J. Aquat. Plant Manage. 36: 101-107

Analysis of the Recreational Fishery and Angler Attitudes Toward Hydrilla in Lake Seminole, a Southeastern Reservoir

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ABSTRACT

Lake Seminole has experienced a dramatic increase in the coverage of hydrilla (*Hydrilla verticillata* Royle) during the past 20 years, peaking at about 65% surface area coverage in 1992. To determine the current status of the fishery, we conducted a roving creel survey during 1996 and compared our results to similar data collected in 1978-79 and 1985. Total angling effort and total catch decreased by over 36% between 1985 and 1996, and nearly all of this decline was attributable to fewer anglers seeking largemouth bass (*Micropterus salmoides* Lacepede). In 1996, catch rates of largemouth bass ≥305 mm total length was extremely low (0.16 fish/h) and likely contributed to the decline in angler effort for this species. For other species, catch rates were similar between 1985 and 1996, except catch rates for sunfish (*Lepomis* spp.) decreased from 3.93 to 2.10 fish/h. Largemouth bass anglers generally preferred the same amount of macrophyte coverage, while most anglers for other species preferred less coverage. Lake Seminole home-owners generally preferred fewer macrophytes, while non home-owners preferred less or the same amount.

Key words: angler effort, catch rates, creel survey, home-owners, submersed macrophytes.

INTRODUCTION

Lake Seminole is an impoundment of the Chattahoochee and Flint Rivers and outlets as the Apalachicola River in Florida (Figure 1). The reservoir lies within the southwest corner of Georgia and a small portion of Florida. The reservoir has a surface area of 13,200 ha, a mean depth of 3.0 m, a maximum depth of 10.7 m and 155 km of shoreline.[2]

Lake Seminole has experienced a dramatic increase in the coverage of hydrilla during the past 20 years. In 1992, hydrilla coverage peaked at about 65% of the surface area, compared to about 8% coverage in 1979 and 40% coverage in 1985.[2] By 1996, hydrilla coverage declined to about 50%, due in part to extreme flooding that occurred as a result of tropical storm activity in 1994 in which 64 cm of precipitation fell within the watershed during a period of three days. Herbicides and mechanical harvesters have been used to reduce aquatic macrophyte coverage in some areas, but large-scale, long-term control has proven to be cost prohibitive in this large reservoir.

