False River Largemouth Bass:
Population and Fishery Characteristics with Size Regulation Simulations
2013 Report

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Introduction

With increased public demand for evaluation of Louisiana (LA) largemouth bass (LMB; *Micropterus salmoides*) harvest regulations, assessment of current management strategy is necessary. Before the efficacy of waterbody-specific harvest regulations can be determined, accurate and precise estimates of the present fishery and population are needed. The primary goal of this project was to develop a statewide database of LMB population and fishery characteristics to inform and evaluate future management decisions.

The success of LMB harvest regulation depends on the vital rate functions, i.e. growth, mortality, and recruitment, of the populations in question. The behaviors of anglers utilizing these fisheries (e.g., rate of voluntary catch and release) are also important. If anglers are hesitant to harvest fish of legal size, potential benefits of length limit restrictions (e.g., protected slot limits and increased growth rates) may not by realized (Allen et al. 2002). Minimum length limits are recommended for populations characterized by low rates of recruitment and natural mortality, moderate to fast growth rates, and high fishing mortality; whereas protected slot limits are recommended for populations characterized by high recruitment and low growth rates (Novinger 1984; Noble and Jones 1993). The False River LMB fishery is currently managed with a 14 inch minimum length limit and a five fish per day harvest limit.

This report presents False River LMB population and fishery characteristics and compares these results to other LA waterbodies included in this project that completed sampling by 2012. Additionally, an age and sex structured population model was constructed to simulate effects of multiple size regulations on False River LMB fishery performance.

Methods

Fishery Independent Collections

Largemouth bass were sampled with standardized LA Department of Wildlife and Fisheries (LDWF) spring electrofishing surveys (LDWF Waterbody Management Plan 1994) for a minimum of three years. If spring electrofishing collections weren't applicable (e.g., riverine systems with a high spring flood pulse), fall electrofishing surveys were substituted. The overall sampling objective was the collection of a minimum of 500 individuals to represent the current size/age distribution of the LMB population in question.

Age Determination

A random sub-sample of up to 10 individuals per inch group <16 inches were sacrificed from each annual electrofishing survey for age determination. Due to larger variation in length-at-age of older LMB, all individuals collected ≥16 inches were sacrificed. Sagittal otoliths were removed, cleaned, and stored in glycerin for processing at the LDWF Office of Fisheries Age and Growth Lab.

Biological ages were assigned to individual fish by assuming an April 1st birthday and adjusting ages to correspond with sample collection dates relative to this birthday (e.g., young-of-the year collected on October 1st would be 0.5 years old). Due to temporal variation in LA LMB annulus formation (i.e., February-June; LDWF unpublished data), biological ages were also adjusted to ensure individual fish were assigned to the correct cohort. For example, biological ages of spring collected LMB without evidence of annuli formation on the otolith margin were advanced by one year; spring collected LMB with evidence of annuli formation on the otolith margin were not adjusted. Biological ages were then used to estimate both sex and non-sex-specific von Bertalanffy growth parameters (see *Growth* section for details).

Annual length at age sample matrices were then converted to age-length-keys, where each matrix cell of annual length at age samples was normalized by the sum of its row to generate empirical probabilities of age given length. These age-length-keys were then used to assign ages to the non-sacrificed LMB collected from each annual electrofishing survey.

<u>Population Characteristics</u>

Growth: The von Bertalanffy (1938) growth function (VBGF) was used to model length at age. The function is configured as:

$$L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right) \quad [1]$$

where L_t is mean total length (TL) at age in years, L_∞ is the asymptotic average maximum TL, K is the rate at which length approaches L_∞, and t_0 is the theoretical age when TL=0. The model was fit to the three year dataset using the SAS nonlinear approximation procedure (PROC NLIN; SAS 1996). Statistical outliers (i.e, absolute studentized residuals >2.5) were then removed and the model refit. The average times to reach stock, quality, and preferred sizes were then estimated by inverting equation [1] and solving for time.

Size Structure Indices: Proportional size distribution indices (PSD-*X*) were calculated over the 3 year sampling period following methods given in Neumann et al. (2012) as:

$$PSD - X = \frac{Number\ of\ fish \geq length\ of\ interest}{Number\ of\ fish \geq minimum\ stock\ length} \times 100 \quad [2]$$

where X indicates the length category of interest (i.e., quality [Q] or preferred [P] sizes; 12 and 15 inches respectively).

Length/Weight Relationship: Weight-length regressions were estimated following methods given in Neumann et al. (2012). The relationship between weight and length can be described with the power function:

$$W = aL^b \quad [3]$$

where W is weight, L is total length, a is the weight-length constant and b is the allometric exponent. The model, after common logarithmic transformation, was fit to the three year dataset with the SAS linear regression procedure (PROC REG; SAS 1996). Statistical outliers (i.e., absolute studentized residuals > 2.5) were then removed and the model refit.

Condition: Condition indices provide a measure of the relative 'plumpness' of fish (Neumann et al. 2012). Mean relative weights of stock, quality, and preferred size fish (i.e., 8, 12, and 15 inches respectively) over the three year sampling period were calculated following methods given in Neumann et al. (2012). Relative weights (W_r) for individual fish were calculated from:

$$W_r = (W/W_s) \times 100 \quad [4]$$

where W is the weight of an individual fish and W_s is a length-specific standard weight reported by Henson (1991).

Recruitment: Mean annual catch rates of age-1 LMB collected from electrofishing surveys were used to calculate a coefficient of variation (CV; standard deviation/mean×100) representing the inter-annual variability in recruitment over the three year electrofishing sampling period.

Mortality: Total instantaneous mortality (Z) was estimated with catch curve analysis (Ricker 1975). The model describing the exponential reduction in abundance at age is configured as:

$$N_{t+1} = N_t e^{-Z_t} \quad [5]$$

where N_t is the number of individuals alive at time t, N_{t+1} is the number alive the following time interval, and Z_t is the instantaneous total mortality rate at time t. Equation [5] is linearized by taking the natural logarithm of both sides to obtain:

$$log_e(N_{t+1}) = log_e(N_t) - Z(t) \quad [6]$$

which was solved with the SAS linear regression procedure (PROC REG; SAS 1996). The interval (i.e., annual in this case) total mortality rate A is then calculated from:

$$A = 1 - e^{-Z} \quad [7]$$

Assumptions of catch curve analysis are: 1) mortality is constant across ages, 2) recruitment is constant, and 3) samples are representative of the true age structure of the population. To alleviate the possibility of violating assumption (1), only the ages considered exploitable, (i.e., not protected by length regulations as determined by predicted mean TL at age computed from equation [1]) were included in the catch curve. To reduce the possibility of violating assumption (2) and concerns with inadequacies in sample size, samples over the three year sampling period were used to create a single pseudo-cohort. Because sampling occurred in successive years with unequal sampling efforts, age-specific mean catch per unit effort over the three year sampling period was substituted for the age-specific number of individuals (N_t) in Equation [6]. Additionally, only age classes considered fully-recruited to the electrofishing gear and containing more than three individuals from the three year sampling period were included in the catch curve.

