Lake Nacogdoches, Texas: A Case History of Largemouth Bass Overharvest and Recovery Utilizing Harvest Regulations

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Abstract: Lake Nacogdoches was opened to fishing in 1978 with 254-mm minimum size and 10-fish daily bag limits for black basses (*Micropterus spp.*). Heavy fishing pressure likely resulted in initial overharvest of largemouth bass during the first 3 weeks after opening. To restore the population, 406-mm minimum length and 3-fish daily bag limits were imposed in 1979. Under these regulations, the bass densities increased, but stockpiling just below the minimum length occurred within 5 years. An experimental 381–533 mm slot length limit was implemented in 1985 and then adjusted in 1988 to the statewide, 356–533 mm slot length limit to allow harvest of the stockpiled bass and increase the number of quality-sized bass in the population. The population structure exhibited a decrease in the number of bass below the slot limit and an increase in the number of bass in the protected slot within 2 years and has remained stable since that time. Both length limit regulations accomplished their desired objectives for management of the largemouth bass population and fishery in the reservoir. The 406-mm minimum length limit protected the largemouth bass population and permitted it to rebuild to high densities. The slot length limit allowed anglers to harvest some of the stockpiled fish, increased the number of bass within the protected slot, and provided excellent catch-and-release angling for quality-sized fish. However, none of the regulations appeared to increase the densities or catch of largemouth bass over 533 mm.

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Lake Nacogdoches is an 890-ha impoundment completed in 1977 on a tributary of the Angelina River in southeastern Texas. This municipal water supply reservoir is clear (average Secchi = 2 m), neutral to slightly alkaline (pH 6.8–7.2), and has mean and maximum depths of 3 m and 16 m, respectively. The reservoir basin was almost completely cleared of standing timber prior to impoundment. Florida largemouth bass (*Micropterus salmoides floridanus*) were stocked in 1977 at 250 fish per ha (Seidensticker 1985). Hydrilla (*Hydrilla verticillata*) was first identified in the reservoir in 1984 and coverage has ranged from 30% to over 50% since 1988.

Fishing was prohibited in the reservoir until the City of Nacogdoches opened public access on 15 December 1978. The lake was opened under the statewide harvest regulations for black basses (*Micropterus* spp.): 254-mm minimum length limit and a 10-fish daily bag limit (Seidensticker 1985). Local game wardens and city lake patrol officers reported heavy fishing pressure (300 or more boats per day) and high harvest rates immediately after the reservoir opened. Fishing success reportedly dropped rapidly after the first 2 weeks (T. Smith, Texas Parks and Wildl. Dep., Nacogdoches, pers. commun.). At the request of anglers and wardens, city authorities closed the reservoir to fishing on 15 January 1979 and reopened it on 15 April 1979. On 1 August 1979, black bass harvest regulations were changed to a 406-mm minimum length limit and a 3-fish daily bag limit. An experimental 381–533 mm slot length limit was instituted 1 September 1985. This limit was adjusted 1 September 1988 to the statewide 356–533 mm slot length limit. The objective of this paper is to document changes in the largemouth bass population and sport fishery associated with each regulation in Lake Nacogdoches.

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Methods

Electrofishing and rotenone sampling were used to evaluate the largemouth bass population during this study at Lake Nacogdoches. Age and growth analyses were conducted at various times during the study. The sport fishery associated with the 406-mm minimum length and slot length limits were evaluated using a spring (March–May) creel survey.

Electrofishing samples were collected in September 1978 (1.0-hour actual shocking time) and March 1983 (1.0 hour) using a 3,000-W generator producing 120 VAC. During March 1986–1990, electrofishing samples were conducted using a 4,000-W generator and a Coffelt VVP-15 Pulsator, producing approximately 300 V pulsed DC at 3–4 A. During March 1991–1993, samples were collected using a Smith-Root GPP 5,000-W electrofishing unit producing approximately 400 V pulsed DC at 5–6 A. All largemouth bass were individually weighed (g) and measured to the nearest mm total length. Population indices evaluated from electrofishing data included catch per unit effort (*N*/hour), Proportional Stock Density (PSD), Relative Stock Density of largemouth bass within the first protected slot length limit ($RSD_{381-533}$), Relative Stock Density of largemouth bass within the second protected slot length limit ($RSD_{356-533}$), and Relative Stock Density of bass above the protected slot length limit (RSD_{533+}). Otoliths were taken from 30 bass in 1988 and 1990 for age and growth analyses.

