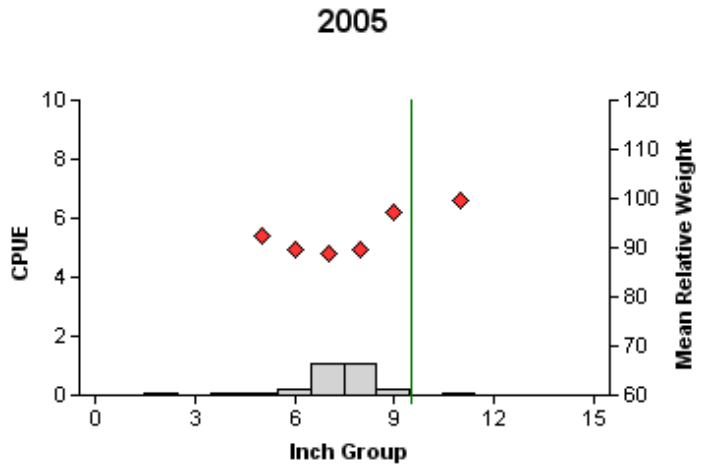
Table 15. Results of genetic analysis, by age class, of largemouth bass collected during fall electrofishing, Waco, Texas, 2006. N = Northern, F = Florida, and Hyb = Northern X Florida Hybrids.

Age	n	Proportion N genotypes	Proportion F genotypes	Proportion Hyb. genotypes	Mean F influence
0	129	0.054	0.008	0.938	0.465
1	124	0.024	0.016	0.960	0.429
2	95	0.032	0.053	0.916	0.459
3	35	0.029	0.057	0.914	0.499
4-6	7	0.000	0.000	1.000	0.425
5	7	0.143	0.000	0.857	
6	7	0.143	0.000	0.857	

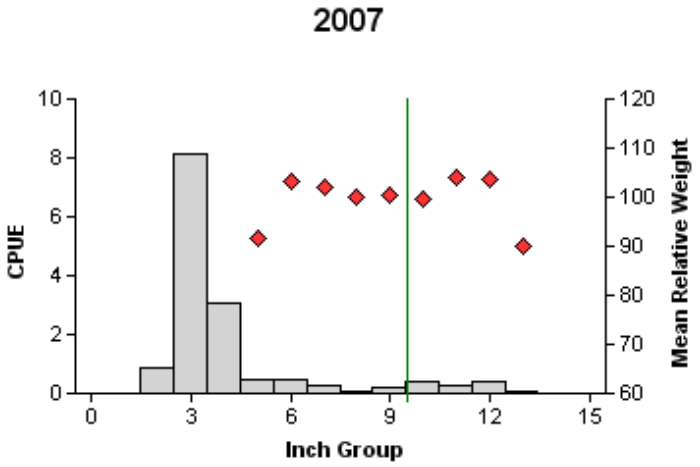
White Crappie



Effort = 10.0
Total CPUE = 5.2 (51; 52)
Stock CPUE = 5.2 (51; 52)
PSD = 79 (8)
RSD-P = 33 (12.6)



Effort = 10.0
Total CPUE = 3.0 (57; 30)
Stock CPUE = 2.8 (58; 28)
PSD = 50 (8.0)
RSD-P = 4 (4.2)



Effort = 30.0
Total CPUE = 14.8 (38; 444)
Stock CPUE = 2.7 (25; 82)
PSD = 55 (7.6)
RSD-P = 44 (6)

Figure 14. Number of white crappie caught per net night (CPUE) and population indices (RSE and N for CPUE and SE for size structure are in parentheses) for fall trap net surveys, Waco Reservoir, Texas, 1999, 2003, and 2005.

White Crappie

Table 16. Creel survey statistics for crappie spp. at Waco Reservoir from June 2007 through May 2008, where total catch per hour is for anglers targeting crappie spp. and total harvest is the estimated number of crappie spp. harvested by all anglers. Relative standard errors (RSE) are in parentheses.

