Differences in Largemouth Bass Food Habits and Growth in Vegetated and Unvegetated North-central Florida Lakes

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Abstract: Stomachs of 5,818 largemouth bass (*Micropterus salmoides*) were examined from 10 north-central Florida lakes to determine differences in food habits of largemouth bass in lakes with abundant aquatic macrophytes (vegetated) and lakes nearly devoid of aquatic macrophytes (unvegetated). We found significant differences ($P < 0.05$) between stomach contents of 6 length groups of largemouth bass (range: 60–640 mm TL) from vegetated and unvegetated lakes. The 152- to 254-mm length group exhibited the greatest number of diet differences. Atherinids, decapods, and odonates were consumed more frequently ($P < 0.05$) by largemouth bass in vegetated lakes, while cichlids, clupeids, and dipterans were more common in the diet of largemouth bass from unvegetated lakes. Largemouth bass from unvegetated lakes were piscivorous by 60 mm TL; those from vegetated lakes did not become piscivorous until they were ≥120 mm TL. Largemouth bass were significantly larger ($P < 0.05$) in unvegetated lakes through age 3+ for females and age 4+ for males.

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Proper management of habitat such as submersed aquatic macrophytes presents a major challenge to warmwater fisheries managers. Aquatic macrophytes can play a vital role in spawning and survival of largemouth bass (Kramer and Smith 1962, Aggus and Elliot 1975, Durocher et al. 1984, Wiley et al. 1984, Killgore et al. 1989, Bruno et al. 1990). However, reduced prey capture efficiency of largemouth bass was observed as plant stem density increased (Savino and Stein 1982). Once excessive vegetation levels (>50% areal coverage) are reached, condition of largemouth bass can decline and may result in slower growth (Colle and Shireman 1980).

The use of grass carp (*Ctenopharyngodon idella*) for aquatic vegetation management has been controversial in water bodies where sport fisheries are important (Bailey 1978, Ware and Gasaway 1978). Total elimination of aquatic macrophytes from lakes where grass carp have been stocked is a concern to many fisheries managers. Short-term decreases in Florida sportfish populations occurred following removal of aquatic macrophytes by grass carp (Ware and Gasaway 1978). However, Bailey (1978) found there were no predictable effects of grass carp stocking on sportfish populations. Hoyer and Canfield (1996) concluded there were no predictable relationships between the abundance (fish/ha) of adult largemouth bass and aquatic macrophyte abundance in Florida lakes <300 ha.

The main objective of this study was to determine whether food habits of largemouth bass differed in lakes with abundant aquatic macrophytes and lakes nearly devoid of aquatic macrophytes due to stocking of grass carp. A secondary objective was to determine differences in largemouth bass growth between the 2 lake types.

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Methods

Largemouth bass were collected for food habit analysis by daytime electrofishing around the perimeter of 10 North-central Florida lakes. Stomach samples ($N \geq 100$) were collected on a quarterly basis from lakes Holden, Killarney, Wales, Patrick, and Barton between June 1988 and December 1989 (Table 1). Samples were collected from lakes Clear, Pasadena, and Okahumpka between November 1989 and April 1990. No submersed aquatic macrophytes were present in 4 of these lakes (Clear, Holden, Killarney, and Wales) in which grass carp had been stocked for >7 years (Leslie et al. 1983, Canfield and Hoyer 1992), and relatively little vegetation (<1% areal coverage) occurred at all. The other 4 lakes (Barton, Okahumpka, Pasadena, and Patrick) were heavily vegetated (>40% areal coverage) with submersed aquatic macrophytes, most notably hydrilla (*Hydrilla verticillata*); however, vegetation levels had been managed with herbicides. Two other lakes, Jackson and Rowell, had variable levels of submersed aquatic macrophytes throughout the study period, also due to herbicide treatments. Data from periods of dense hydrilla infestation (>40% areal coverage) were used only in food habit analysis.

Largemouth bass were measured (total length, TL, mm: all lengths reported in this paper are total lengths) and stomach contents were removed from live fish >120 mm using acrylic tubes (Van Den Avyle and Roussel 1980). When possible, during each sample of every lake a random sample ($N \geq 30$) of largemouth bass <120 mm

Table 1. North-central Florida lakes sampled for largemouth bass food habits and age determination, June 1988–April 1990.