Instantaneous natural mortality (M) was approximated following the approach recommended by Hewitt and Hoenig (2005) as:

$$M \sim \frac{4.22}{t_{max}} \quad [8]$$

where t_{max} represents the maximum age in the population. For this project, t_{max} is taken as the oldest age observed in the population or 8 years, whichever is greater. Instantaneous fishing mortality (F) was then approximated by difference, i.e. $Z - M$.

Most LA LMB fisheries can be categorized as Type 2 fisheries, where natural and fishing mortality occur simultaneously. Interval natural (v) and fishing (u) mortality rates for Type 2 fisheries are calculated from:

$$v = \frac{MA}{Z} \ , \ u = \frac{FA}{Z} \quad [9, 10]$$

where Z, F, and M are instantaneous total, fishing, and natural mortality rates respectively, and A is the interval total mortality rate.

Fishery Characteristics

A LDWF Inland Fisheries creel survey (LDWF Waterbody Management Plan 1994) was conducted once during the three year fishery-independent sampling period for each waterbody included in this project. Estimates of the proportion of legal sized LMB retained (i.e., harvested), calculated as the ratio of the annual harvest to annual catch of legal sized LMB, are presented in this report. Fishery-specific estimates are used in LMB length limit simulations for each waterbody included in this project (see *Population Simulations* Section below).

Population Simulations

An age and sex structured population model was constructed to simulate the effects of size-specific harvest regulations (i.e., no length limit, a 14 inch minimum length limit, a 14 to 17 inch protected slot limit, and a17 inch maximum length limit) on False River LMB fishery performance.

Model Configuration: Abundance at age a and sex s was modeled as:

$$N_{a,s} = R_s S_{a,s} \quad [11]$$

where R_s is equilibrium sex-specific constant recruitment calculated from $R \times 0.5$. Sex-specific survivorship-at-age ($S_{a,s}$) was calculated recursively from $S_{a,s-1} e^{-Z_{a,s}}$, $S_{1,s} = 1$ where $Z_{a,s}$ are age and sex-specific total instantaneous mortality rates. Separated into additive components this becomes:

$$Z_{a,s} = M + H_{a,s} + D_{a,s} \quad [12]$$

where M is the constant non-sex-specific instantaneous natural mortality rate taken from equation [8]. Instantaneous sex-specific harvest and discard mortalities ($H_{a,s}$, $D_{a,s}$) vary across ages. Age and sex-specific instantaneous harvest mortalities were calculated from:

$$H_{a,s} = F V_{h(a,s)} \quad [13]$$

where F is the overall instantaneous fishing mortality rate and $V_{h(a,s)}$ are the age and sex-specific vulnerabilities to harvest. Age and sex-specific instantaneous discard mortalities were calculated from:

$$D_{a,s} = F d V_{d(a,s)} \quad [14]$$

where d is the proportion of discards not surviving and $V_{d(a,s)}$ are the age and sex-specific vulnerabilities to discarding.

Age and sex-specific vulnerabilities to harvest and discard were developed as knife-edged vectors evaluated with predicted mean total lengths at age calculated from equation [1] using the sex-specific False River von Bertalanffy growth parameters for each simulated size-specific harvest regulation. Vulnerabilities to harvest were calculated as the product of the retention rate of legal sized LMB estimated from the False River creel survey (see *Fishery Characteristics* Section for details) and the proportion of legal sized LMB of age a and sex s, evaluated with equation [1], for each simulated size regulation. Vulnerabilities to discard were calculated similarly, but as two components: 1) the proportion of non-legal size LMB of age a and sex s larger than the minimum size vulnerable to the fishery, and 2) the proportion of legal sized fish of age a and sex s reduced by the retention rate estimate of legal sized fish. To approximate changes in growth through each age interval, TL at age was calculated using the age interval midpoints (i.e. $a + 0.5$).

Fishery Performance: Equilibrium total catch (i.e., harvest + releases) and total catches ≥ 15 or 20 inches were used to evaluate False River LMB fishery performance.

Equilibrium harvest (i.e., number of individuals harvested) was calculated as:

$$C_H = \sum_a \sum_s N_{a,s} H_{a,s} \frac{(1-e^{-Z_{a,s}})}{Z_{a,s,}} \quad [17]$$

Equilibrium releases (i.e., number of individuals discarded) was calculated as:

$$C_R = \sum_a \sum_s \frac{N_{a,s} D_{a,s} \frac{(1-e^{-Z_{a,s}})}{Z_{a,s,}}}{d} \quad [18]$$

Equilibrium total catch (C_T; harvest + discards) was then calculated by summation ($C_H + C_R$). Equilibrium total catches of individuals greater than preferred and memorable sizes were calculated with equations [17-19], but where summation only occurs over ages with TL ≥ 15 or 20 inches respectively.

Results

<u>Fishery-independent Collections</u>:

Annual size frequency distributions of LMB collected from spring False River electrofishing surveys are presented in Figure 1 below.

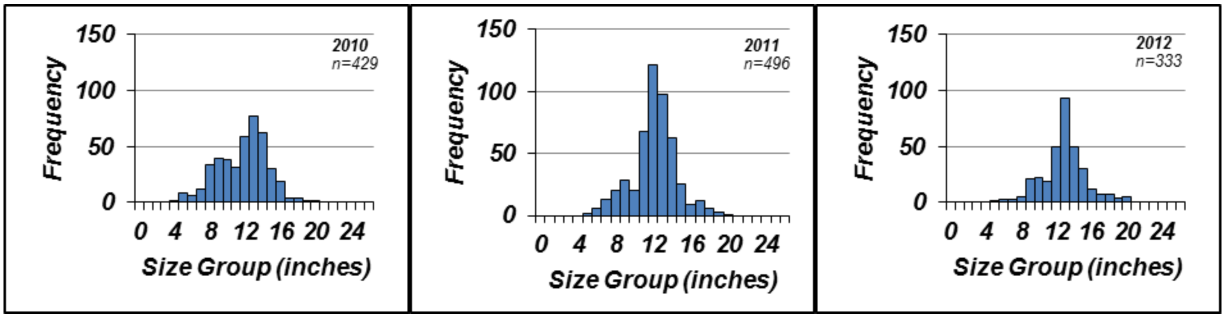

Figure 1: Annual size frequency distributions of the False River largemouth bass spring electrofishing survey 2010-2012. Sample sizes (n) are presented in each graphic.

<u>Age Determination</u>

Annual length at age sample matrices of LMB collected from spring False River electrofishing surveys 2010-2012 are presented in Table 1 below.

