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Use of Flathead Catfish to Reduce Stunted Fish Populations in a Small Kentucky Impoundment

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Abstract

Flathead catfish were stocked (3,990 total) from 2007-2011 in A.J. Jolly Lake, a 175-acre eutrophic impoundment located in Campbell County, Kentucky in an effort to improve bluegill and largemouth bass size structures. There was also an established gizzard shad population present in the lake throughout the study. Largemouth bass and bluegill were sampled with daytime 60 pps-DC electrofishing, along with flathead catfish when observed. Low pulse 15 pps-DC electrofishing was used in the summer in addition to jug-lines and trotlines to collect flathead catfish from 2008-14. Flathead catfish were identified as resident or Georgia stock by the absence or presence of an adipose fin clip. Largemouth bass and bluegill were separated into length groups for analysis of CPUE. The data was segregated into two time periods: sampling in 2007 and prior were analyzed as pre-flathead catfish stocking, while 2008 and after were analyzed as post-flathead catfish stocking. Comparisons of mean CPUE between periods for each length group were made using a repeated measures analysis of variance (ANOVA) using the MIXED procedure in SAS. Total CPUE for largemouth bass, as well as the 8.0-11.9 in length group significantly decreased post-flathead stocking. Bluegill CPUE in the 6.0-7.9 in length group also decreased significantly post-flathead stocking. A total of 331 flathead catfish were sampled from April-October 2008-2014. Seventy-one of the 331 flathead catfish were from the Georgia stockings, while the remaining 260 flathead catfish were resident fish or from the Pfeiffer Hatchery stocking. Overall, sampling numbers were relatively low for flathead catfish despite extensive effort using various gear types. It was difficult to assess the flathead catfish population size due to ineffective sampling gears. The stocking of flathead catfish in A.J. Jolly Lake did not have the desired effect on restructuring the sunfish and largemouth bass populations. The presence of gizzard shad is likely the leading cause of the stunted bluegill population. Removal of gizzard shad with a light dose of rotenone would be an option if a sunfish fishery were desired. Without conducting a creel survey and angler attitude survey it is difficult to estimate fishing pressure and angler preferences on management actions at the lake.

Introduction

The flathead catfish *Pylodictis olivaris* is a large bodied predacious fish native to the Great Lakes and several river systems including the Mississippi, Mobile, and Rio Grande (Hubbs and Lagler 1947, Blair et al. 1968, Lee et al. 1980, Lee and Terrell 1987). Range expansion of this species has taken place with introductions into southern areas of the U.S. such as Texas (Gholson 1970) and North Carolina (Guier et al. 1984). Although this species is typically considered a lotic species, populations are also found in lentic systems (Jackson 1999). In Kentucky, flathead catfish are found in several major watersheds including the Cumberland River, Licking, Big Sandy, Kentucky River, Salt River, Green River, Tradewater River, as well as minor Mississippi River tributaries and the mainstem Ohio River (Warren et al. 2000). Summerfelt and Hart (1972) found that flathead catfish in a reservoir were usually located in shallow water (less than 10 ft). Movement of flathead catfish is generally minimal (Funk 1957, Robinson 1977, Quinn 1988), and limited to nighttime (Robinson 1977, Skains 1992). Food habits of flathead catfish are well documented. Juveniles feed on invertebrates and switch to an almost exclusive fish diet between 9.0-14.0 in (Brown and Dendy 1961, Holz 1969, Roell and Orth 1993). Introduced populations of 12.0-24.0 in flathead catfish in the Flint River, Georgia consumed other flathead catfish, unidentified fish, and channel catfish *Ictalurus punctatus* (Quinn 1987). Flathead catfish over 24 in fed on gizzard shad *Dorosoma cepedianum*, sunfish (*Lepomis spp.*), and suckers (Catostomidae). Flathead catfish growth is fast at almost 4 in each year of life (Jackson 1999). However, current research demonstrates that flathead catfish growth is faster in reservoirs than rivers, and that introduced populations exhibit faster growth than native populations (Kwak et al. 2006).

Population growth of non-native flathead catfish can be rapid. Flathead catfish introduced into the Cape Fear River, North Carolina, expanded from an initial release of eleven sexually mature fish to comprising almost 11% of the total number of fish present in ten years (Guier et al. 1984). Moser and Roberts (1999) found that introduced blue and flathead catfish eliminated native ictalurids from the Cape Fear River system. Thomas (1993) documented flathead catfish starting from minimal numbers in the early 1980's to becoming the leading predator in the Altamaha River, Georgia. However, other studies such as ones completed by Davis (1985) and Odenkirk et al. (1999) revealed successful control of carp and bullheads, but not centrarchids for reservoirs where flathead catfish populations were introduced.