Lake	Area (ha)	Vegetation coverage (% areal)	Trophic status[a]	Forage (kg/ha)[a] Littoral blocknets	Forage (kg/ha)[a] Open water blocknets
		Lakes with <1% aquatic vegetation			
Holden	102	<1	hypereutrophic	195.5	52.2
Killarney	96	<1	eutrophic	309.3	189.7
Wales	132	<1	hypereutrophic	35.2	46.1
Clear	64	<1	eutrophic	206.8	5.6
		Lakes with >40% aquatic vegetation			
Barton	57	40–60			
Patrick	159	90	eutrophic	119.5	46.1
Pasadena	151	50–70	eutrophic	77.4	79.7
Okahumpka	271	60–90	hypereutrophic	62.5	90.9
Jackson[b]	1,619	50–80			
Rowell[b]	417	40–90			

[a] From Canfield and Hoyer (1992).

[b] Used only in food habit analysis.

was immediately placed on ice to minimize post-capture digestion and stomach contents were removed and identified in the laboratory. All food items were identified to the lowest possible taxon and expressed as percent frequency of occurrence in stomachs containing food.

Data were analyzed separately for 6 length groups of largemouth bass: 60–151 mm, 152–254 mm, 255–356 mm, 357–456 mm, 457–559 mm, and >560 mm. The length at which largemouth bass become piscivorous was determined using criterion set by Bettoli et al. (1992). All largemouth bass stomach samples were grouped into 1 of 2 lake types, vegetated or unvegetated, for data analysis. Chi-square analysis was used to test for differences in frequency of occurrence of food items between vegetated and unvegetated lakes. For all statistical analyses, significance was set at $P \leq 0.05$.

Otoliths were removed from a random sample ($N \geq 100$) of largemouth bass collected during fall electrofishing samples in each of the 4 vegetated and 4 unvegetated lakes. Otoliths were prepared and ages interpreted using techniques described in Taubert and Tranquilli (1982). Data from lakes Jackson and Rowell were not included in the growth analyses due to the variability in hydrilla coverage during the study period. Samples were separated by sex for analyses due to sexually dimorphic growth rates. Back-calculated lengths at age were computed by employing the Frazer-Lee method (Coleman et al. 1984) for each fish and pooled by age for vegetated and unvegetated lakes. Lillifors test was used to measure normality of the back-calculated lengths at age (Wilkinson and Hill 1994). Homogeneity of variances was assessed using Bartlett's test. Most of the pooled back-calculated lengths at age were nonnormal and heteroscedastic. Therefore, a Mann-Whitney test was used to test for differences in length at age between vegetated and unvegetated lakes.

Results

From the 10 lakes studied, 5,818 largemouth bass stomachs were examined. Twenty-five species of fish representing 11 families were identified as prey. Twenty-three species of fish were consumed by largemouth bass from vegetated lakes compared to 15 species in unvegetated lakes. Two orders of crustaceans and 7 orders of insects were also identified as prey (Table 2).

The percentage of empty largemouth bass stomachs in the 60- to 151-mm length group in vegetated lakes (43%) was significantly higher than in unvegetated lakes (23%). All other length groups were similar in the percentage of empty stomachs.

Differences in frequency of occurrence of forage items between vegetated and unvegetated lakes were evident for all length groups (Table 2). Cichlids, clupeids, and dipterans were found in significantly higher frequencies in the diet of 60- to 151-mm largemouth bass in unvegetated lakes. In contrast, decapods were consumed more frequently by this length group in vegetated lakes.

Greater differences in frequency of occurrence of food items were observed in the 152- to 254-mm length group than in any other (Table 2). Significantly higher frequencies of atherinids, decapods, and odonates were consumed by largemouth bass in vegetated lakes, while cichlids, clupeids, and dipterans were consumed more often in unvegetated lakes.

Centrarchids and decapods were consumed in significantly higher frequencies by 255- to 356-mm largemouth bass in vegetated lakes (Table 2). Cichlids and clupeids were ingested significantly more frequently by this length group in unvegetated lakes.