Directed effort (h)	33,254.00 (13)
Directed effort/acre	3.93
Total catch per hour	1.94 (46)
Total harvest	19,720.00
Harvest/acre	2.33

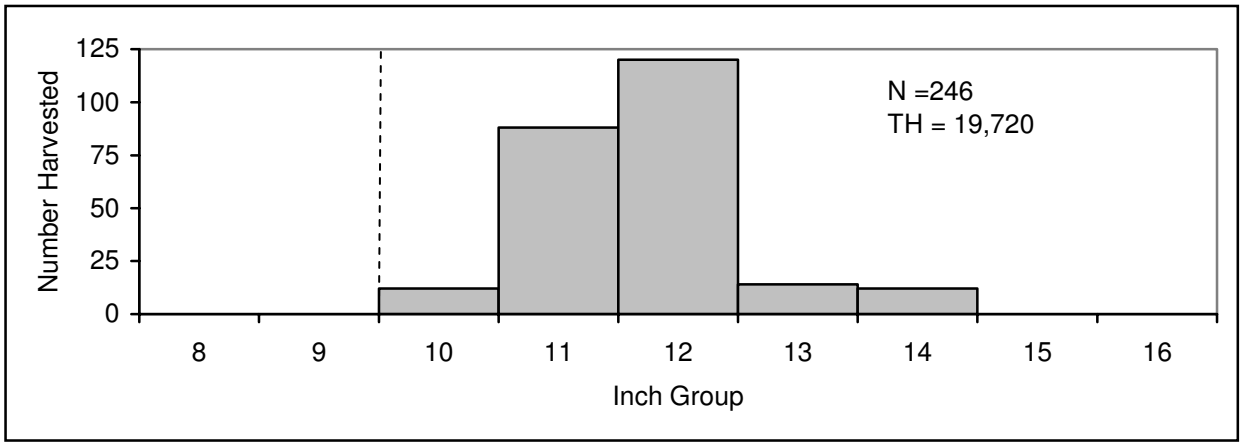


Figure 15. Length frequency of harvested crappie spp. observed during creel surveys at Waco Reservoir, Texas, June 2007 through May 2008, all anglers combined. N is the number of harvested crappie spp. observed during creel surveys, and TH is the total estimated harvest for the creel period.

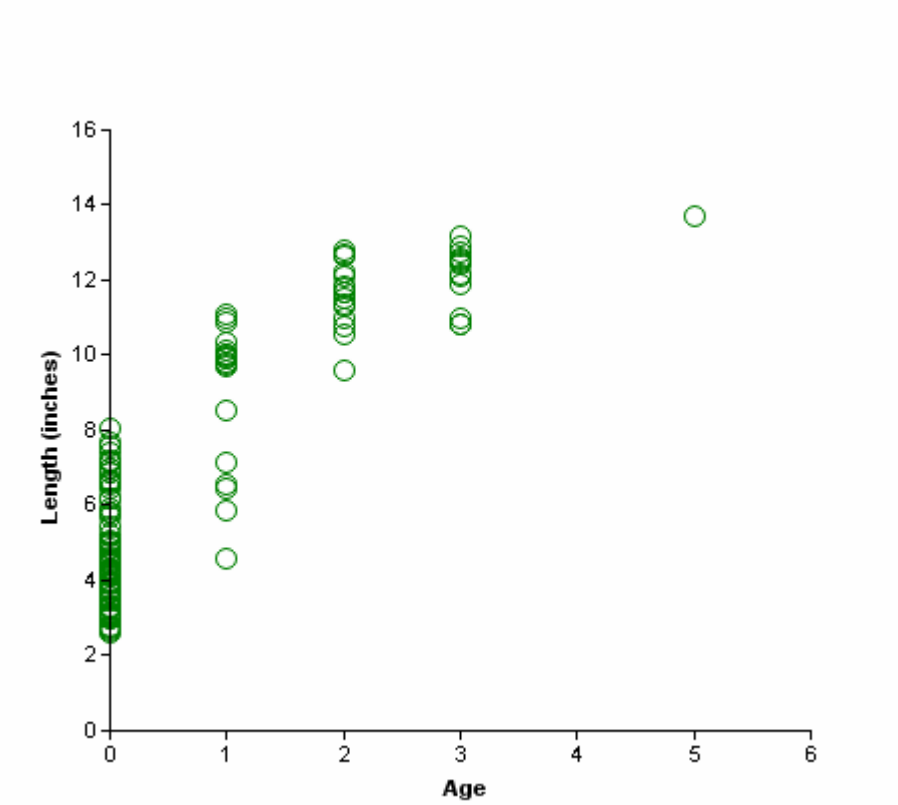


Figure 16. Length at age for white crappie collected by trapnetting at Waco Reservoir, Texas, Fall, 2007.