Predator-prey dynamics in lentic systems have been studied since the 1950's. When properly stocked with a healthy balance of predators and prey, reservoirs can produce quality-sized fish. If lakes have an initial imbalance in the fish population or are not managed properly, the result can be an overpopulation of forage or nuisance fish species and undesirable-sized fish. Gizzard shad, which are common in southeastern reservoirs, can quickly overpopulate and affect growth of other fish species higher up the food chain (Noble 1981). Dettmers et al. (1998) conducted tank experiments using hybrid striped bass *Morone saxatilis* x *M. chrysops* to control gizzard shad populations. Based on tank experiments and bioenergetics modeling, they found that hybrid striped bass would not effectively control gizzard shad populations in Ohio reservoirs. Bluegill *Lepomis macrochirus* can also become stunted in a system if largemouth bass *Micropterus salmoides* or other top predators have additional forage fish to consume (Noble 1981). Studies have explored using striped bass *Morone saxatilis* (Pardue and Huntington 1985), and bowfin *Amia calva* (Mundahl et al. 1998), as supplementary predatory species to control bluegill populations in various systems. In the striped bass study, existing populations of largemouth bass resulted in too many top predators for the ponds to adequately support (Pardue and Huntington 1985). In Lake Winona, Minnesota, Mundahl et al. (1998) demonstrated that bowfin preferred consuming fathead minnows *Pimephales promelas* and crayfish over bluegill and did not reduce numbers of overpopulated bluegill. On the contrary, Neal et al. (1999) found that hybrid striped bass helped control prey fish populations in small impoundments in North Carolina. Hybrid striped bass (average sizes ranging from 0.09-0.67 lbs) were stocked in ponds ranging from 6-16 acres. Gut analysis revealed that hybrid striped bass almost exclusively consumed larval centrarchids, which reduced competition and increased lengths and relative weights of both bluegill and black crappie *Pomoxis nigromaculatus*.

Management strategies for flathead catfish vary. In a catfish management survey, Michaletz and Dillard (1999) found that most states stock channel catfish over flathead catfish and were more likely to stock channel catfish in small impoundments. They did find that managers would stock flathead catfish in small impoundments to control prey. Odenkirk et al. (1999) stocked 77 flathead catfish in 1990 (average length 10.5 in, 1 fish/acre) and 34 flathead catfish in 1994 (average length 15.0 in, 0.4 fish/acre) into a 79-acre Virginia lake in an attempt to reduce a stunted brown bullhead population. In six years, creel surveys showed that angler harvest of brown bullhead *Ameiurus nebulosus* fell from 2,285 to 25 fish with a significant increase in the weight of each harvested fish. Gill net results showed similar findings with brown bullhead catch decreasing and average weight increasing. While studies have demonstrated that flathead catfish can reduce stunted fish populations (Swingle 1964, Hackney 1965, Odenkirk et al. 1999), others have reported inconclusive results about the ability of flathead catfish to reduce overcrowded fish populations (Crowell 1976). There is a paucity of data on flathead catfish impacts to other prey species such as bluegill.

A.J. Jolly Lake, a 175-acre eutrophic impoundment located in Campbell County, just south of the city of Alexandria, has historically contained poor populations of sunfish and largemouth bass. Gizzard shad are present in the lake and have been for some time; however, the year of introduction is unknown. The Kentucky Department of Fish and Wildlife Resources (KDFWR) has tried several alternative management actions in an attempt to improve the size structure and growth of sunfish and largemouth bass, including stocking intermediate-sized largemouth bass to improve recruitment of bass and stocking blue catfish *Ictalurus furcatus* and saugeye *Sander vitreus x S. canadensis* to consume small overabundant sunfish (i.e. bluegill, green sunfish *Lepomis cyanellus,* and crappie *Pomoxis*). Unfortunately, these management actions have proven unsuccessful in restructuring sunfish and largemouth bass populations, although the stocking of blue catfish and saugeye has resulted in the development of additional sport fisheries at A.J. Jolly Lake.

In the current study, flathead catfish were stocked in 2007, 2009, and 2011 in A.J. Jolly Lake in another effort to improve sunfish and largemouth bass populations. The specific objectives were to determine if stocking an additional predator such as flathead catfish can improve sport fish populations at A.J. Jolly Lake. Specifically, 1) Improve bluegill growth and size structure, 2) Improve largemouth bass growth, size structure, and year-class production. We hypothesize that these two outcomes are co-dependent, in that flathead catfish would reduce sunfish numbers which prey on largemouth bass eggs and fry. With the reduction of sunfish numbers, we would expect to see an increase in largemouth bass recruitment and densities.