Very few differences were observed in stomach contents of largemouth bass >356 mm between lake types. Frequency of cichlids and clupeids in the diet of 352- to 456-mm fish was significantly higher in unvegetated compared to vegetated lakes (Table 2). Cichlids occurred in significantly higher frequencies in the diet of 457- to 559-mm largemouth bass from unvegetated lakes. A significantly higher frequency of catostomids in vegetated lakes and cichlids in unvegetated lakes were the only differences for largemouth bass >560 mm (Table 2).

The length at which largemouth bass became piscivorous was different between vegetated and unvegetated lakes. Largemouth bass in unvegetated lakes were piscivorous by 60 mm (Fig. 1). However, piscivory in vegetated lakes did not occur until largemouth bass were >120 mm.

Back-calculated lengths at age of largemouth bass were significantly larger in unvegetated lakes through age 3+ for females and age 4+ for males (Table 3). No significant differences were observed once females reached age 4+ and males reached age 5+.

Discussion

Moyle and Holzhauser (1978) found the size at which fish become piscivorous is an important factor limiting growth rates of age-0 largemouth bass. They observed

Table 2. Frequency of occurrence (%) of food items for various length groups (mm) of largemouth bass. Samples were combined for fish collected from 4 densely vegetated (>40% areal coverage) lakes (veg) and 4 lakes devoid (<1% areal coverage) of vegetation (unveg) in north-central Florida.

Food	60–151 mm		152–254 mm		255–356 mm		357–456 mm		457–559 mm		≥560 mm	
	veg	unveg	veg	unveg	veg	unveg	veg	unveg	veg	unveg	veg	unveg
N fish containing food	285	311	724	387	797	415	216	267	70	95	30	17
% empty	42.7	22.6	35.0	31.1	37.1	36.9	47.2	43.9	48.9	49.2	57.1	55.3
Fish	54.7	71.7	76.2	89.2	79.6	88.4						
Atherinidae	4.6	2.9	6.2[a]	1.0	4.0		1.4	0.8				
Catostomidae			0.1				0.9		4.3		23.3[a]	
Centrarchidae	9.8	3.2	19.9	13.2	32.8[a]	9.6	28.2	19.1	35.7	19.0	16.7	29.4
Cichlidae		9.6[a]		7.5[a]		16.4[a]		15.4[a]		19.0[a]		11.8[a]
Clupeidae	0.4	9.0[a]	0.8	19.6[a]	3.0	18.3[a]	4.2	9.0[a]	5.7	2.1	6.7	5.9
Cyprinidae		0.3	2.1	0.5	4.0	1.7	3.7	1.1	4.3	5.3	3.3	
Cyprinodontidae	3.5	1.3	7.7	8.5	6.9	6.3	3.7	4.9		3.2		
Esocidae						0.3						
Ictaluridae		0.6	0.3	0.3	1.3	1.7	1.9	1.1	1.4	3.2	3.3	
Percidae	2.5	4.5	5.5	1.8	2.4	0.2						
Poeciliidae	7.7	5.5	6.1	2.1	3.1	0.2	2.3					
Crustacea	31.2[a]	7.4	31.2[a]	4.1	28.0[a]	5.5	14.8	7.5	4.3	2.1		5.9
Amphipoda	0.4	4.2		0.5		0.3						
Decapoda	31.2[a]	2.9	31.1[a]	3.6	28.0[a]	5.3	14.8	7.5	4.3	2.1		5.9
Amphibia							0.5		1.4			
Annelida	0.7	0.3			0.1		0.5	0.4				
Insecta	35.8	34.4	15.6	12.9	10.3	7.2	5.6	9.4	2.9	1.1		
Coleoptera	0.4											
Diptera	8.4	22.2[a]	1.2	6.7[a]	0.4	4.3		7.9	1.4			
Ephemeroptera	11.9	2.6	5.1	1.0	1.4		0.9	0.4				
Hemiptera	10.5	8.4	1.2	3.6	0.8	1.2	0.5	0.4				
Hymenoptera		0.3	0.1									
Odonata	6.0	4.5	5.9[a]	0.8	6.0	0.7	3.7	0.8	1.4	1.1		
Tricoptera		0.6	0.1	0.3				0.4				
Aves							0.5					
Mollusca			0.1	1.0	0.3	1.0		1.5		4.2		
Gastropoda			0.1	0.5	0.3	0.5		1.1		2.1		
Pelecypoda				0.5		0.5		0.4		2.1		

[a] Significantly higher ($P < 0.05$) within length group.