Table 1: Annual length at age sample matrices of the False River spring electrofishing survey 2010-2012. Totals represent the sum across rows/columns.

2010

TL / Age	0	1	2	3	4	5	6	7	8	9	10	Totals
2												
3												
4		1										1
5		9										9
6		6										6
7		10										10
8		10										10
9		10										10
10		8	2									10
11			11									11
12			10									10
13			4	3	3							10
14				3	7							10
15				2	5	3	1					11
16				1	11	4	2		1			19
17					2	2						4
18					2			2				4
19										1		1
20						1	1					2
21												
22												
23												
24												
25												
Totals		54	27	9	30	10	4	2	1	1		138

2011

TL / Age	0	1	2	3	4	5	6	7	8	9	10	Totals
2												
3												
4												
5		2										2
6		6										6
7		11										11
8		9										9
9		10										10
10		4	6									10
11			10									10
12			10		1							11
13			9	1								10
14			6		2	2						10
15				3	2	3						8
16				1	4	2	1					8
17					5	4	2	1				12
18					1	3	1		1			6
19						1	2					3
20								1				1
21												
22												
23												
24												
25												
Totals		42	41	5	15	15	6	2	1			127

2012

TL / Age	0	1	2	3	4	5	6	7	8	9	10	Totals
2												
3												
4												
5		2										2
6		3										3
7		3										3
8		5										5
9		10										10
10		9	1									10
11			9	1								10
12			5	4	1							10
13			1	5	5							11
14				4	5	1						10
15				1	6	2	1					10
16					5	4	2	1				12
17					4		1	2				7
18					1	4	1	1				7
19						1	2	1				4
20						1	2		1	1		5
21												
22												
23												
24												
25												
Totals		32	16	15	27	13	9	5	1	1		119

Population Characteristics

Growth: Observed and predicted TL at age of LMB collected from False River fishery independent surveys (2010-2012) are presented in Figure 2 below.

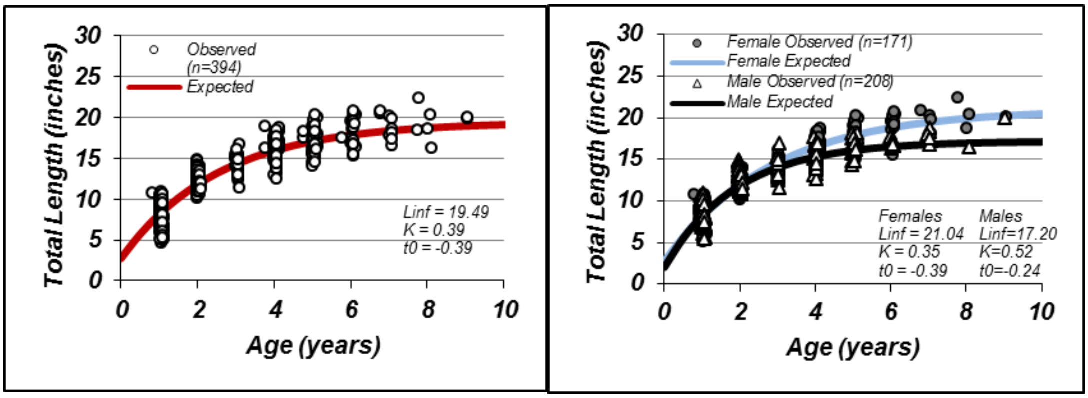

Figure 2: Observed and predicted total length at age of False River largemouth bass (2010-2012). Von Bertalanffy parameter estimates and sample sizes (n) are presented in each graphic. Right graphic depicts sex-specific von Bertalanffy model fits and parameter estimates.

Average time in years for LMB (i.e., non-sex-specific) to reach stock, quality, and preferred sizes for waterbodies included in this project are presented in Table 2 below. This table illustrates variation in LMB growth rates among waterbodies.

Table 2: Average time in years for LMB to reach stock, quality, and preferred sizes (Growth_type). Average times are sorted from lowest to highest with False River results highlighted.

Waterbody	Growth_type	Years	Season	Time_yrs
Poverty	t_stock	2010-12	Spring	0.73
Concordia	t_stock	2010-12	Spring	0.91
False	t_stock	2010-12	Spring	0.94
D'Arbonne	t_stock	2010-12	Spring	1.04
Toledo	t_stock	2010-12	Spring	1.14
Black/Clear	t_stock	2010-12	Spring	1.15
Vernon	t_stock	2010-12	Spring	1.16
Cross	t_stock	2010-12	Spring	1.22
Atchafalaya	t_stock	2009-11	Fall	1.28
Chicot	t_stock	2010-12	Spring	1.29
Cataouatche	t_stock	2010-12	Spring	1.30

Waterbody	Growth_type	Years	Season	Time_yrs
Poverty	t_quality	2010-12	Spring	1.56
Concordia	t_quality	2010-12	Spring	1.89
False	t_quality	2010-12	Spring	2.00
D'Arbonne	t_quality	2010-12	Spring	2.12
Chicot	t_quality	2010-12	Spring	2.12
Toledo	t_quality	2010-12	Spring	2.19
Vernon	t_quality	2010-12	Spring	2.20
Black/Clear	t_quality	2010-12	Spring	2.26
Cross	t_quality	2010-12	Spring	2.27
Cataouatche	t_quality	2010-12	Spring	2.39
Atchafalaya	t_quality	2009-11	Fall	2.46

Waterbody	Growth_type	Years	Season	Time_yrs
Poverty	t_preferred	2010-12	Spring	2.57
Concordia	t_preferred	2010-12	Spring	3.08
Chicot	t_preferred	2010-12	Spring	3.27
Toledo	t_preferred	2010-12	Spring	3.35
False	t_preferred	2010-12	Spring	3.36
D'Arbonne	t_preferred	2010-12	Spring	3.39
Vernon	t_preferred	2010-12	Spring	3.44
Cross	t_preferred	2010-12	Spring	3.48
Black/Clear	t_preferred	2010-12	Spring	3.58
Cataouatche	t_preferred	2010-12	Spring	3.77
Atchafalaya	t_preferred	2009-11	Fall	3.90

Size Structure Indices: Mean proportional size distribution indices (PSD-Q and PSD-P) of LMB collected over the three year electrofishing sampling period for waterbodies included in this project are presented in Table 3 below. This table illustrates variation in PSD indices among LA LMB populations.

Table 3: LMB proportional size distribution indices (PSD-Q and PSD-P), upper and lower 95% confidence intervals (CI), and years and season of electrofishing collections. Size structure indices are sorted from highest to lowest with False River results highlighted.