Methods

Stocking- In June 2007, the KDFWR stocked 417 flathead catfish that ranged in length from 8.4-36.0 in with weights ranging from 0.5-19.7 lbs (Table 1). In September 2009, an additional 308 flathead catfish were stocked, ranging in size from 3.0-32.3 in, with weights ranging from 0.1-19.1 lbs. In June 2011, an additional 403 flathead catfish were stocked into A.J. Jolly Lake. The fish ranged in size from 3.0-38.2 in, with weights ranging from 0.1-30.8 lbs. The flathead catfish stocked in 2009 and 2011 were smaller on average than the fish stocked in 2007, with 80% and 66% of stocked fish being ≤ 12.0 in, respectively (Figure 1). Catfish stocked in 2007 averaged 5.75 lbs, whereas catfish in 2009 and 2011 averaged 1.24 and 1.50 lbs respectively (Table 1). The fish were obtained from the Georgia Department of Natural Resources as part of their non-native flathead catfish eradication program in the Satilla River. All flathead catfish stocked from Georgia were adipose fin clipped prior to stocking and transported to Kentucky by the KDFWR Fish Transportation Branch. In addition to the Georgia flathead catfish, Pfeiffer Fish Hatchery raised 2,862 flathead catfish averaging 5.1 in that were stocked in September 2011. The catfish stocked from Pfeiffer Hatchery were not fin clipped due to their small size and considered resident stock. A regulation was passed in 2009 that prohibited the harvest of flathead catfish from A.J. Jolly Lake. Prior to that, there were no creel or length limits on harvest; however, set lines, trotlines and jug lines had always been prohibited gear types, since the lake is less than 500 acres (301 KAR 1:410).

Sampling- Largemouth bass (15-min transects) and bluegill (7.5-min transects) were sampled in the spring using diurnal electrofishing from 1996-2014 for largemouth bass and 1997-2014 for bluegill. Sampling consisted of ten transects parallel to the shoreline for each species (bluegill sample was typically 2-4 weeks after bass sample). Electrofishing was conducted with a Smith-Root 5.0 GPP Electrofisher set at 1,000 V DC and 60 pulses per second. A largemouth bass sample was not conducted in 2004 and there was no bluegill sample conducted in 2006. Catch-per-unit effort (CPUE), and lengths to the nearest 0.1 in were recorded for the targeted species. Flathead catfish were also collected while electrosampling for largemouth bass and bluegill. Low pulse 15 pps-DC electrofishing was used in the summer in addition to jug-lines and trotlines to collect flathead catfish at A.J. Jolly Lake from 2008-14. Sampling effort and gear types varied by year. Flathead catfish were identified as resident or Georgia stock by the absence or presence of an adipose fin clip.

Sampling Analysis- Largemouth bass were separated into five length groups for analysis of CPUE: < 8.0 in, 8.0-11.9 in, 12.0-14.9 in, $\geq$ 15.0 in, and total CPUE. A CPUE was calculated for each length group for every transect. The data was segregated into two time periods: sampling in 2007 and prior were analyzed as pre-flathead catfish stocking, while 2008 and after were analyzed as post-flathead catfish stocking. To eliminate zeros from the data set, 3/8 was added to the response variable, prior to square root transformation that normalized the data for all length groups of largemouth bass. Comparisons of mean CPUE between periods for each length group were made using a repeated measures analysis of variance (ANOVA) using the MIXED procedure in SAS (SAS v 9.4; Cary, NC). The residuals of the mixed ANOVA test were tested for normality.

Bluegill were separated into three length groups for analysis of CPUE: 3.0-5.9 in, 6.0-7.9, and total CPUE $\geq$ 3.0 in. Bluegill in the < 3.0 in length group were omitted from analysis, as the catch data was highly variable from year to year and appeared dependent on the sampling crew. No bluegill $\geq$ 8.0 in were sampled at this lake. A CPUE was calculated for each length group for every transect. The data was segregated into two time periods: sampling in 2007 and prior were analyzed as pre-flathead catfish stocking, while 2008 and after were analyzed as post-flathead catfish stocking. To eliminate zeros from the data set, 0.5 was added to the response variable, before a $\log_{10}$ transformation that normalized the data for all length groups of bluegill. Comparisons of mean CPUE between periods for each length group were made using a repeated measures analysis of variance (ANOVA) using the MIXED procedure in SAS (SAS v 9.4; Cary, NC). The residuals of the mixed ANOVA test were tested for normality.