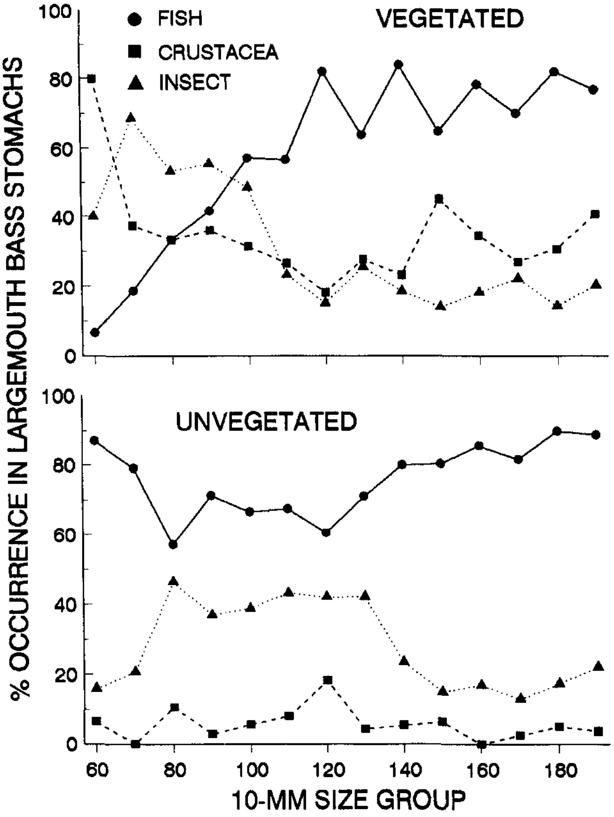

Figure 1. Percent occurrence of 3 food groups found in largemouth bass stomachs in vegetated (>40% areal coverage) and unvegetated lakes (<1% areal coverage) in north-central Florida.

greatly accelerated growth rates of largemouth bass following a switch to a piscivorous diet. Aggus and Elliot (1975) found stomachs of small piscivorous largemouth bass contained 7 times the relative volume of food compared to stomachs of bass that fed on invertebrates in Bull Shoals Reservoir, Missouri-Arkansas. Thus, larger ration size in a predominantly piscivorous fish may facilitate faster growth rates. Bettoli et al. (1992) found that when submersed vegetation covered about 40% of Lake Conroe, Texas (8,100 ha), largemouth bass did not become piscivorous until >140 mm. However, once vegetation was eliminated by grass carp, largemouth bass became piscivorous by >60 mm, and grew significantly faster during their first year. Largemouth bass in this study became piscivorous at >120 mm in vegetated lakes, whereas fish in unvegetated lakes were already piscivorous by 60 mm. It appears that this diet switch at a smaller size contributed to an initial growth advantage for age-0 bass in unvegetated Florida lakes and resulted in larger back-calculated lengths at age through age 3+ for females and age 4+ for males.

Bettoli et al. (1993) observed reductions in the number of fish species present in Lake Conroe, Texas, following elimination of submersed vegetation by grass carp.

Table 3. Average back-calculated total lengths at age for largemouth bass from 4 vegetated (>40% areal coverage) lakes and 4 unvegetated (<1% areal coverage) lakes in north-central Florida.

	Vegetated lakes				Unvegetated lakes			
Age	*N*	Mean TL	SE	Median	*N*	Mean TL	SE	Median
				Females				
0	32	129	5	127	38	161[a]	9	164
1	41	210	5	211	84	295[a]	5	293
2	52	288	6	281	34	383[a]	5	387
3	34	361	10	362	28	417[a]	6	421
4	22	448	15	467	5	495	11	494
5	7	491	29	510	6	522	5	520
6	2	563	8	563	5	552	19	545
7	3	535	20	534	1	575		575
8	3	600	24	581				
9	2	606	16	606	2	584	13	584
10					2	582	1	582
11	1	622		622				
				Males				
0	30	131	5	130	39	166[a]	9	182
1	50	204	4	201	92	281[a]	3	280
2	45	264	4	259	38	336[a]	4	337
3	33	310	7	298	14	378[a]	6	378
4	13	327	12	303	3	413[a]	14	404
5	3	391	46	405	6	397	18	398
6	2	411	58	411	1	420		420
7	2	437	19	437				

[a] Significantly greater ($P < 0.05$) within age class between different lakes.