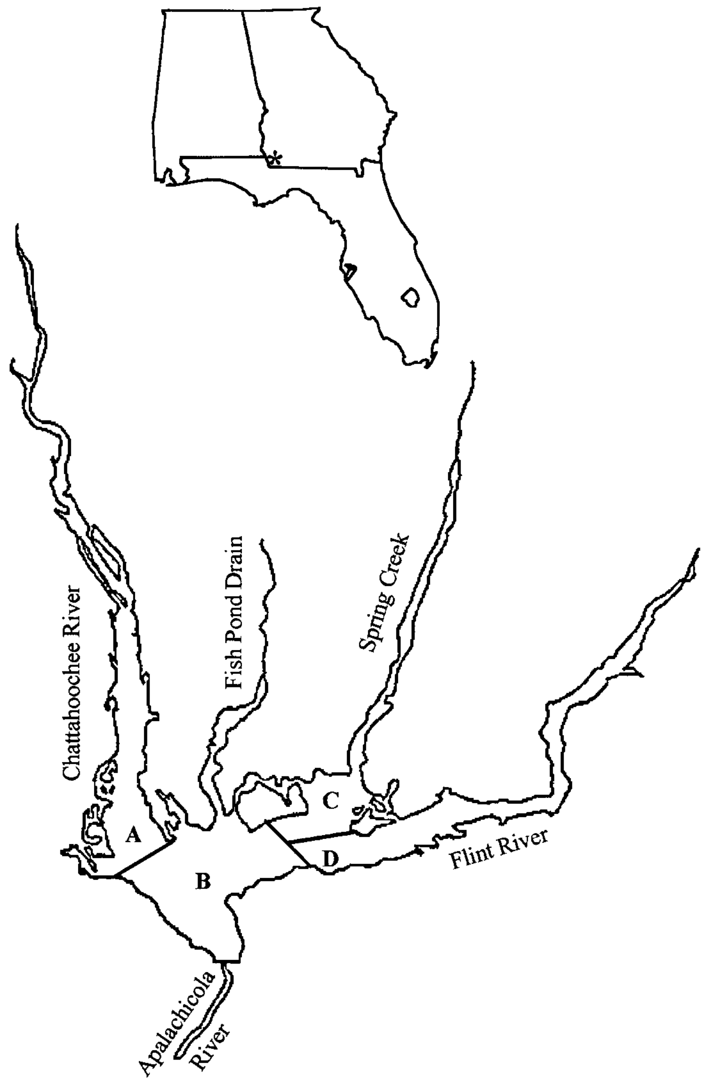

Figure 1. Map of Lake Seminole indicating sections used for the creel survey and aerial counts.

Recreational fishing has been a popular and important economic activity on Lake Seminole. Angler fishing effort

[1]Department of Fisheries and Allied Aquacultures, Alabama Agricultural Experiment Station, Auburn University, Alabama 36849. Received for publication October 9, 1997 and in revised form May 14, 1998.

[2]USACE (U.S. Army Corps of Engineers). 1996. Lake Seminole, FL-GA-AL hydrilla action plan. Supplement to Environmental Impact Statement. U.S. Army Corps of Engineers, Mobile District, Mobile, Alabama.

declined 33% between 1978-79 and 1985 as hydrilla coverage increased.[3] Total recreational visitation to Lake Seminole also declined dramatically with the increase in hydrilla.[2] A similar decline in fishing effort and angler visitation was observed in a Florida lake as hydrilla coverage increased (Colle et al. 1987). In Lake Seminole, fishing effort directed at largemouth bass increased from 36% to 73% of the total angling effort between 1978-79 and 1985, while effort directed at sunfish, crappie (*Pomoxis* spp.), and catfish (Ictaluridae) declined. Angler catch rates (number/h) of largemouth bass, crappie, catfish, and hybrid striped bass (*M. chrysops* Rafinesque × *Morone saxatilis* Walbaum) also appeared to decline between 1978-79 and 1985.

Objectives of our study were to determine the current status of the recreational fishery in Lake Seminole and to compare current fishery characteristics to similar data obtained in 1978-79 and 1985 to determine how the increase in the coverage of aquatic macrophytes has impacted the fishery. We also evaluated angler attitudes and perceptions regarding the abundance of aquatic vegetation in this multi-purpose reservoir.

MATERIALS AND METHODS

A stratified, two-stage, nonuniform probability, roving creel survey was used to collect data on angler effort, catch, harvest and opinions (Malvestuto et al. 1978). We followed the same survey design as that used by the Georgia Department of Natural Resources (GDNR) on Lake Seminole in 1978-79 and 1985.[3] Surveys were conducted between February 1 and June 30, 1996 because this period historically accounted for an estimated 80% of the annual fishing effort on Lake Seminole (L. Keefer, GDNR, personal communication). Sampling days were the primary sampling units and were stratified as either weekend (WE) or weekday (WD). Sampling units within each day were either AM or PM periods. The reservoir was partitioned into four sections (A = 2,900 ha, B = 4,100 ha, C = 2,200 ha, and D = 3,400 ha) which served as secondary sampling units (Figure 1).[4] Probabilities for reservoir section, day-of-week, and time-of-day were obtained from the results of previous surveys conducted by the GDNR.