Rotenone sampling was conducted during August–September, 1980, 1981,

1984, 1985, and 1987. Either 2 or 3 cove samples were taken each year and the area sampled ranged from 1.54 ha to 2.37 ha. Two additional coves (1.42 ha) were sampled in 1987 to evaluate changes in population structure which occurred after the 381–533 mm slot length limit was implemented. Largemouth bass from cove samples were processed according to methods outlined in the TPWD Reservoir Survey Procedures Manual (1975). Scales were taken from 30 bass during 1980, 1981, and 1984 and otoliths were taken from 30 bass during 1985 and 1987 for age and growth analyses.

Indices evaluated from rotenone sample data were largemouth bass density (kg/ha and *N*/ha), Relative Stock Density (RSD_{406}) of largemouth bass exceeding the minimum length limit, and Relative Stock Density ($RSD_{305-405}$) of largemouth bass in the 100-mm size group just under the minimum length limit. $RSD_{305-406}$ was used to evaluate stockpiling of bass that could occur below the 406-mm minimum length limit. The variation in data collection protocol from electrofishing and rotenone samples precluded any statistical analysis.

A creel survey was conducted on the reservoir during March–May 1984–1988 and 1991–1992. Creel data were collected at all access points on 9 randomly-selected days (5 weekend days and 4 week days). During 1984 and 1985, surveys were conducted from sunrise to sunset. Fishing pressure was estimated using the total number of interviews each day. Catch and release data were obtained from each fishing party by asking them to estimate the number of bass, both above and below the minimum length limit, caught and released during their trip. In 1986, the survey period ran from 1200 hours to 1800 hours. In 1987, 1988, 1991, and 1992, the survey began at randomly-selected starting times between sunrise and 1400 hours and ran for 6 consecutive hours. Fishing pressure was estimated using roving angler counts at 3 randomly-selected times during each survey day. Catch-and-release data were obtained by asking each fishing party to estimate the number of bass, both within the protected size group (illegal-length fish) and the number of bass outside the protected size group (legal-length fish), caught and released during their trip. Creel surveys were conducted according to methods outlined in the TPWD Reservoir Survey Procedures Manual All data were analyzed according to methods outlined in the Texas Statewide Creel Survey Program.

Results and Discussion

254-mm Minimum Length Limit

Prior to the opening of Lake Nacogdoches, electrofishing samples indicated the largemouth bass population consisted of 2 size classes which included the largemouth bass stocked in 1977 plus any present in the stream before impoundment (254–356 mm total length) and the fish spawned in 1978 (75–178 mm total length). When the lake was opened to fishing in December 1978, harvest was directed at the larger size group.

The reported heavy harvest and apparent decline in fishing success indi-

cated a high percentage of the largemouth bass population was removed while the 254-mm minimum length and 10-fish daily bag limits were in effect. This "opening day effect," resulting in heavy initial harvest of existing largemouth bass populations, has been reported by several authors including Rawstron (1967), Rawstron and Hashagen (1972), Hoey and Redmond (1974), Redmond (1974), and Paragamian (1982).

406-mm Minimum Length Limit

Rotenone samples from 1980–1981 (Table 1) revealed relatively low biomass and low densities of bass >203 mm total length as well as low PSD's and low $RSD_{305-405}$'s. The biomass of largemouth bass more than doubled by 1984 and 1985 and densities of bass over 203 mm also increased. The high $RSD_{305-405}$ values in 1984 and 1985 indicated stockpiling of largemouth bass was occurring just below the 406-mm minimum length limit. Rasmussen and Michaelson (1974) reported similar results in small Missouri lakes placed under a 305-mm minimum length limit. The RSD_{406} never increased to more than 3 at any time while the 406-mm minimum length limit was in effect.

Age and growth analyses from 1980, 1981, and 1984 (Fig. 1) revealed a steady decline in length-at-age for Age 1, 2, and 3 largemouth bass under the 406-mm minimum length limit. Although the 1985 samples showed a sharp increase in length-at-age for these same age groups, these increases may be attributable to our first use of otoliths and possible errors in reading and/or measuring the annuli. The declines from 1980 to 1984 were further indications that stockpiling below the minimum length was occurring in Lake Nacogdoches. Similar declines were reported in several Missouri lakes (Rasmussen and Michaelson 1974).