Canfield and Hoyer (1992) reported the number of fish species that occurred in our 4 unvegetated study lakes (range: 12–18; median: 15) as lower than the 4 vegetated study lakes (range: 16–31; median: 25). This reduction in fish species (and therefore prey species) probably occurred over a period of years rather than immediately. This was evident in Lake Rowell following eradication of hydrilla as a result of fluridone treatment. Between 6 and 18 months following eradication of hydrilla, 30 fish species were still present in Lake Rowell (Canfield and Hoyer 1992), including several species such as bluefin killifish (*Lucania goodei*) and golden topminnow (*Fundulus chrysotus*) that have been associated with dense stands of hydrilla (Haller et al. 1980). Since aquatic macrophytes in our unvegetated study lakes had been eliminated >7 years before the study began, the species present in these systems during the study probably reflect a reduction in the number of species available as prey compared to when the lakes were vegetated.

Occurrence of cichlids (blue tilapia, *Tilapia aurea*) in the diet of largemouth bass may be misleading in its significance, as cichlids were rare or absent from the vegetated study lakes and very common in the unvegetated study lakes (Canfield and Hoyer 1992). Also, the lake chubsucker (*Erimyzon succetta*) was found significantly more often in stomachs of largemouth bass >560 mm from vegetated systems. Lake chubsuckers were sampled in all 4 of the vegetated lakes but in only 1 of the unvegetated lakes (Canfield and Hoyer 1992). With the exception of these 2 species, significant differences in diets of largemouth bass >356 mm were not observed between lake types.

Canfield and Hoyer (1992) reported substantial variation in the biomass (kg/ha) of forage fishes estimated with littoral and open water blocknet samples in 7 of the 8 lakes sampled in this study (Table 1). Differences in food habits of largemouth bass between unvegetated and vegetated lakes probably occurred due to opportunistic feeding of largemouth bass and differences in relative abundance of available prey in the 2 lake types.

Savino and Stein (1982) indicated that prey-capture efficiency of largemouth bass declined as habitat complexity increased. Higher percentages of empty stomachs in small largemouth bass in vegetated lakes may reflect reduced prey-capture efficiency. This may have also contributed to reduced growth of small largemouth bass in our vegetated study lakes.

The bioenergetic value of prey will influence growth rates of largemouth bass. Miranda and Muncy (1989) concluded that largemouth bass feeding on shad (*Dorosoma* spp.) had better growth and survival than largemouth bass feeding on bluegill (*Lepomis macrochirus*). They speculated that the bioenergetic value of shad was higher due to larger ration sizes, faster digestion, and evacuation of the stomach, and possibly easier location and capture of prey. Occurrence of threadfin shad (*D. petenense*) in largemouth bass diets has been found to increase growth and condition (Von Geldern and Mitchell 1975). Bettoli et al. (1990) found an inverse relationship of areal coverage of submersed aquatic macrophytes and threadfin shad density in a Texas reservoir. The significantly higher occurrence of shad in the diets of largemouth bass in our unvegetated study lakes may partially explain the faster growth of small largemouth bass in these lakes.

Schramm and Zale (1985) observed largemouth bass selection of small blue tilapia over bluegill in tanks without vegetative cover. The high occurrence of blue tilapia in the diets of largemouth bass in our unvegetated lakes could be attributed to this selection. Schooling behavior of young tilapia (personal observations during largemouth bass sampling) may increase prey-capture efficiency and yield higher ration sizes which could lead to increases in growth.

Canfield and Hoyer (1992) reported that densities of ≥250-mm largemouth bass in our unvegetated lakes (8–13 bass/ha) were lower than in the vegetated lakes (20–42 bass/ha). In Florida, strong year classes of largemouth bass have been associated with expanding levels of hydrilla in lakes Parker (Moxley and Langford 1982), Rowell (Porak et al. 1990), and Lochloosa (Estes et al. 1990). Durocher et al. (1984) indicated that submersed vegetation coverage below 20% in Texas reservoirs resulted in a reduction of recruitment and standing crops of largemouth bass.