The survey period consisted of 151 days, of which 107 days (63 WD and 44 WE) were surveyed by a roving creel clerk. For a particular section, anglers were interviewed on the water and questioned about their catch, and all harvested fish were weighed in aggregate by species-group. Anglers were asked about trip details including length of trip up to the time of interview, species sought, and location of residence. Anglers also were asked if they were a Lake Seminole property owner and if they fished Lake Seminole during most of the year; if anglers answered yes to either of these two questions, they were then asked whether they would like to see more, less, or the same amount of aquatic vegetation in the lake. Finally, anglers were asked if they had answered the plant preference question in a previous interview, and if so, these date were not included in the analysis to avoid duplication of responses.

Differences in responses were tested for homogeneity with χ^2 analysis. The relative importance of angler characteristics in relation to their responses was examined with categorical regression. Areal coverage of submersed aquatic macrophytes was estimated for each section surveyed using a combination of aerial color photography and on-site mapping with differentially corrected Global Positioning System (GPS) equipment and Geographical Information System (GIS) software (D. Morgan, USACE, personal communication). These data were used to examine the association between macrophytes and the fishery.

Due to the morphological complexity and size of Lake Seminole, aerial flights were conducted concurrently with the roving creel survey on two randomly chosen days each week, one weekend day and one weekday, to obtain estimates of total angling effort. Flights were conducted on 41 (21 WD and 20 WE) of the 107 days in which on-the-water surveys were conducted. Flight times varied and were dependent upon the time necessary to count all anglers in a particular section.

Catch per unit effort (CPUE) was calculated for each species group based on data obtained through angler interviews with the procedures and formulae of Malvestuto et al. (1978) and Jones et al. (1995). Percent of total fishing effort by species group also was obtained through angler interviews. Total angler effort was estimated based on data obtained through aerial counts of anglers with the procedures and formulae of Malvestuto et al. (1978). Estimates of total catch and harvest by species group were obtained by multiplying species-specific rate estimates by the total estimated effort expended for each species group.

Estimates of angler effort, catch, and harvest from the present study were compared to estimates from creel surveys conducted in 1978-79 and 1985 at Lake Seminole to determine how changes in aquatic plant coverage since that time might have affected angler effort and success. No data regarding angler demographics, nor opinions of aquatic plant coverage, however, were available from 1978-79 or 1985. Original creel survey data from February through June, 1985 were obtained from GDNR (unpublished data). Original data from 1978-79 were destroyed in a 1994 flood in Albany, Georgia, and only published summary statistics representing annual values were available for comparisons. Statistical comparisons of species-group specific catch rates among reservoir sections were conducted using one-way analyses of variance (ANOVA).

RESULTS

From interviews, we collected information from 1,224 anglers, 517 (42%) of whom stated that they were targeting largemouth bass. Total fishing effort for the study period was 126,900 h, compared to 264,500 h for the comparable time period in 1985. Most of this decline in fishing effort was the result of a decline in anglers seeking largemouth bass, as

[3]Keefer, L. C. 1988. A survey of the sport fisheries of four major reservoirs in southwest Georgia. Georgia Department of Natural Resources, Game and Fish Division, Final Report, Federal Aid Project F-28, Atlanta, Georgia.

[4]Keefer, L. C. 1981. A survey of the Lake Seminole fishery with emphasis on the success of stocking *Morone* hybrids. Georgia Department of Natural Resources, Game and Fish Division, Final Report, Federal Aid Project F-28, Atlanta, Georgia.

effort for this species was 193,900 h in 1985, compared to 67,300 h in 1996. Plant coverage in sections A, B, C, and D were 20.5, 34.3, 84.5, and 16.5%, respectively, in 1996 (Figure 2). Total fishing effort adjusted for area was similar in all sections except B, where effort was lowest. Total effort and pressure (effort per unit area; h/ha) varied by section in 1996, but did not appear to be related to percent coverage of aquatic vegetation (Figure 2). Thus, anglers as a whole did not appear to select fishing areas based on plant coverage. However, anglers targeting a particular species did appear to select fishing areas according to the amount of plant coverage, although a limited number of data points precluded a formal statistical analysis. Species-specific fishing pressure was highest in section C (highest plant coverage) for anglers who targeted largemouth bass and crappie, whereas section A (intermediate plant coverage) accounted for the highest fishing pressure for sunfish and catfish.