Results

A total of 331 flathead catfish were sampled from April-October 2008-2014 using electrofishing gear, jug lines, and trotlines (Table 2). Seventy-one of the 331 flathead catfish were from the Georgia stockings, while the remaining 260 flathead catfish were resident fish or from the Pfeiffer Hatchery stocking. With the exception of 2009, unmarked resident flathead catfish made up a higher proportion of the catch than the Georgia stocked flathead catfish. Of the 331 flathead catfish sampled, 204 were < 12.0 in (62%; Table 3). However, from 2008-10, 70% of flathead catfish sampled were $\geq$ 12 in. This was prior to the final stocking from Georgia and the Pfeiffer Hatchery stocking of smaller flathead catfish. While the number of flathead catfish sampled in 2008-10 was relatively low, the majority of catfish sampled were large in size compared to 2011-14. In 2012, a year after the Pfeiffer Hatchery flathead catfish stocking, 110 of the 123 flathead catfish sampled were $\leq$ 10 in (89%). Overall, sampling numbers were relatively low for flathead catfish despite extensive effort using various gear types. It was difficult to assess the population size due to ineffective sampling gears.

Total CPUE for spring largemouth bass electrofishing averaged 87.6 fish/hr during the pre-flathead stocking period (1996-2007), whereas CPUE averaged 73.4 fish/hr post-flathead stocking (2008-14; Table 4; Figure 2). This was a significant decrease ($\alpha = 0.1$) on total bass catch rates between the periods ($F = 3.20$; df = 1, 16; $P = 0.09$). There was also a significant decrease in the CPUE of largemouth bass in the 8.0-11.9 in length group, with a catch rate of 32.3 fish/hr during the pre-flathead stocking period, compared to 21.0 fish/hr during the post-stocking period ($F = 5.32$; df = 1, 16; $P = 0.03$). For bass in the < 8.0 in, 12.0-14.9 and $\geq$ 15.0 in length groups the CPUE differences between periods were not significant. Largemouth bass were well distributed through all length groups; however, overall catch rates were relatively low compared to other lakes in the region. In viewing catch rates for all length groups of largemouth bass there is noticeable variance in CPUE between years, but no discernible trend of increased catch rates for any length group of bass after flathead catfish were stocked (Figure 2).

The catch rate for bluegill in the 6.0-7.9 in length group averaged 53.4 fish/hr during the pre-flathead stocking period (1996-2007), whereas CPUE averaged 8.0 fish/hr post-flathead stocking (2008-14; Table 5; Figure 3). This was a significant decrease ($\alpha = 0.1$) on bluegill catch rates between the periods (F = 20.18; df = 1, 15; P = < 0.01). Bluegill CPUE in the 3.0-5.9 in and total $\geq$ 3.0 in length groups were not significantly different between periods. The bluegill in A.J. Jolly Lake exhibit slow growth with fish reaching sexual maturity at a small size. Very few bluegill reach a size desired by anglers. The CPUE of small bluegill remained high, with no significant decrease in overall bluegill numbers after the flathead catfish stockings. The overall slight decrease in bluegill CPUE $\geq$ 3.0 in between periods can be attributed to the significant decrease in CPUE of 6.0-7.9 in length group of bluegill (Figure 3). Flathead catfish do not appear to be foraging on small sunfish adequately enough to reduce overall numbers and shift the size structure as desired.

A total of 1,295 common carp were removed from A.J. Jolly Lake with electrofishing gear from 2011-14. The average weight was 2.96 lbs, resulting in an estimated 3,831 lbs of carp eliminated from the lake. Carp were utilized for their plasma by the Center for Mollusk Conservation research lab in Frankfort. The effect of this common carp removal on predator/prey interactions of the flathead catfish is unknown.

Discussion

The stocking of flathead catfish in A.J. Jolly Lake did not have the desired effect on restructuring the sunfish and largemouth bass populations. Sampling numbers were low for flathead catfish throughout the study, so it was difficult to estimate the population size. Even after stocking, sampling efforts revealed very few fish despite thermocline and habitat limitations on where flathead catfish would likely be located. Post-stocking survival of flathead catfish was not studied; however, hauling stress or delayed mortality could have contributed to poor survival. Jug-lines and limb-lines are illegal on A.J. Jolly Lake; however, limb-lines were observed routinely during sampling trips. It is possible anglers could have removed flathead catfish from the 2007 stocking as sportfishing regulations were not yet in place to outlaw harvest. Alternatively, it is possible the legal and illegal harvest of flathead catfish may have lowered the density beyond the level where they could have the desired effect. The 2,862 5.0-in flathead catfish stocked in 2011 from Pfeiffer Fish Hatchery, assuming 4.0 in of growth a year (Jackson 1999), would take a couple years to reach a size where they would forage on sunfish. Assuming this growth, we wouldn't expect to see an immediate effect from the flathead catfish stockings in 2011 from Pfeiffer Hatchery.