Waterbody	Years	Season	PSD-Q	L95%CI	U95%CI
Poverty	2010-12	Spring	82.3	79.5	85.1
False	2010-12	Spring	74.4	72.0	76.9
Cross	2010-12	Spring	71.2	68.5	73.8
Chicot	2010-12	Spring	67.7	63.8	71.6
Concordia	2010-12	Spring	67.3	64.2	70.3
D'Arbonne	2010-12	Spring	60.7	56.8	64.6
Toledo	2010-12	Spring	51.2	49.4	53.1
Black/Clear	2010-12	Spring	40.8	37.5	44.0
Atchafalaya	2009-11	Fall	37.7	33.8	41.6
Cataouatche	2010-12	Spring	36.7	33.1	40.3
Vernon	2010-12	Spring	30.3	26.3	34.2

Waterbody	Years	Season	PSD-P	L95%CI	U95%CI
Poverty	2010-12	Spring	59.6	56.0	63.2
Cross	2010-12	Spring	39.2	36.4	42.1
Chicot	2010-12	Spring	38.7	34.6	42.8
Concordia	2010-12	Spring	32.5	29.5	35.5
D'Arbonne	2010-12	Spring	22.3	19.0	25.6
False	2010-12	Spring	15.4	13.4	17.5
Black/Clear	2010-12	Spring	12.7	10.5	15.0
Toledo	2010-12	Spring	11.9	10.7	13.1
Cataouatche	2010-12	Spring	9.2	7.0	11.3
Vernon	2010-12	Spring	8.7	6.2	11.1
Atchafalaya	2009-11	Fall	5.2	3.4	7.0

Length/Weight Relationship: Observed and predicted LMB weight at total length developed from False River fishery independent surveys (2010-2012) are presented in Figure 3 below.

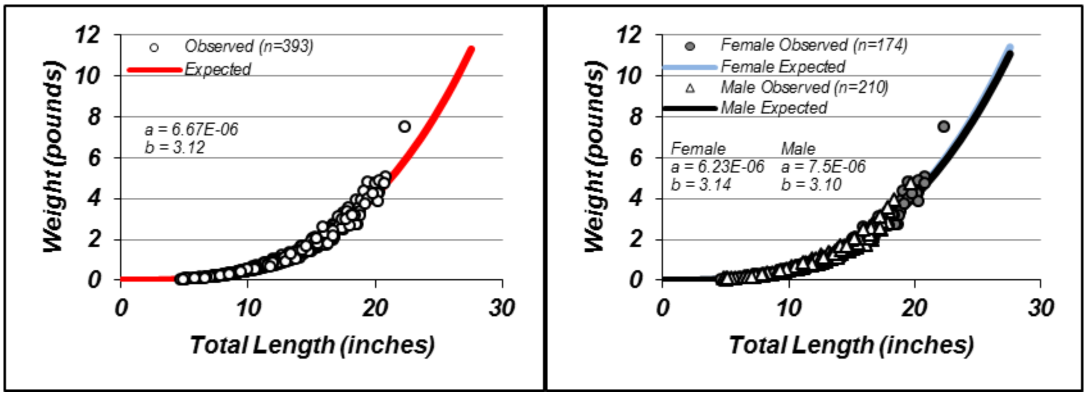

Figure 3: Observed and predicted weight at total length of False River largemouth bass 2010-2012. Parameter estimates for the power function $W = aTL^b$ and sample sizes (n) used in model fitting are presented in each graphic. Right graphic depicts sex-specific weight-length relationships and parameter estimates.

Condition: Mean relative weights of stock, quality and preferred sized LMB collected from electrofishing surveys for waterbodies included in this project are presented in Table 4 below. This table illustrates variation in condition indices among LA LMB populations.

Table 4: Mean relative weights (W_r) of stock, quality and preferred size LMB (listed under Size) as three-year averages. Upper and lower 95% confidence intervals (CI), and years and season of electrofishing collections are also presented. Mean relative weights are sorted from highest to lowest with False River results highlighted.

Waterbody	Size	Years	Season	Wr	L95%CI	U95%CI
Cross	Stock	2010-12	Spring	107.9	106.7	109.1
Concordia	Stock	2010-12	Spring	107.6	103.1	112.1
Atchafalaya	Stock	2009-11	Fall	106.6	105.8	107.5
Black/Clear	Stock	2010-12	Spring	105.7	103.9	107.5
Toledo	Stock	2010-12	Spring	103.4	102.5	104.3
False	Stock	2010-12	Spring	100.0	99.0	101.0
Poverty	Stock	2010-12	Spring	99.7	97.1	102.4
D'Arbonne	Stock	2010-12	Spring	99.7	97.3	102.1
Cataouatche	Stock	2010-12	Spring	99.4	98.1	100.6
Chicot	Stock	2010-12	Spring	98.7	97.1	100.3
Vernon	Stock	2010-12	Spring	97.7	96.4	99.0

Waterbody	Size	Years	Season	Wr	L95%CI	U95%CI
Poverty	Quality	2010-12	Spring	111.2	109.4	113.0
Atchafalaya	Quality	2009-11	Fall	107.4	106.0	108.9
Cross	Quality	2010-11	Spring	105.6	104.4	106.8
Concordia	Quality	2010-12	Spring	102.7	101.3	104.0
Chicot	Quality	2010-12	Spring	101.9	100.1	103.7
Black/Clear	Quality	2010-12	Spring	99.1	97.8	100.5
Toledo	Quality	2010-12	Spring	99.0	98.4	99.6
D'Arbonne	Quality	2010-12	Spring	97.6	96.2	99.1
Cataouatche	Quality	2010-12	Spring	95.8	94.5	97.2
Vernon	Quality	2010-12	Spring	95.1	93.5	96.7
False	Quality	2010-12	Spring	92.1	91.4	92.8

Waterbody	Size	Years	Season	Wr	L95%CI	U95%CI
Poverty	Preferred	2010-12	Spring	114.7	113.5	116.0
Atchafalaya	Preferred	2009-11	Fall	109.3	104.3	114.3
Cross	Preferred	2010-11	Spring	105.7	104.7	106.7
Concordia	Preferred	2010-12	Spring	103.9	102.4	105.3
Cataouatche	Preferred	2010-12	Spring	99.5	96.5	102.6
Chicot	Preferred	2010-12	Spring	98.4	96.6	100.3
Black/Clear	Preferred	2010-12	Spring	98.0	96.3	99.7
Toledo	Preferred	2010-12	Spring	97.3	96.2	98.4
Vernon	Preferred	2010-12	Spring	96.7	93.3	100.1
D'Arbonne	Preferred	2010-12	Spring	94.0	91.6	96.3
False	Preferred	2010-12	Spring	91.9	90.5	93.2

Recruitment: Coefficients of variation describing the magnitude of variation in annual mean age-1 spring electrofishing catch rates for waterbodies included in this project are presented in Table 5 below. This table illustrates variation in inter-annual recruitment among LA LMB populations

Table 5: Coefficients of variation describing the magnitude of variation in mean annual age-1 electrofishing catch rates. Also presented are years and season of LMB electrofishing collections. Coefficients of variation are sorted from lowest to highest with False River results highlighted.