A shift in species-specific effort by Lake Seminole anglers was evident between 1985 and 1996. Anglers targeting largemouth bass accounted for 73% of the total effort expended in 1985, compared to only 53% of the total effort in 1996 (Table 1). In 1985, anglers targeting sunfishes accounted for 9% of the total effort, but by 1996, effort directed at sunfishes had increased to 27% of the total. The percentages of total effort attributable to anglers fishing for crappie and catfish were similar between 1985 and 1996, but lower than 1978-79.

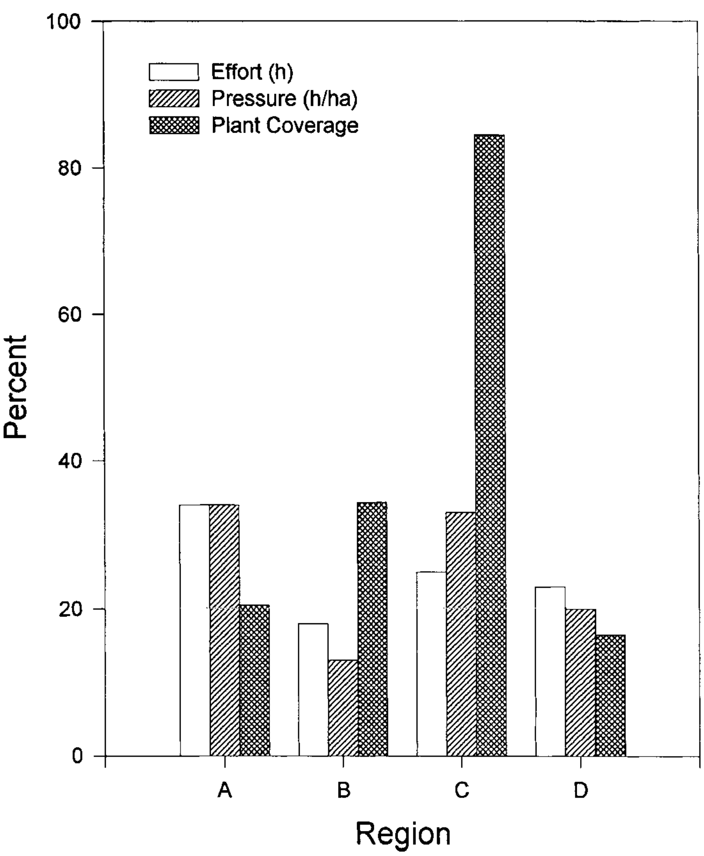

Figure 2. Percent of total effort (h) and pressure (h/ha) expended in each section of Lake Seminole in 1996 and a comparison to the percent coverage of aquatic vegetation in each section.

The total number of fish caught at Lake Seminole was at least 36% lower in 1996 than in 1985 (Table 2). Largemouth bass showed the most substantial decrease between the two study periods, while sunfish accounted for the lowest percentage change. Also, the sunfish group accounted for the highest number of fish caught during both 1985 and 1996.

The total biomass harvested decreased between 1985 and 1996 for all species groups (Table 2). Largemouth bass harvest decreased by about 90% from 1985 to 1996, while sunfish harvest decreased by only 17% on a per weight basis. Largemouth bass accounted for 62% of the total biomass harvested between February and June, 1985, compared to only 24% in 1996. Sunfish was the most abundant species-group harvested in terms of biomass in 1996 and accounted for 41% of the total harvest. In 1985, sunfish biomass harvest was only 9% of the total harvest, but was still higher than in 1996 (Table 2). The mean weight of harvested largemouth bass also decreased from 1.47 kg in 1985 to 0.80 kg in 1996 (Table 1). The mean weights of harvested fish for other species were similar among survey years.