Largemouth bass recruitment or increased numbers have not been observed post-flathead stocking. Bass recruitment into the 8.0-11.9 in length group has declined along with overall bass densities compared to pre-flathead catfish stocking. Additionally, no positive changes with the bluegill size structure or reduced CPUE of small sunfish was observed. On the contrary, there was a noticeable decline in CPUE of 6.0-7.9 in length group of bluegill after flathead catfish stockings began in 2007. The decline actually began prior to the initial flathead catfish stocking, with the spring 2017 sample showing a decline in the CPUE of 6.0-7.9 in length group of bluegill. The stocking of large flathead catfish in 2007 could have negatively impacted the bluegill size structure with flathead catfish selectively preying on larger bluegill; however, this wouldn't explain the decline in 2007. Flathead catfish are opportunistic feeders and one of the least gape limited foragers of any of the North American freshwater piscivores (Slaughter and Jacobson 2008). A 15-in flathead catfish is capable of preying on a 6-in bluegill.

The presence of an abundant common carp population may be inhibiting largemouth bass foraging capabilities on sunfish. The lake remains turbid throughout most of the year. This may be due in part to the carp keeping sediment suspended with their feeding habitats. Abundant common carp may also be disrupting bass spawning activity. However, it is more likely that the gizzard shad are disrupting the food web, limiting sunfish growth, leading to a stunted bluegill population and contributing to poor largemouth bass recruitment.

Management Implications

The bluegill size structure did not improve with the introduction of flathead catfish. On the contrary, electrofishing catch rates of bluegill > 6.0 in decreased significantly. The presence of gizzard shad is likely the leading cause of the stunted bluegill population. Removal of gizzard shad with a light dose of rotenone would be an option if a sunfish fishery were desired. However, blue catfish and saugeye are reliant on the gizzard shad for forage, and provide additional sport fisheries. Without conducting a creel survey and angler attitude survey it is difficult to estimate the utilization and fishing pressure on these species and angler preferences on management actions at the lake. Largemouth bass densities for the lake are relatively low compared to other lakes in the region. However, there are currently good numbers of large bass present and condition of fish indicate a population that is not crowded with plenty of available forage. The number of largemouth bass and size distribution seem to be holding steady at the lake. The bluegill fishery is unlikely to improve to a level desired by sunfish anglers with gizzard shad present, as no bluegill $\geq$ 8.0 in have ever been sampled from the lake. The catch rate of bluegill 6.0-7.9 in was higher prior to the flathead catfish stockings (1997-2007), but the lake has never had an exceptional bluegill population since monitoring commenced in 1996. Bluegill in the $\geq$ 7.0 in class have historically been extremely rare.

The stocking of flathead catfish at A.J. Jolly Lake was halted in 2011. The catch and release regulation for flathead catfish was subsequently removed in March 2016 after the completion of the study. Largemouth bass will continue to be sampled as part of routine monitoring at A.J. Jolly Lake. With the lake not being managed as a panfish fishery, formal bluegill monitoring will be discontinued.

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Table 1. Source, number, and size of flathead catfish stocked at A.J. Jolly Lake from 2007-11.

Year	Source	Number	Size range (in)	Average size (in)	Weight range (lbs)	Average weight (lbs)
2007	Georgia	417	8.4 - 36.0	22.9	0.5 - 19.7	5.75
2009	Georgia	308	3.0 - 32.3	10.1	0.1 - 19.1	1.24
2011	Georgia	403	3.0 - 38.2	12.5	0.1 - 30.8	1.50
2011	Pfeiffer Hatchery	2,862	-	5.1	-	-

Table 2. Origin and number of flathead catfish sampled at A.J. Jolly Lake from 2008-14. Resident fish included flathead catfish stocked from Pfeiffer Hatchery (2011-2014) and naturally reproduced fish (2008-14).

Year	Origin		Total
	Resident	Georgia	
2008	20	6	26
2009	7	10	17
2010	16	15	31
2011	31	18	49
2012	111	12	123
2013	25	7	32
2014	50	3	53
Total	260	71	331

Table 3. Length frequency of flathead catfish collected at A.J. Jolly Lake from 2008-2014 using multiple sampling gears and varying effort.