Table 17. Average length at capture for white crappie (sexes combined) ages 0 – 5 collected in electrofishing surveys, Waco Reservoir, fall 2007. Lengths are followed by the sample size. Note that the age-0 data may not be representative of the actual size distribution because of gear bias against smaller fish.

	Growth	
Age	Total Length	Number of fish
0	4.7	90
1	9.0	19
2	11.6	16
3	12.1	13
5	13.7	1

Table 18. Proposed sampling schedule for Waco Reservoir, Texas. Gill netting surveys are conducted in the spring, while electrofishing and trap netting surveys are conducted in the fall. Standard survey denoted by S and additional survey denoted by A.

Survey Year	Electrofisher	Trap Net	Gill Net	Creel Survey	Report
Fall 2008-Spring 2009					
Fall 2009-Spring 2010					
Fall 2010-Spring 2011					
Fall 2011-Spring 2012	S	S	S		S

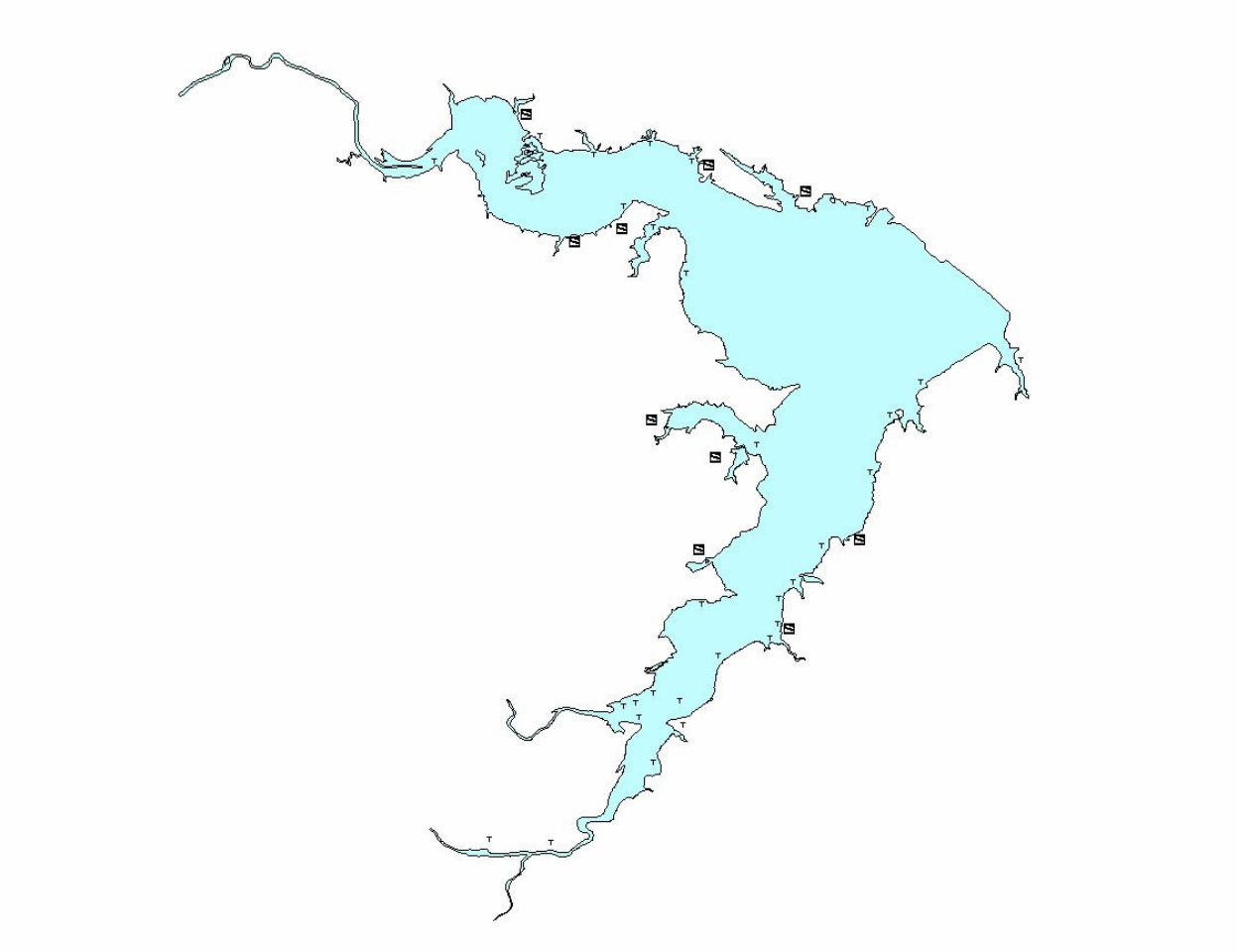
APPENDIX A

Number (N) and catch rate (CPUE) of all target species collected from all gear types from Waco Reservoir, Texas, 2007-2008.

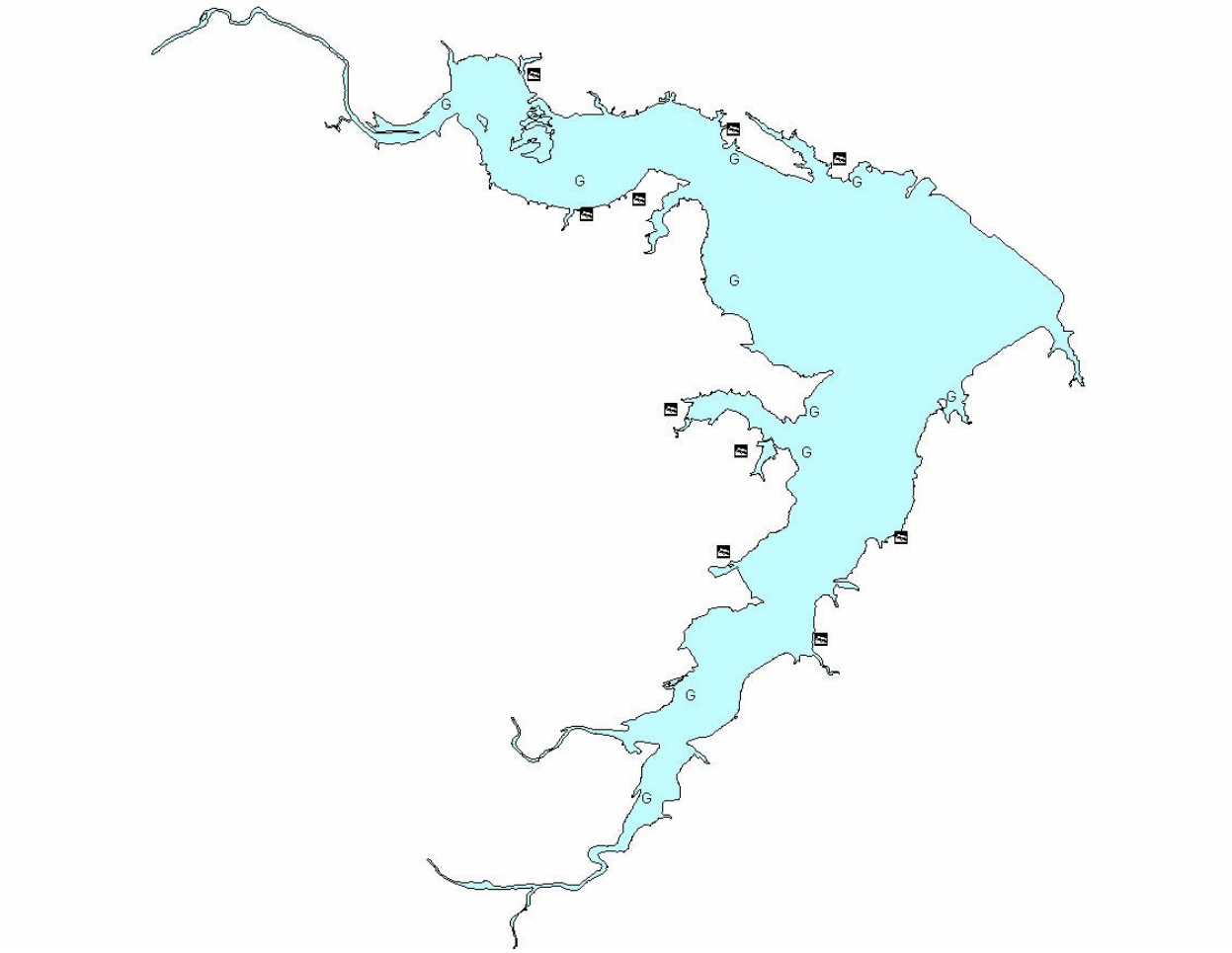
Species	Gill Netting		Trap Netting		Electrofishing	
	N	CPUE	N	CPUE	N	CPUE
Gizzard shad					921	614.0
Threadfin shad					261	174.0
Blue catfish	53	5.3				
Channel catfish	75	7.5				
Flathead catfish	1	0.1				
White bass	9	0.9			203	135.3
Redbreast sunfish						
Green sunfish					3	2.0
Warmouth					4	2.67
Bluegill					471	314.0
Longear sunfish					149	99.3
Redear sunfish					34	22.7
Spotted bass					13	8.7
Largemouth bass					631	420.7
White crappie			444	14.8		
Black crappie			12	0.40		