Low densities of largemouth bass in unvegetated lakes suggest that stock enhancement has the potential to increase the number of bass available to anglers. Improved growth of age-0 bass in our unvegetated study lakes suggests that adequate prey may be available to support supplemental stocking. If this option were considered by fishery managers, we recommend that forage fish populations be sampled to determine if sufficient prey is available to support higher densities of bass. We also recommend that stocked largemouth bass are large enough to avoid high mortality associated with predation, since protective cover (e.g., aquatic macrophytes) is virtually absent from lakes in which grass carp have been stocked in densities high enough to eliminate vegetation.

In systems in which vegetation is managed for multiple user groups, periodic fluctuations in vegetation levels may be a good compromise. By allowing aquatic macrophytes to expand, strong year classes of bass may be produced. A subsequent reduction in vegetation levels could increase the vulnerability of prey species to bass (Bennett 1970) and may promote better growth and condition of recruits. Reducing vegetation levels can also increase vulnerability of bass to anglers (Porak et al. 1990) which may increase angler catch rates.

Novinger (1984) pointed out the need to carefully consider the influence of recruitment, growth, and mortality of black bass (*Micropterus* spp.) when making management decisions on harvest restrictions. Our study indicated that growth rates of largemouth bass will be affected by the type of aquatic plant management strategy used in a given water body. Other studies cited in this discussion concluded that recruitment will also be affected by plant management strategies. Therefore, fishery managers must also consider the influence of aquatic plant management efforts on a water body when making decisions on harvest restrictions for largemouth bass.

In summary, several factors have been attributed to differences in growth of largemouth bass in unvegetated and vegetated lakes in Florida. The significantly smaller size at which largemouth bass become piscivorous in unvegetated lakes likely give the fish a growth advantage in their first year of life. Higher utilization of certain prey (e.g., shad and blue tilapia) in unvegetated lakes may increase bioenergetic efficiency of largemouth bass in those systems. A reduction in prey-capture efficiency for small largemouth bass may have occurred when high vegetation levels were achieved in our study lakes. These factors may have influenced the significantly larger sizes that largemouth bass in unvegetated lakes attained to age 3+ for females and age 4+ for males compared to those in vegetated Florida lakes. However, it must be questioned whether the advantage in growth in unvegetated systems, which disappears after age-4 for both sexes, outweighs the need for cover and survival of largemouth bass to produce a good fishery. By fluctuating vegetation levels, strong year classes of largemouth bass could survive, promote good growth and condition, and increase the vulnerability of the fish to the angler.

Literature Cited

Aggus, L. R. and G. V. Elliot. 1975. Effects of cover and food on year class strength of largemouth bass. Pages 317–322 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fish. Inst., Washington, D.C.

Bailey, W. M. 1978. A comparison of fish populations before and after extensive grass carp stocking. Trans. Am. Fish. Soc. 107:181–206.

Bennett, G. W. 1970. Management of lakes and ponds, 2nd ed. Van Nostrand Reinhold Co., New York, N.Y. 375pp.

Bettoli, P. W., T. Springer, and R. L. Noble. 1990. A deterministic model of the response of threadfin shad to aquatic macrophyte control. J. Freshwater Ecol. 5:445–454.

———, M. J. Maceina, R. L. Noble, and R. K. Betsill. 1992. Piscivory in largemouth bass as a function of aquatic vegetation abundance. North Am. J. Fish. Manage. 12:509–516.

———, ———, ———, and ———. 1993 Response of a reservoir fish community to aquatic vegetation removal. North Am. J. Fish. Manage. 13:110–124.

Bruno, N. A., R. W. Gregory, and H. L. Schramm, Jr. 1990. Nest sites used by radio-tagged largemouth bass in Orange Lake, Florida. North Am. J. Fish. Manage. 10:80–84.

Canfield, D. E., Jr. and M. V. Hoyer. 1992. Aquatic macrophytes and their relation to the limnology of Florida lakes. Publ. SP115. Inst. Food and Agric. Sci, Univ. Fla., Gainesville. 599pp.

Colemann, W. S., S. Crawford, and W. F. Porak. 1984. Age and growth of largemouth bass. Fla. Game and Fresh Water Fish Comm., Fed. Aid in Sport Fish Restor., Final Rep., Proj. F-24, Tallahassee. 95pp.