Waterbody	Years	Season	CV
D'Arbonne	2010-12	Spring	10
Cross	2010-12	Spring	24
Toledo	2010-12	Spring	28
Cataouatche	2010-12	Spring	42
Poverty	2010-12	Spring	49
False	2010-12	Spring	52
Concordia	2010-12	Spring	59
Vernon	2010-12	Spring	70
Chicot	2010-12	Spring	73
Black/Clear	2010-12	Spring	96
Atchafalaya	2009-11	Fall	116

Mortality: Total catch at age, mean CPUE at age, and corresponding 95% confidence intervals for the spring False River electrofishing survey (2010-2012) are presented in Table 6 below. The shaded area identifies ages included in the catch curve analysis. Age-1 catches were considered not fully-recruited to LDWF electrofishing gear and excluded from model fitting.

Table 6: Total catch, mean total length (TL) and mean catch per unit effort (CPUE) at age for the False River largemouth bass spring electofishing survey (2010-2012). Shaded area represents ages included in the catch curve analysis.

Age	Catch	TL (inches)	CPUE	L95%CI	U95%CI
0					
1	264	8.2	19.9	15.5	24.3
2	497	11.8	45.3	32.8	57.7
3	156	14.3	10.4	8.5	12.3
4	236	16.0	16.7	14.1	19.4
5	68	17.1	5.6	4.6	6.5
6	23	17.9	1.6	1.2	2.0
7	9	18.4	0.6	0.3	0.9
8	3	18.7	0.2	0.1	0.3
9	2	19.0	0.2	-0.1	0.4

Observed and predicted mean log_eCPUE at age of LMB collected from False River spring electrofishing surveys (2010-2012) are presented in Figure 4 below.

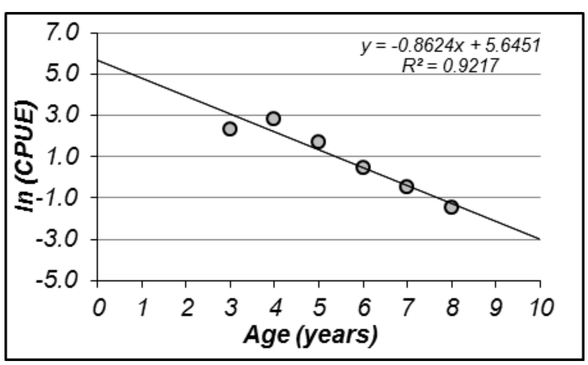

Figure 4: Observed (circles) and predicted (line) mean log_e catch per unit effort of the False River largemouth bass spring electrofishing survey (2010-2012). The catch curve equation and coefficient of determination (R^2) are presented in graphic.

Instantaneous and interval total, natural, and fishing mortality rate estimates for the False River LMB population (2010-2012) are presented in Table 7 below.

Table 7: False River LMB mortality estimates, upper and lower 95% confidence intervals (CI), and derivation descriptions.

Mortality Type		Estimate	L95%CI	U95%CI	Derivation
Z (total)	Instantaneous	-0.86	-1.21	-0.51	Catch curve (ages 3-8)
M (natural)	Instantaneous	-0.47	.	.	4.22 / t_{max}
F (fishing)	Instantaneous	-0.39	.	.	Z-M
AM (total)	Interval	0.58	0.40	0.70	1-exp^{Z}
v (natural)	Interval	0.31	.	.	M*AM/Z
u (fishing)	Interval	0.26	.	.	F*AM/Z

Total instantaneous and interval mortality rate estimates for LMB populations included in this project are presented in Table 8 below. This table illustrates variation in total mortality rate estimates among LA LMB populations.

Table 8: Total instantaneous (Z) and interval (A) mortality rates for waterbodies included in this project, ages included in each catch curve, 95% confidence intervals, years of electrofishing collections, and current size limit regulations. Estimates are sorted from lowest to highest with False River results highlighted. Note: Total mortality for the Atchafalaya LMB population was not estimable following the methodology detailed in this report.

Waterbody	Years	Ages	Size Regulation	Z	L95%CI	U95%CI	A	L95%CI	U95%CI
Chicot	2010-12	2,5-9	14-17" PSL	-0.42	-0.71	-0.12	0.34	0.12	0.51
Poverty	2010-12	2,6-11	15-19" PSL	-0.42	-0.59	-0.26	0.34	0.23	0.44
Cross	2010-12	2,3,5-9	14-17" PSL	-0.66	-0.92	-0.40	0.48	0.33	0.60
Vernon	2010-12	2,3,5-7	14-17" PSL	-0.69	-0.94	-0.43	0.50	0.35	0.61
Concordia	2010-12	2-8	None	-0.69	-0.97	-0.42	0.50	0.34	0.62
Black/Clear	2010-12	2-8	None	-0.83	-1.07	-0.58	0.56	0.44	0.66
D'Arbonne	2010-12	2-7	None	-0.83	-0.94	-0.72	0.57	0.52	0.61
False	2010-12	3-8	14" MinLL	-0.86	-1.21	-0.51	0.58	0.40	0.70
Cataouatche	2010-12	2-7	None	-0.90	-1.00	-0.80	0.59	0.55	0.63
Toledo	2010-12	3-8	14" MinLL	-1.04	-1.14	-0.94	0.65	0.61	0.68

Maximum observed age for LMB populations included in this project are presented in Table 9 below. This table illustrates variation in longevity among LA LMB populations.

Table 9: Maximum observed age of LMB for waterbodies included in this project,and years of electrofishing collections. Maximum observed ages are sorted from highest to lowest with False River results highlighted.

Waterbody	Age_max	Years
Cross	12	2010-12
Poverty	11	2010-12
Toledo	11	2010-12
D'Arbonne	10	2010-12
Vernon	10	2010-12
Chicot	10	2010-12
False	9	2010-12
Atchafalaya	9	2009-11
Black/Clear	8	2010-12
Concordia	8	2010-12
Cataouatche	7	2010-12

Instantaneous and interval fishing mortality rate estimates (F and u respectively) for LMB populations included in this project are presented in Table 10 below. This table illustrates variation in fishing mortality rate estimates among LA LMB populations.

Table 10: Instantaneous and interval fishing mortality rate estimates ($F$and u) for waterbodies included in this project, ages included in each catch curve, years of electrofishing collections, and current size limit regulations. Estimates are sorted from highest to lowest with False River results highlighted. Note: Fishing mortality for the Atchafalaya LMB population was not estimable following the methodology detailed in this report.