	Inch class																																			
Year	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	Total
2008					1				1	1		1	2	2	1	2	2	2	1	2	3	1	2	1			1									26
2009			1	1	1	2	1					1		1		1	1		2		2	1	1				1									17
2010	2			1	2	6	3	1	2		1			1		1					1	3	2		2	1	1				1					31
2011	1	3	3	6	1	6	5		2	3	1	2	2			1		1	1	2	1				1		2		1	1		1		1	1	49
2012	8	67	21	3	8	1	2		2				2	1		1	1	1		1	1	1	1										1			123
2013			1	4	4	1	3	1	4	1	1	2	1	2	1	1	2	1				1		1												32
2014				3	9	9	3	9	4	5	2	1	1		1	1				1		1		2				1								53

Table 4. Spring electrofishing CPUE data (fish/hr) for each length group of largemouth bass collected at A.J. Jolly Lake from pre-flathead stocking (1996-2007) and post-flathead stocking (2008-14) periods. Standard errors are in parentheses. Significant differences (α = 0.1) are in bold italics.

	Length group (in)				
Period	< 8.0	8.0 - 11.9	12.0 - 14.9	≥ 15.0	Total
Pre	22.6 (2.0)	***32.3 (1.9)***	16.7 (1.2)	16.1 (1.2)	***87.6 (3.4)***
Post	17.5 (1.7)	***21.0 (1.7)***	17.2 (1.3)	17.7 (1.5)	***73.4 (4.1)***

Table 5. Spring electrofishing CPUE data (fish/hr) for each length group of bluegill collected at A.J. Jolly Lake from pre-flathead stocking (1997-2007) and post-flathead stocking (2008-14) periods. Standard errors are in parentheses. Significant differences (α = 0.1) are in bold italics.

	Length group (in)			
Period	3.0 - 5.9	6.0 - 7.9	≥ 8.0	Total (≥ 3.0 in)
Pre	307.7 (17.9)	***53.4 (5.5)***	-	361.1 (21.0)
Post	333.5 (24.2)	***8.0 (1.4)***	-	341.5 (24.7)