APPENDIX B

Location of electrofishing sites, Waco Reservoir, Texas, 2007. Standard electrofishing stations are indicated by S and daytime electrofishing stations are indicated by D. Water level was near full pool at time of sampling.



Location of trap netting sites, Waco Reservoir, Texas, 2007. Stations are indicated by T. Water level was near full pool at time of sampling.



Location of gill netting sites, Waco Reservoir, Texas, 2008. Stations are indicated by G. Water level was near full pool at time of sampling.

Appendix C: Results from FAST modeling

Introduction

Recruitment, growth, exploitation, 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 2006 (largemouth bass), 2007 (largemouth bass, white crappie), and 2008 (white bass) using Fishery Analysis and Simulation Tools (FAST, Slipke and Maceina, 2000).

Methods

Largemouth bass, white bass, white crappie otoliths were collected using a stratified random approach in which ten fish per centimeter group were selected for otolith extraction. The remaining fish were assigned ages using a length-age key. An exception to this was the fall, 2006 largemouth bass sample in which all collected fish were aged as part of another research project. Collection and processing of otoliths was conducted according to the Texas Parks and Wildlife Department Inland Fisheries Assessment Procedures (unpublished, revised manual 2002).

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 examine annual mortality, theoretical maximum age, and year class strength. The Von Bertalanffy growth function was used to determine L-infinity. Only data from age-0 through age-3 were used for largemouth bass to calculate total annual mortality, theoretical maximum age, and year class strength, because of possible gear bias for older fish described in the Texas Parks and Wildlife Department Inland Fisheries Assessment Procedures (unpublished, revised manual 2005). Theoretical maximum length was calculated using length data from all ages, as length-at-age is less affected by gear bias than other variables. Not including all data results in a very different and much lower estimate of theoretical maximum length. Only data from age-2 through age-6 were used for white bass because fish were collected by electrofishing spawning fish in the spring. It is widely accepted that in Texas, many males are sexually mature at age-1, but females don't sexually mature until age-2. Data from all ages were used for white crappie. 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 2002). Estimates of exploitation were determined from this information.

Results and Discussion

The results are shown in the accompanying table. The largemouth bass population was sampled in 2006 as part of a special project, and again in 2007 as part of this comprehensive survey. The results were very different between years. This is likely due to violations of the FAST model assumptions of consistent recruitment and mortality over time. Alternating low and high water conditions as well as increased angling pressure may be the cause.

The white bass population exhibits moderate total mortality, low exploitation, a long maximum length of 16.7", a maximum age of 8.8 years, and consistent recruitment.

The white crappie population exhibits high total mortality, low exploitation, a short maximum length of 13.9", a maximum age of only 5 years, and variable recruitment.

It is clear that with such low exploitation, additional harvest restrictions will do little to restructure any of these populations at the current time. The mortality observed appears to be primarily natural mortality. However, if angling pressure were to increase in the future, it is possible that exploitation might become a factor, necessitating additional harvest restrictions.

Population parameters of sport fishes in Waco Reservoir, 2006-2008. Estimates were obtained using the Fast Modeling Program.