Waterbody	Size Regulation	Years	Ages	F	u
Toledo	14" MinLL	2010-12	3-8	-0.66	0.41
D'Arbonne	None	2010-12	2-7	-0.41	0.28
False	14" MinLL	2010-12	3-8	-0.39	0.26
Cataouatche	None	2010-12	2-7	-0.37	0.25
Cross	14-17" PSL	2010-12	2,3,5-9	-0.31	0.23
Black/Clear	None	2010-12	2-8	-0.30	0.20
Vernon	14-17" PSL	2010-12	2,3,5-7	-0.26	0.19
Concordia	None	2010-12	2-8	-0.17	0.12
Poverty	15-19" PSL	2010-12	2,6-11	-0.04	0.03
Chicot	14-17" PSL	2010-12	2,5-9	-0.03	0.03

Fishery Characteristics

A LDWF creel survey was conducted on False River from January through December 2010. Estimates of the percent retention of legal sized LMB for waterbodies included in this project are provided in Table 11 below. Estimates represent LMB anglers only.

Table 11: Percent retention of legal sized LMB and creel survey year(s) for waterbodies included in this project. Results are sorted from highest to lowest with False River results highlighted.

Waterbody	Metric	Estimate	Year(s)
Toledo	%LMB_retained (legal sizes only)	61.2	2009,10
Concordia	%LMB_retained (legal sizes only)	46.4	2010
Black/Clear	%LMB_retained (legal sizes only)	46.3	2010
Cataouatche	%LMB_retained (legal sizes only)	24.8	2010,11
Chicot	%LMB_retained (legal sizes only)	22.8	2010,11
D'Arbonne	%LMB_retained (legal sizes only)	17.5	2011
Vernon	%LMB_retained (legal sizes only)	17.2	2010
False	%LMB_retained (legal sizes only)	12.8	2010
Atchafalaya	%LMB_retained (legal sizes only)	10.6	2009
Cross	%LMB_retained (legal sizes only)	8.0	2010
Poverty	%LMB_retained (legal sizes only)	7.8	2012

Population Simulations

Parameter values used in the False River LMB age and sex structured simulation model are presented in Table 12 below.

Table 12: Parameter values used in the False River age and sex structured LMB population simulations.

Parameter	Description	Values
Age_max	Longevity (years)	9
M	Instantaneous natural mortality rate (years^{-1})	0.47
F	Instantaneous fishing mortality rate (years^{-1})	0 to 2.0
%retention	Retention rate of legal sized LMB	13%
d	Discard mortality rate (proportion not surviving)	0.1
R	Constant recruitment	10000
Lvul	Length at recruitment to fishery (inches)	8.0
Linf_female	Female asymptotic average maximum length (inches)	21.04
K_female	Female von Bertalanffy growth coefficient	0.35
t0_female	Female von Bertalanffy time at zero TL (years)	-0.39
a_female	Female length-weight constant	6.23E-06
b_female	Female length-weight allometric parameter	3.14
Linf_male	Male asymptotic average maximum length (inches)	17.20
K_male	Male von Bertalanffy growth coefficient	0.52
t0_male	Male von Bertalanffy time at zero TL (years)	-0.24
a_male	Male length-weight constant	7.50E-06
b_male	Male length-weight allometric parameter	3.10

Simulation results illustrating the effect of four size regulations: 1) no length limit, 2) a 14 inch minimum length limit, 3) a 17 inch maximum length limit, and 4) a 14 to 17 inch protected slot limit on the False River LMB fishery are presented in Figures 5 and 6 below.

Figure 5 illustrates the effect of each simulated size regulation on False River LMB total catch (i.e., harvest + releases), total catch of individuals ≥ 15 inches (preferred size), and total catch of individuals ≥ 20 inches (memorable size) as a function of instantaneous fishing mortality.

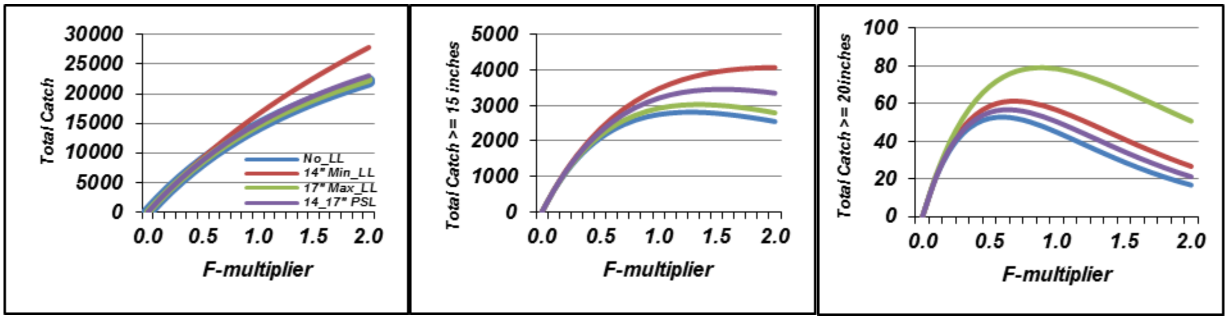

Figure 5: Model results illustrating the effect of four simulated size regulations (i.e., no length limit, a 14 inch minimum length limit, a 17 inch maximum length limit, and a 14-17 inch protected slot limit) on False River LMB total catch, and total catch ≥15 and 20 inches versus instantaneous fishing mortality (F-multiplier). A 13% retention rate estimate of legal sized LMB derived from the False River creel survey was applied in this simulation. Note: Units are relative to constant recruitment of 10,000 individuals.

Figure 6 illustrates the effect of each simulated size regulation on False River LMB total catch ≥ 15 inches as a function of instantaneous fishing mortality at three different retention rates of legal sized LMB, i.e. high (100%), moderate (50%), and low (5%). These results demonstrate the efficacy of size regulations across a range of retention rates of legal sized LMB.

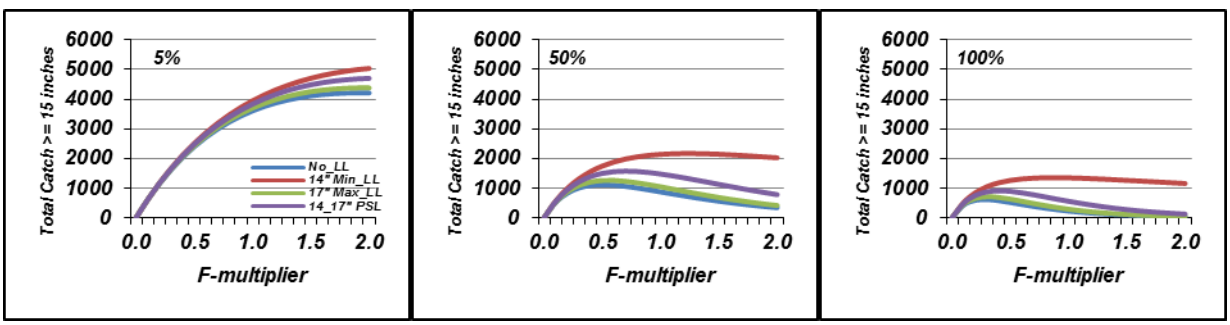

Figure 6: Model results illustrating the effect of four simulated size regulations (i.e., no length limit, a 14 inch minimum length limit, a 17 inch maximum length limit, and a 14-17 inch protected slot limit) on False River LMB total catch ≥ 15 inches versus instantaneous fishing mortality (F-multiplier). Each graphic represents a different retention rate of legal sized LMB (from left to right; 5, 50 and 100% respectively). Note: Units are relative to constant recruitment of 10,000 individuals.