Creel survey results from 1984 and 1985 showed relatively high total catch rates for largemouth bass, 0.78 and 0.72 bass per hour, respectively (Fig. 2); however, harvest rates were only about 0.05 and 0.03 bass per hour. These catch rates were similar to angler catch rates under the same minimum length limit at Tradinghouse Reservoir, Texas (Mitchell and Sellers 1989), and West Point Reservoir, Georgia (Ager 1989). Length distribution of largemouth bass harvested in 1985 (Fig. 3) showed most bass were just above the minimum length. However, the harvest also included bass up to 24 inches in length. Fishing pressure during the spring creel period was estimated to be 22.2 hours/ha in 1984

Table 1. Summary of largemouth bass population indices from rotenone samples, Lake Nacogdoches, Texas.

Year	Kg/ha	Total *N*/ha	*N*/ha >203mm	PSD	$RSD_{305-405}$	RSD_{406+}
1980	27.7	257	11	29	28	1
1981	20.3	205	17	12	11	1
1984	55.6	178	20	59	56	3
1985	47.8	119	20	63	61	2
1987	46.5	78	20	46	40	6

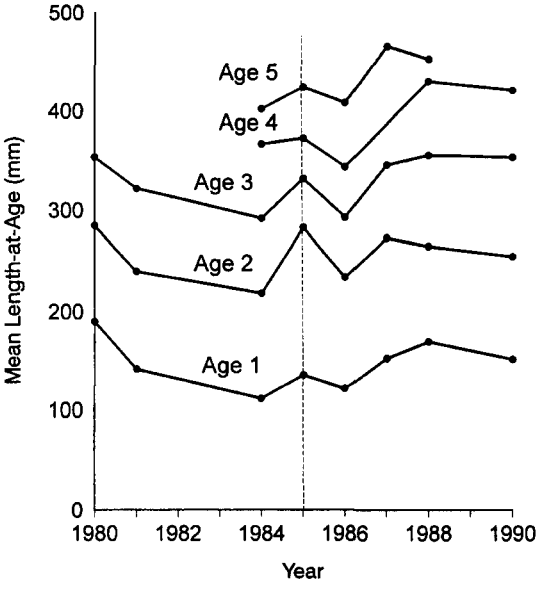

Figure 1. Mean length-at-age for largemouth bass by age class from selected sample years between 1980 and 1990, Lake Nacogdoches, Texas. Sample years included 1980, 1981, 1984–1988, and 1990. Dashed line indicates when minimum length limit was changed to slot length limit.

and then increased to 35.6 hours/ha in 1985. Increased fishing pressure in 1985 may have resulted from a lake record bass (6.37 kg) and several other bass >5.5 kg caught prior to the 1985 spring creel period.

381–533 mm and 356–533 mm Slot Length Limits

After implementation of the slot length limit in 1985, rotenone samples indicated that biomass of largemouth bass in Lake Nacogdoches had declined slightly by 1987 and the population structure indices had changed (Table 1). PSD and $RSD_{305-405}$ had declined since bass below 381 mm were now available for harvest and RSD_{406} had increased since these bass were now protected under the new slot length limit.

Electrofishing samples indicated the $RSD_{381-533}$ increased from 13 in 1983 to 26 in 1988 (Table 2). PSD values generally decreased from 71 in 1983 under the 406-mm minimum length limit to 49 in 1990 (except in 1987) under the slot length limits. These changes in population structure were similar to those reported for several heated Texas reservoirs including Lakes Calaveras and Monticello (Dean et al. 1991), Gibbons Creek Reservoir (Kurzawski and Durocher 1993), and Fayette County Lake (M. J. Ryan, TPWD, Marshall, Texas, unpubl. data). However, PSD values increased from 49 in 1990 to 75 in 1991 and 87 in 1992. $RSD_{356-533}$ also increased during these same years from 29 in 1990 to a high of 55 in 1992. These increases can probably be attributed to the additional protection of the 356–533 mm slot length limit. Largemouth bass over 533 mm were collected infrequently and RSD_{533+} never exceeded 3 during any sample period.