Species	N aged	Total Mortality	Exploitation rate	Maximum size (L-infinity)	Maximum age	Residuals
Largemouth bass (2006)	403	34.0%	unknown	39.2”	12.2	-0.267 to 0.316
Largemouth bass (2007)	632	71.1%	1.49/acre	No solution	4.5	-1.157 to 0.825
White bass	212	48.7%	3.45/acre	16.7”	8.8	-0.143 to 0.499
White crappie	446	64.3%	1.09/acre	13.9”	5.0	-1.003 to 0.720

Appendix D: Results from night vs. day electrofishing

Introduction

The current standardized electrofishing procedures require that sampling be conducted at night no earlier than 30 minutes after sunset (Texas Parks and Wildlife Department Inland Fisheries Assessment Procedures, revised manual 2002). The reasons traditionally cited for this include increased fish activity in shallow water at night, decreased avoidance of the electrofishing boat, and the ability to sample larger fish. We tested whether these assumptions affected catch rates of largemouth bass in Waco Reservoir during fall 2007 electrofishing.

Methods

A total of 36 five-minute stations were randomly selected throughout the lake for the day vs. night electrofishing comparison, 18 for each treatment. Night samples were collected on 10/8/07. Day samples were collected on 10/10/07. During night electrofishing, all target species were collected. During day electrofishing, only largemouth and spotted bass were collected. Water clarity ranged from 60 to 90 cm, as measured by a secchi disk.

Results and Discussion

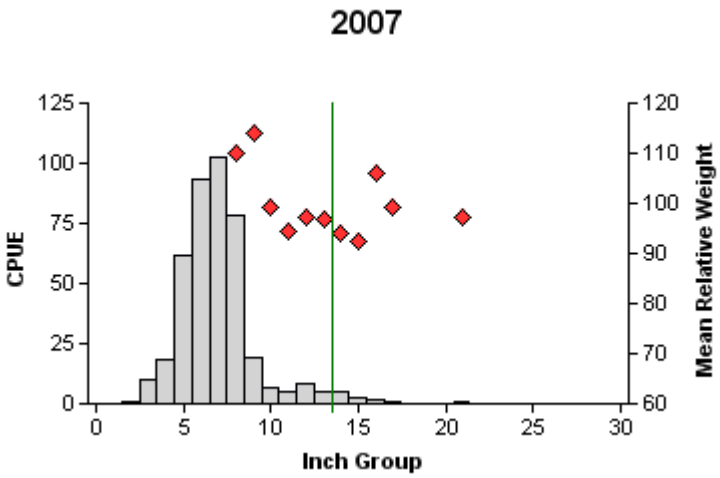
The results are shown in the next two pages. The first figure on each page is the standard night electrofishing with the associated population indices for largemouth bass and spotted bass, respectively. The second figure is the accompanying day electrofishing for largemouth bass and spotted bass..

The day and night graphs for largemouth bass look similar, although catch rates during the day are about half compared to night electrofishing. Catch of fish larger than 10” appears very similar across sizes for day and night samples. The maximum size of bass collected for the day sample was similar to that of the night sample (20” vs 21”). However, the PSD and RSD-P of the day sample were higher than that of the night sample (54 vs. 18 and 13 vs. 4, respectively). This was due to reduced catches of bass less than 10” in length. Length-at-age information collected during daytime electrofishing should be as representative as that which was collected during nighttime electrofishing.

The day and night graphs for spotted bass are very different. Catch rates during the day were twice that of night electrofishing. Whereas no spotted bass larger than 10” were collected at night, over half the daytime sample was comprised of fish larger than 10”. The maximum size of the day sample was over 14”, as compared to only 9” for the night sample. The PSD and RSD-P of the day sample were higher than that of the night sample (71 vs. 0 and 12 vs. 0, respectively). The results of day electrofishing show a modest fishery not detected by night electrofishing.