Figure 7 illustrates the effects of a 14 inch minimum length limit on LMB total catch (left graphic), total catch of LMB ≥ 15 inches (center graphic), and total catch of LMB ≥ 20 inches (right graphic) as functions of instantaneous fishing mortality for three LA LMB population types: 1) fast growth and low natural mortality rates (Poverty Point Reservoir), 2) moderate growth and natural mortality rates (Vernon Lake), and slow growth and high natural mortality rates (Lake Cataouatche). Each population type was parameterized with each population’s sex-specific von Bertalanffy and weight-length relationship parameter estimates. Each population was simulated with the same TL at recruitment to the fishery (8 inches) and the average fishery retention rate of legal sized LMB for all waterbodies included in this study (25%). These results demonstrate size regulation effectiveness for various LA LMB population types.

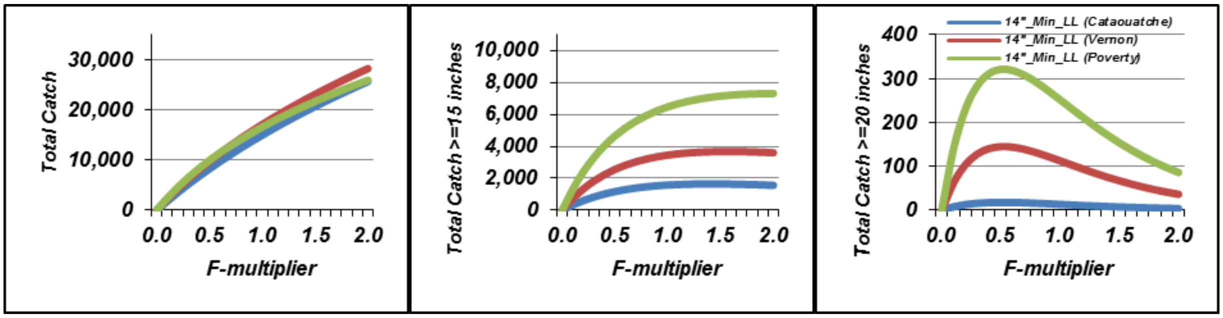

Figure 7: Model results for three LA LMB population types: 1) fast growth and low natural mortality rate (Poverty Point Reservoir), 2) moderate growth and natural mortality rates (Vernon Lake), and 3) slow growth and high natural mortality rates (Lake Cataouatche) illustrating the effects of a 14 inch minimum length limit on LMB total catch (left graphic), total catch of LMB ≥ 15 inches (center graphic), and total catch of LMB ≥ 20 inches (right graphic) versus instantaneous fishing mortality (F-multiplier). Each population was simulated with a 25% retention rate of legal sized LMB.

Discussion:

Population Characteristics:

Growth: An examination of Table 2 shows the False River LMB population has a relatively fast growth rate compared to other waterbodies included in this project. The time in years to reach stock, quality and preferred sizes for the False River LMB population (0.9, 2.0, and 3.4 years, respectively) are slightly higher than the population exhibiting the fastest growth rate (Poverty Point Reservoir; 0.7, 1.6, and 2.6 years, respectively), but lower than the population with the slowest growth rate (Atchafalaya Basin; 1.3, 2.5, and 3.9 years respectively). The Bayou D'Arbonne Lake LMB population has the most similar growth rate (i.e., 1.0, 2.1, and 3.4 years, respectively).

The method of von Bertalanffy model fitting used in this assessment assumed that the data are representative samples of lengths from each age-class. If this assumption fails (e.g., size-selective sampling and cumulative effects of fishing mortality), model parameters can only describe the current population available to harvest (Taylor et al. 2005). In other words, the current VBGF fitting methodology may underestimate growth when faster growing individuals are removed from the population disproportionaly due to size-selective fishing mortality. If determining potential growth rates under a no harvest scenario is of interest, then the methodology detailed in Taylor et al. (2005) could be used in future analyses.

Size Structure Indices: An examination of Table 3 indicates the False River LMB population has a higher proportion of individuals that are larger than quality size than most other waterbodies included in this project. The False River proportional size distribution (PSD) index for quality and larger sized fish (PSD-Q; 74) is slightly less than the highest estimate (Poverty Point Reservoir; 82). The False River PSD index for preferred and larger sized fish (PSD-P; 15) is substantially lower than the population with the highest estimate (Poverty Point Reservoir; 60). When compared to other populations in this project, the False River LMB population is unique in that it has a high PSD-Q and a low PSD-P. This could be explained by the strong 2009 cohort (Figure 1), natural mortality, and/or high fishing mortality of preferred size LMB given the 14 inch minimum length limit.

Optimum ranges of PSD indices have been proposed for maintaining balanced LMB populations (Neumann et al. 2012). The False River estimate for quality size LMB (PSD-Q = 74) falls above the recommended range (PSD: 40-70). The False River estimate for preferred sized LMB (PSD-P = 15) is at the lower end of the recommended range (PSD-P: 10-40). Indices falling outside these ranges may indicate unstable LMB recruitment, growth, and mortality, or that population density is above optimum levels.

An important assumption in obtaining unbiased estimates of PSD indices is that samples are representative of the standing LMB population size structure. If this assumption fails (e.g., dome-shaped vulnerability to survey gear where older fish are not fully represented in samples), estimates will be biased low. This is an important limitation not only for unbiased estimates of population size structure, but also for obtaining accurate estimates of age-specific relative abundance and subsequent estimates of total mortality.

Condition: Table 4 presents size-specific mean relative weight estimates for waterbodies included in this project. The False River mean W_r estimate for stock size fish (101) is within the recommended range (95-105) of a balanced LMB population (Neumann et al. 2012); however, estimates for quality and preferred size fish (both 93) are below this range and the lowest when compared with other project waterbodies. Mean W_r estimates well below 100 may indicate a problem with prey availability or feeding conditions (Neumann et al. 2012).