Age and growth analyses indicated that length-at-age for all year classes of

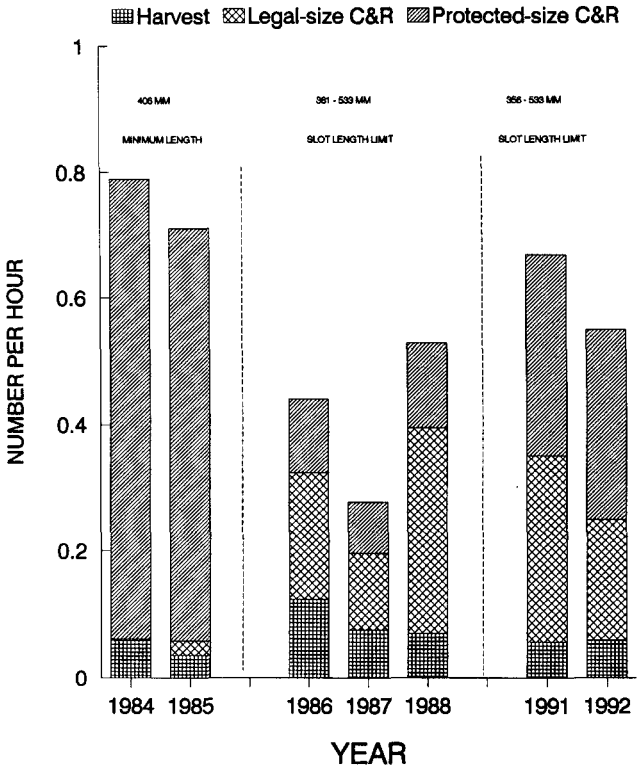

Figure 2. Angler catch rates, including harvest, catch and release of protected-length fish, and voluntary catch and release of legal-length fish, from spring creel surveys, Lake Nacogdoches, Texas.

bass generally improved under the slot length limits. This improvement suggests that the slot length limits corrected the stockpiling problems which had occurred under the 406-mm minimum length limit.

When the slot limit was first implemented and anglers were allowed to harvest smaller bass, the harvest rate doubled to 0.12 bass per hour in 1986, while catch and release of protected-length bass (381–533 mm total length) dropped to 0.12 bass per hour (Fig. 2). The low catch and release of protected-length bass would be expected since densities of bass within the slot had not yet had time to increase. All catch rates continued to decrease in 1987, but then began to rebound in 1988. By 1992, the harvest rate was only 0.04 bass per hour, but anglers were releasing legal bass at a rate of 0.25 bass per hour. Catch and release of protected-length bass had increased to 0.31 bass per hour. Total catch rate (0.60 bass per hour) had returned to a level somewhat lower than under the 406-mm minimum length limit. Mosher (1991) reported that Kansas lakes with minimum length limits had higher catch and release rates than lakes with slot length limits even though harvest was similar under both types of regulations.

Fishing pressure declined slightly to 26.2 hours/ha after the slot length limit was implemented in 1986, but then increased to 28.4 hours/ha in 1987 and 39.2