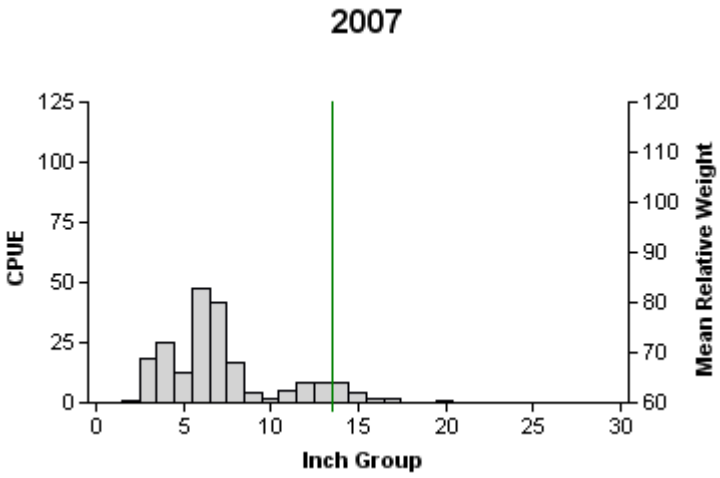
We believe that strong consideration should be given to modifying the current electrofishing procedures to allow for day electrofishing in reservoirs with reduced water clarity or in reservoirs where a similar comparison to this has been completed with satisfactory results. Compelling reasons for this change include increased safety, as well as greater ease of fish collection for age and growth analysis. If such a change were implemented, consideration should be given to collected CPUE data for Waco reservoir during the day, with any additional length-at-age information also collected during the day.

Night Electrofishing – Largemouth bass



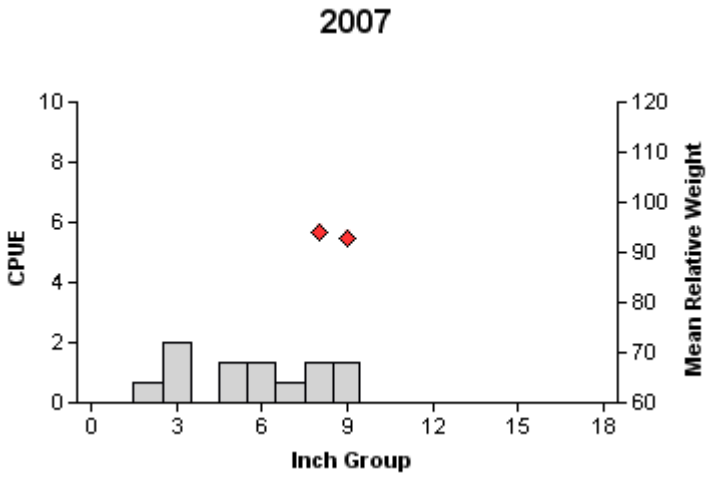
Effort =	1.5
Total CPUE =	420.7 (22; 631)
Stock CPUE =	134.0 (34; 201)
PSD =	18 (4.3)
RSD-P =	4 (1.9)

Day Electrofishing – Largemouth bass



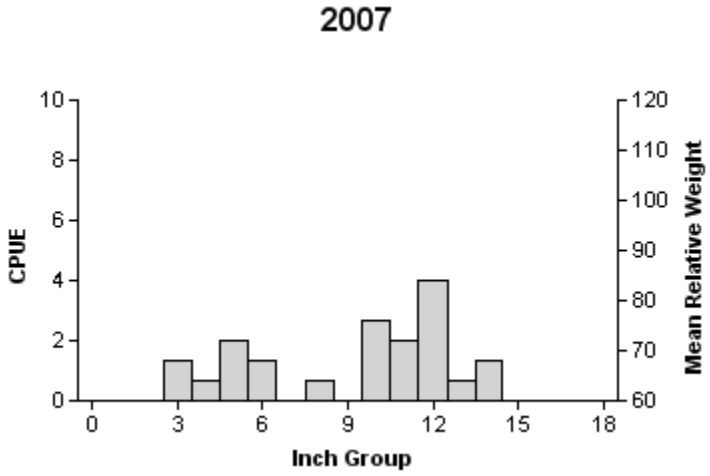
Effort =	1.5
Total CPUE =	206.7 (13; 310)
Stock CPUE =	60.7 (13; 91)
PSD =	54 (4.6)
RSD-P =	13 (4.6)

Night Electrofishing – Spotted bass



Effort = 1.5
Total CPUE = 8.7 (29; 13)
Stock CPUE = 3.3 (49; 5)
PSD = 0 (98.7)
RSD-P = 0 (0)

Day Electrofishing – Spotted bass



Effort = 1.5
Total CPUE = 16.7 (31; 25)
Stock CPUE = 11.3 (42; 17)
PSD = 71 (11.2)
RSD-P = 12 (7.4)