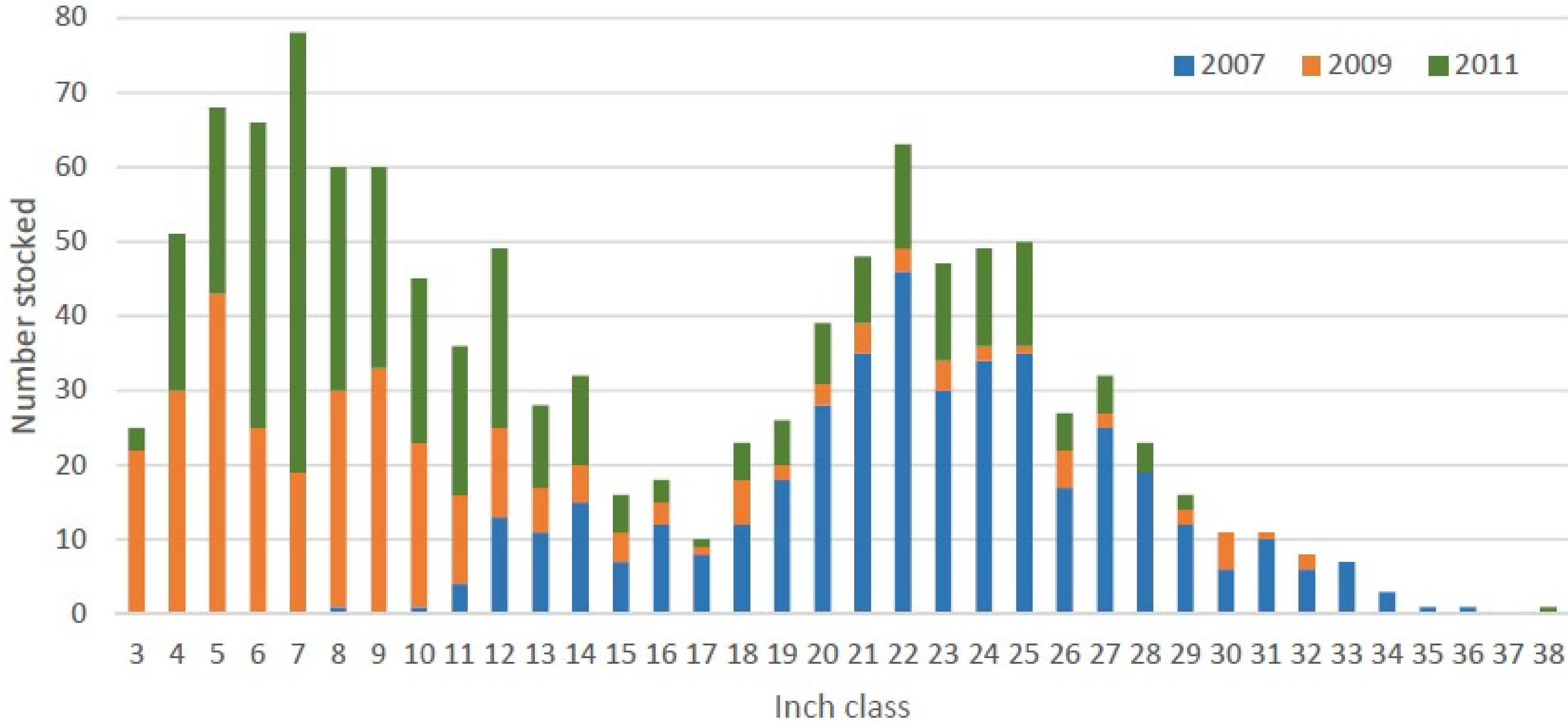

Figure 1. Number and size of flathead catfish harvested from Satilla River, Georgia and stocked at A.J. Jolly Lake in 2007 (n=417), 2009 (n=308) and 2011 (n=403).

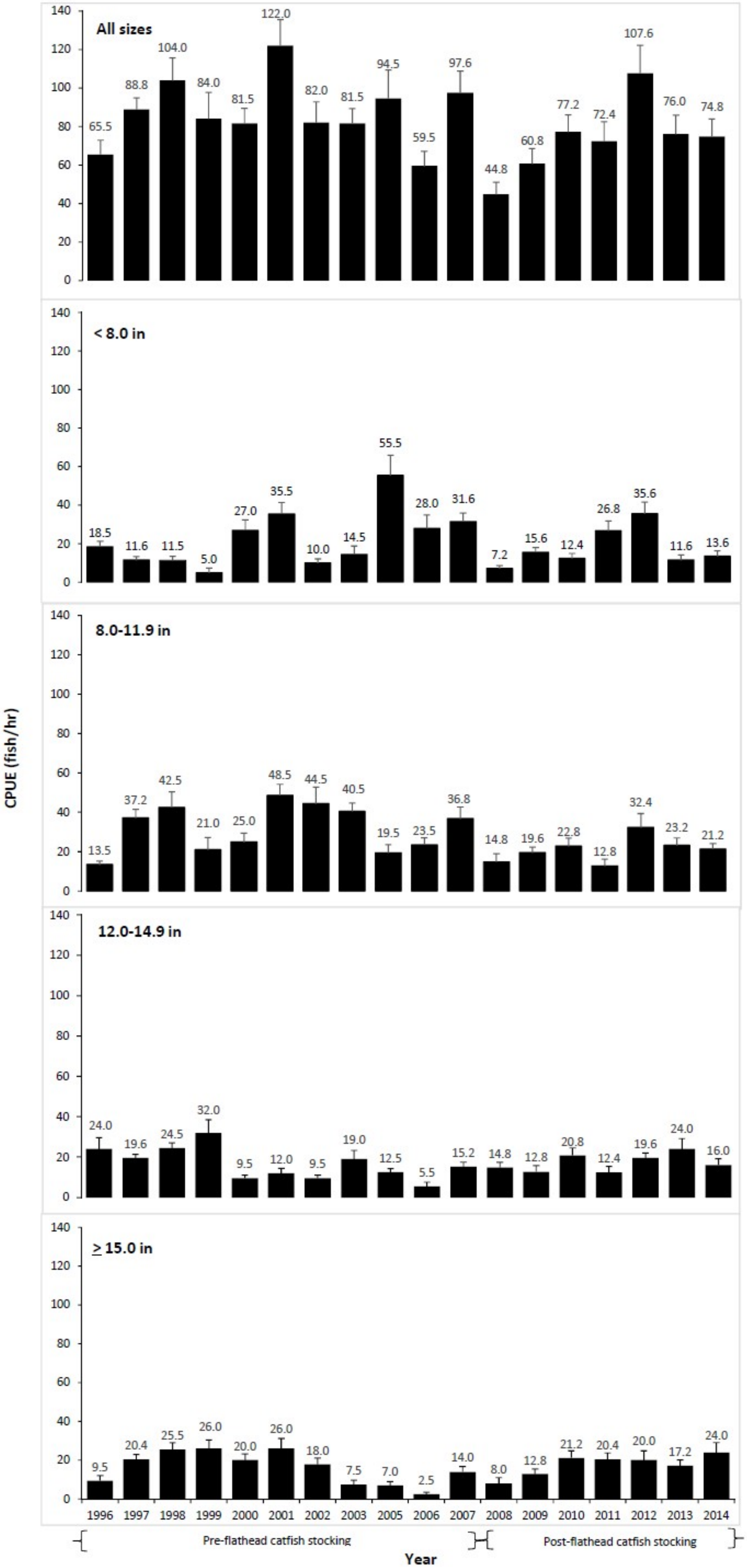

Figure 2. Spring electrofishing mean relative abundance (fish/hr) of all sizes, < 8.0-in, 8.0-11.9-in 12.0-14.9-in, and ≥ 15-in largemouth bass in A.J. Jolly Lake from 1996-2014. No sample was collected in 2004. Error bars represent the standard error.