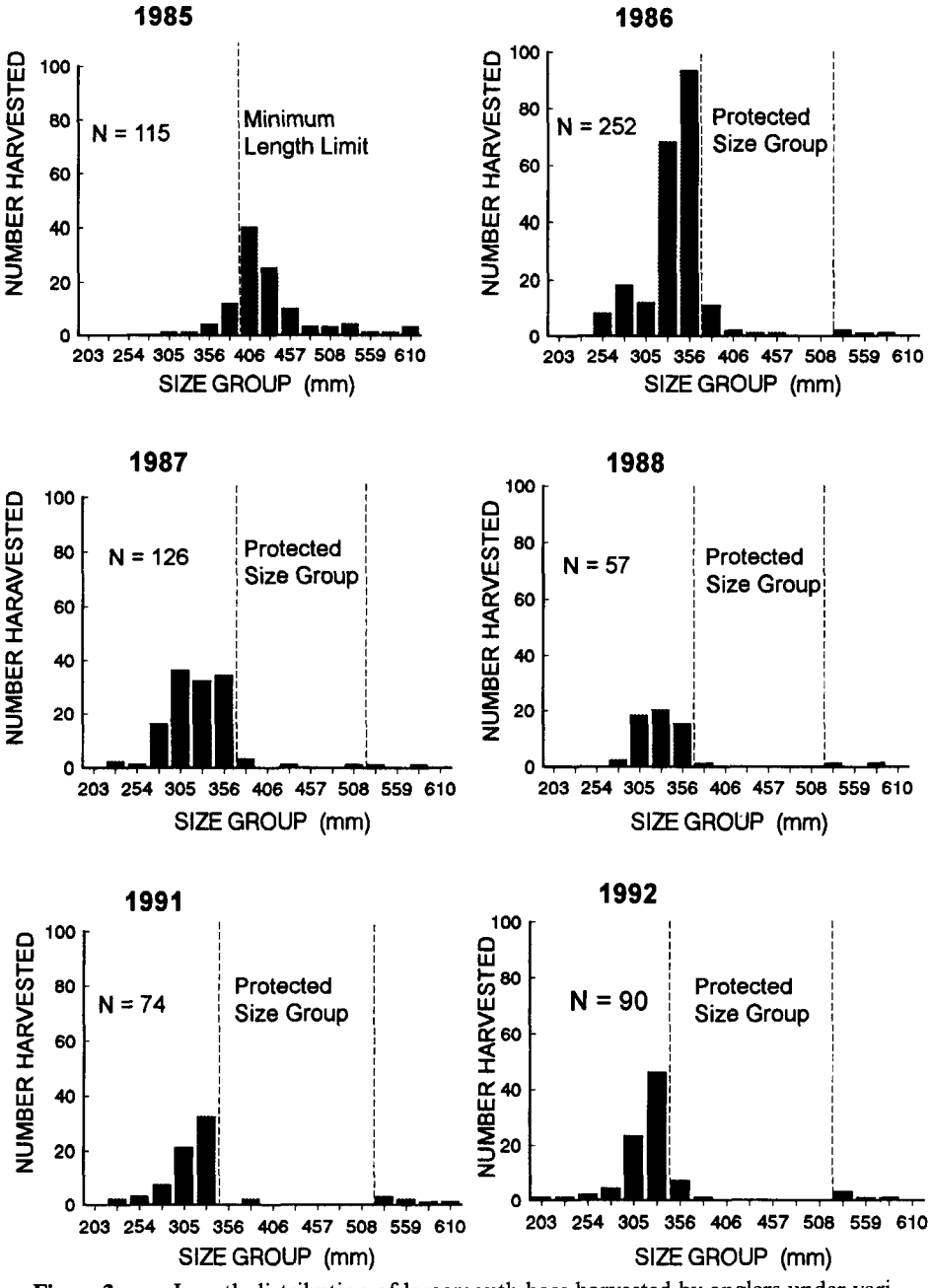

Figure 3. Length distribution of largemouth bass harvested by anglers under various length limits at Lake Nacogdoches, Texas.

Table 2. Summary of largemouth bass population indices from electrofishing samples, Lake Nacogdoches, Texas.

Year	*N*/hour	PSD	$RSD_{381-533}$	$RSD_{356-533}$	RSD_{533+}
1978[a]	64	32	0	0	0
1983[a]	24	71	9	21	0
1986[b]	22	51	17	22	0
1987[b]	53	72	21	33	1
1988[b]	50	52	26	26	0
1989[b]	85	58	23	31	3
1990[b]	80	49	22	29	0
1991[c]	181	75	27	34	1
1992[c]	114	87	42	55	1
1993[c]	189	75	31	42	0

[a]3,000-W generator producing 120 VAC.
[b]4,000-W generator and Coffelt VVP-15 pulsator producing 300 V pulsed D.C. at 3–4 A.
[c]5,000-W Smith-Root GPP 5.0 electrofishing unit producing 400 V pulsed D.C. at 5–6 A.

hours/ha in 1988. Creel surveys indicated a slight decrease in fishing pressure in 1991 to 34.3 hours/ha, but then showed a dramatic increase to 53.6 hours/ha in 1992. The largemouth bass population in Lake Nacogdoches was apparently sufficient to support the increasing fishing pressure while maintaining total catch rates at acceptable levels.