Recruitment: False River LMB recruitment can be considered moderately variable (CV=52; Table 5). The Bayou D'Arbonne Lake LMB population exhibited the most stable recruitment (CV=10) of the waterbodies included in this project, whereas the Atchafalaya Basin population exhibited the largest variability in recruitment (CV=116).

Via simulation analysis, Allen and Pine (2000) demonstrate that LMB population responses to length limit implementation are often obscured by variable recruitment. Their results suggest that populations with above average recruitment variability may not have detectable responses to length limit implementation, unless the regulation change is significant. False River inter-annual recruitment variability was moderate compared to other populations included in this study; however, each coefficient of variation was estimated with only three years of data. Future analyses incorporating annual age-1 CPUE data over a longer time-series will allow a more accurate assessment of recruitment variability in and among LA LMB populations.

Mortality: The False River LMB population has the third highest estimate of total mortality (Z=-0.86/year; A=0.58/year) when compared to the other populations included in this project (Table 8). The lowest total mortality rate (Z=-0.42/year; A=0.34/year) is estimated for the Chicot Lake LMB population; the highest estimate (Z=-1.04/year; A=0.65/year) is for the Toledo Bend Reservoir LMB population. Of the waterbodies included in this project, LMB populations with fisheries currently managed with protected slot limits have the lowest total mortality estimates.

To obtain unbiased estimates of total mortality rates via catch curve analysis, three assumptions must be met: 1) mortality is constant across ages, 2) recruitment is constant, and 3) samples are representative of the true age structure in the population. The first two assumptions are rarely met, but their impacts are lessened in this assessment as described in *Methods*. If the third assumption of representative sampling is not met (e.g., dome-shaped vulnerability to survey gear), mortality rate estimates will be biased. Future efforts utilizing mark and recapture techniques could be initiated to elucidate size-specific LMB vulnerability to LDWF electrofishing gear.

The maximum observed age of the False River LMB population was 9 years (Table 9). The Cross Lake population has the oldest age observed (12 years), and Lake Cataouatche has the lowest maximum age observed (7 years). Given the approximation of M from equation [8], LMB populations with low maximum observed ages correspond to higher estimates of M; populations with high maximum observed ages correspond to lower estimates of M. However, if exploitation is high in the population in question, and all ages are considered exploitable, equation [8] is unlikely to provide a reliable estimate of M.

The False River LMB population has a relatively high fishing mortality rate (F=-0.39/year; u=0.26/year) when compared to other LMB populations included in this project (Table 10). The lowest fishing mortality rate estimate is for the Chicot Lake LMB population (F=-0.03/year; u=0.03/year); the highest estimate (F=-0.66/year; u=0.41/year) is for the Toledo Bend Reservoir LMB population. Fishing mortality rate estimates presented in this report are approximated by difference (i.e., $Z - M$). If approximation of M from equation [8] is unreliable due to high exploitation, fishing mortality estimates would also be considered uncertain. Future efforts to directly estimate M could reduce this uncertainty.

Fishery Characteristics

The annual estimate of the percent of legal sized LMB retained from the False River fishery was 13% (Table 11). The highest estimates were for the Toledo Bend Reservoir (61%), Lake Concordia (46%), and Black/Clear Lake (46%); indicating moderate levels of harvest in these fisheries. The lowest estimates were for Cross Lake and Poverty Point Reservoir (both 8%); indicating low levels of harvest in these fisheries. The percent of legal sized LMB retained, averaged across fisheries included in this project, was 25% (i.e., a 75% voluntary catch and release rate).

Population Simulations:

Population simulations presented in this report are based on equilibrium conditions (i.e., long-term averages) and do not include more complex dynamics such as recruitment variability, density dependent growth, and environmental conditions.

Simulation results presented in Figure 5 indicate that length limit restrictions would have negligible effects on False River LMB catches (i.e., total catch and total catches $\geq$ 15 and 20 inches) at low levels of fishing mortality. At moderate to high levels of fishing mortality, total catch and total catch of LMB $\geq$ 15 inches could be maximized with a 14 inch minimum length limit, whereas total catch of LMB $\geq$ 20 inches could be maximized with a 17 inch maximum length limit. The estimate of F for the False River LMB population is 0.39/year.

In recent decades, a voluntary catch-and-release ethic has become popular among LMB anglers (Quinn 1996). The estimated percent of legal sized LMB retained for the False River fishery (13%) indicates a moderate to high level of voluntary catch and release (87%). Simulation results presented in Figure 6 demonstrate the consequence of increasing voluntary catch and release rates on LMB catches $\geq$ 15 inches. As voluntary catch and release increases, simulated catches increase substantially due to higher abundance in the population (i.e., less fish are removed). However, the effectiveness of length limit regulations is substantially reduced as voluntary catch and release rates increases, where much higher levels of F (i.e., effort) are needed to detect differences in fishery response (i.e., catches) for each simulated size regulation. A discard mortality rate of 10% is applied in all simulations. If discard mortality is higher in fisheries with greater levels of voluntary catch and release then the potential benefits of this practice (i.e., higher catches) would be reduced.

Simulation results presented in Figure 7 clearly show that LMB populations with fast growth and low natural mortality rates support fisheries with considerably higher total catches of LMB $\geq$ 15 and 20 inches when compared to fisheries of populations with slower growth and higher natural mortality rates (center and right graphics). These results support earlier work of Beamesderfer and North (1995) and Allen et al. (2002), who found that LMB populations characterized by slow growth and high natural mortality rates have the least potential for desirable population responses from length limit implementation.

Conclusions

It is important to note that LMB populations and their fisheries are not only influenced by fishing effort, but also by anthropogenic and environmental factors. The type and degree of human activity within watersheds, riparian zones, and specific waterbodies can affect LMB populations by altering critical habitats. Additional factors influencing LMB populations include aquatic vegetation coverage, water level management, supplemental LMB stocking programs, and habitat improvements. The frequency of floods, drought, and hurricanes can also influence LMB populations. While consideration of these factors are important in effective fisheries management, evaluating how these factors affect the False River LMB population/fishery is beyond the scope of this report.

The False River LMB population has a moderate maximum age, fast growth rate, high mortality rate, with moderate recruitment variability when compared with the other LMB populations included in this project. The prevalence of voluntary catch and release in the False River LMB fishery is high. The False River LMB fishery is currently managed with a 14 inch minimum length limit and a five fish per day harvest limit. The current size regulation is precautionary, allowing LMB to spawn at least once before harvest. However, given the dynamics of the False River LMB population and fishery, the existing 14 inch minimum length limit has minor influence on fishery catches. At current levels of fishing mortality, the existing size limit produces fishery catches (and catches greater then preferred size) similar to the other simulated size regulations. Unless fishing mortality increases, we expect no benefit to the fishery from the current regulation. Furthermore, if anglers remain hesitant to harvest LMB of legal size, the effectiveness of any size regulation to manage the False River LMB population is severely limited.

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