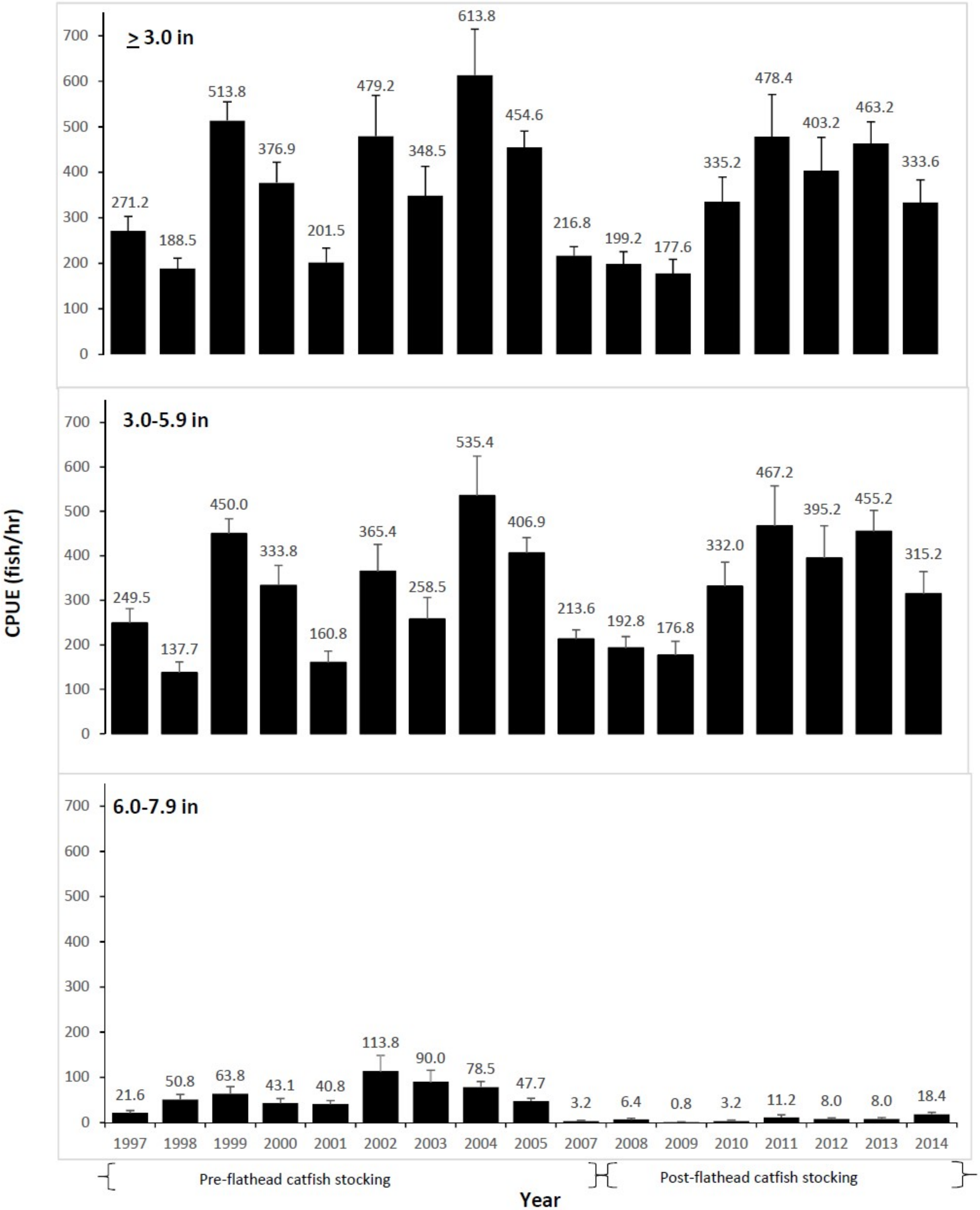

Figure 3. Spring electrofishing mean relative abundance (fish/hr) of ≥ 3.0-in, 3.0-5.9-in and 6.0-7.9-in bluegill in A.J. Jolly Lake from 1997-2014. No sample was collected in 2006. Error bars represent the standard error.