Under the slot length limits (1986–1992), most bass were harvested between 254 mm and 355 mm (Fig. 3). Largemouth bass exceeding 533 mm were not frequently seen in the creel. However, the catch-and-release ethic among bass anglers has grown and larger bass could have been released rather than harvested. This data was not collected during the creel surveys since anglers were not asked to differentiate between fish released above and below the protected slot limits.

Mean weight of bass harvested declined, as expected, after the minimum length limit was changed to the slot length limit in 1985 because anglers were harvesting smaller fish (Fig. 4). A large increase in the number and weight harvested per hectare was evident in 1986 after the length limit was changed. However, after initially harvesting large numbers of small bass, anglers began to practice voluntary catch and release of legal-length bass, resulting in a decline in harvest to pre-slot limit levels. These declines occurred despite apparent increases in the abundance of bass below the protected slot from 1987 to 1993. Voluntary catch and release of legal-sized bass, exceeding 10 percent of the total catch, will result in a decline in harvest, a decrease in total mortality of largemouth bass, and an increase in abundance of bass in the reservoir (Clark 1982).

Summary

The apparent initial overharvest of largemouth bass at Lake Nacogdoches occurred because of liberal length and bag limits on black basses. More restrictive size and bag limits would have lessened the initial impact and extended

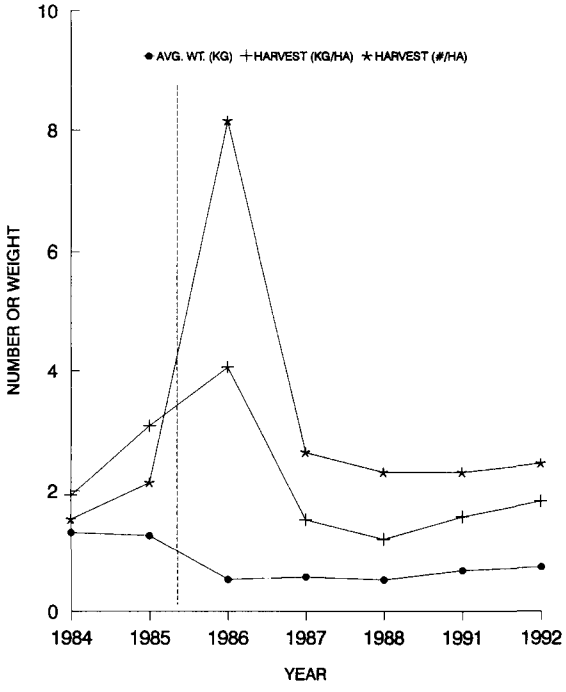

Figure 4. Estimated harvest and average weight of largemouth bass from spring creel survey data, Lake Nacogdoches, Texas. Dotted line denotes when 406-mm minimum length limit was changed to 381–533 mm slot length limit.

the period of good fishing (Buynak 1991). However, both types of length limit regulations utilized for recovery and management of the largemouth bass fishery produced the desired results.

The 406-mm minimum length limit protected the largemouth bass remaining in the lake and allowed the population to rebuild to a high density within 4 to 5 years before stockpiling occurred. The slot length limits allowed the abundance of largemouth bass to remain high while shifting the size distribution within the population toward larger fish. Similar changes in population structure were reported from Missouri by Eder (1984) and from Kansas by Gabelhouse (1987). Results of slot length limits in other states have varied from no impact to some improvement in bass populations (Nazary 1982, Gabelhouse 1984, Mosher 1986, Porak et al. 1988). The slot limits allowed anglers to harvest stockpiled bass below the protected slot and produced an excellent catch-and-release fishery for protected-length bass. Total catch rates were slightly higher under the 406-mm minimum length limit than under the slot length limits, but both types of regulation produced acceptable catch rates.

However, no data were collected that indicated any of the regulations increased the abundance of largemouth bass over 533 mm either in the population or in the creel. The production of largemouth bass exceeding 533 mm is probably more related to genetics and habitat than to harvest regulations.

In order to prevent initial overharvest of largemouth bass in a new reser-

voir, the fishery should be opened under a high minimum length limit. This will extend the period of good fishing and avoid the "opening day effect." If stockpiling of bass under the minimum length occurs within several years, then a slot length limit should be implemented to allow the anglers to harvest the stockpiled bass and shift the population structure towards larger fish.

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