Colle, D. E. and J. V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla-infested lakes. Trans. Am. Fish. Soc. 109:521–531.

Durocher, P. P., W. C. Provine, and J. E. Kraai. 1984. Relationship between abundance of largemouth bass and submerged vegetation in Texas reservoirs. North Am. J. Fish. Manage. 4:84–88.

Estes, J. R., W. A. Sheaffer, and E. P. Hall. 1990. Lower Oklawaha basin fisheries investigations. Fla. Game and Fresh Water Fish Comm., Fed. Aid in Sport Fish Restor., Final Rep., Proj. F-55, Tallahassee. 86pp.

Haller, W. T., J. V. Shireman, and D. F. DuRant. 1980. Fish harvest resulting from mechanical control of hydrilla. Trans. Am. Fish. Soc. 109:517–520.

Hoyer, M. V. and D. E. Canfield, Jr. 1996. Largemouth bass abundance and aquatic vegetation in Florida lakes: an empirical analysis. J. Aquat. Plant Manage. 34:23–32.

Killgore, K. J., R. P. Morgan II, and N. B. Rybicki. 1989. Distribution and abundance of fishes associated with submersed aquatic plants in the Potomac River. North Am. J. Fish. Manage. 9:101–111.

Kramer, R. H. and L. L. Smith, Jr. 1962. Formation of year classes in largemouth bass. Trans. Am. Fish. Soc. 91:29–41.

Leslie, A. J., Jr., L. E. Nall, and J. M. Van Dyke. 1983. Effects of vegetation control on selected water quality variables in four Florida lakes. Trans. Am. Fish. Soc. 112:777–787.

Miranda, L. E. and R. J. Muncy. 1989. Bioenergetic values of shads and sunfishes as prey for largemouth bass. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 43:153–163.

Moxley, D. J. and F. H. Langford. 1982. Beneficial effects of hydrilla on two eutrophic lakes in central Florida. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 36:280–286.

Moyle, P. B. and N. J. Holzhauser. 1978. Effects of the introduction of Mississippi silverside (*Menidia audens*) and Florida largemouth bass (*Micropterus salmoides floridanus*) on the feeding habits of young-of-year largemouth bass in Clear Lake, California. Trans. Am. Fish. Soc. 107:574–582.

Novinger, G. D. 1984. Observations on the use of size limits for black basses in large impoundments. Fisheries 9(4):2–6.

Porak, W. F., S. Crawford, D. Renfro, and R. L. Cailteux. 1990. Study XIII: Largemouth bass population responses to aquatic plant management strategies. Fla. Game and Fresh Water Fish Comm., Fed. Aid in Sport Fish Restor., Compl. Rep., Proj. F-24, Tallahassee. 91pp.

Savino, J. F. and R. A. Stein. 1982. Predator-prey interaction between largemouth bass and bluegill as mediated by simulated, submerged vegetation. Trans. Am. Fish. Soc. 111:255–266.

Schramm, H. L., Jr. and A. V. Zale. 1985. Effects of cover and prey size on preferences of juvenile largemouth bass for blue tilapia and bluegills in tanks. Trans. Am. Fish. Soc. 114:725–731.

Taubert, B. D. and J. A. Tranquilli. 1982. Verification of the formation of annuli in otoliths of largemouth bass. Trans. Am. Fish. Soc. 111:531–534.

Van Den Avyle, M. J. and J. E. Roussel. 1980. Evaluation of a simple method for removing food items from live black bass. Prog. Fish-Cult. 42:222–223.

Von Geldern, C. E., Jr. and D. F. Mitchell. 1975. Largemouth bass and threadfin shad in California. Pages 436–449 *in* R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fish. Inst., Washington, D.C.

Ware, F. J. and R. D. Gasaway. 1978. Effects of grass carp on native fish populations in two Florida lakes. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 30:324–335.

Wiley, M. J., R. W. Gordon, S. W. Waite, and T. Powless. 1984. The relationship between aquatic macrophytes and sportfish production in Illinois ponds: a simple model. North Am. J. Fish. Manage. 4:111–119.

Wilkinson, L. and M. Hill. 1994. Using SYSTAT: SYSTAT for DOS. SYSTAT, Inc., Evanston, Ill. 871pp.