Mean weights of harvested fish in 1996 appeared to be related to macrophyte coverage, particularly for largemouth bass. The mean weight of harvested largemouth bass was lowest in section C (0.57 kg; highest macrophyte coverage) and highest in section D (1.14 kg; lowest macrophyte coverage), although the relationship was only marginally significant ($r = -0.86$; $P < 0.15$).

Mean angler fished-for catch rates (N/h) varied between years for most species groups (Table 3). Seasonal catch rate estimates were not available for 1985 and 1978-79; therefore, data presented for these years were based on annual catch rates. Catch rates for largemouth bass were similar between 1985 and 1996, and were lower than in 1978-79. The catch rate of largemouth bass partitioned by length-group resulted in a catch rate for fish ≥305 mm total length (TL) of 0.16 fish/h, and 0.12 fish/h for largemouth bass <305 mm TL in 1996. Data from the 1985 survey indicated that the catch rate of largemouth bass ≥305 mm was 0.28 fish/h (Table 3).[3] The catch rate for anglers targeting sunfish decreased each survey year from 4.4 fish/h in 1978-79 to 3.9 fish/h in 1985 and 2.1 fish/h in 1996. Mean angler catch rates for crappie decreased slightly in 1985 and 1996 from a high of 1.5 fish/h in 1978-79. The catch rate of catfish was similar for all survey years. Also in 1996, fished-for catch rates for each species group did not differ by reservoir section (ANOVA; $P > 0.10$).

A total of 429 anglers responded that they either owned a home on Lake Seminole or fished the lake during most of the year, and hence, were asked whether they would like to see more, less or the same amount of aquatic vegetation in the lake. Overall, responses by anglers regarding the abundance of aquatic plants were not evenly distributed ($\chi^2 = 89.96$; $P < 0.01$). About 49% of anglers responded that they would prefer to see fewer aquatic plants in Lake Seminole, which was much higher (z-test = 6.43; $P < 0.01$) than the 13% that said they would like to see more.

Responses toward aquatic plant abundance were distributed differently between Lake Seminole home-owners and non home-owners ($\chi^2 = 29.58$; $P < 0.01$). Most anglers (66%)

TABLE 1. TARGETED EFFORT (H), PERCENT TARGETED EFFORT (%), AND MEAN WEIGHTS OF HARVESTED FISH FOR ANGLERS FISHING LAKE SEMINOLE. DATA FOR 1978-79 REPRESENT MEAN ANNUAL VALUES, WHEREAS DATA FOR 1985 AND 1996 COVER THE CREEL SURVEY PERIOD FROM FEBRUARY THROUGH JUNE EACH YEAR.

	Year								
	1978-79			1985			1996		
Species	Targeted Effort (h)	Percent Effort (%)	Mean Weight (kg)	Targeted Effort (h)	Percent Effort (%)	Mean Weight (kg)	Targeted Effort (h)	Percent Effort (%)	Mean Weight (kg)
Largemouth bass	165,500	36	0.80	193,900	73	1.47	67,300	53	0.80
Sunfish	135,600	29	0.14	22,700	9	0.19	34,000	27	0.12
Crappie	82,100	18	0.29	27,200	10	0.32	14,100	11	0.30
Catfish	66,700	14	0.11	12,700	5	0.16	10,600	8	0.10
Other	14,500	3		7,900	3		841	1	

who owned a home on the lake preferred fewer aquatic plants, while anglers who did not own a home on the lake appeared to be more evenly distributed in their responses (Figure 3). When home-owners and non home-owners were grouped, responses toward aquatic plant coverage differed by the species for which anglers fished ($\chi^2 = 104.35$; $P < 0.01$). While responses from largemouth bass anglers were relatively even in distribution, anglers targeting other species preferred less or the same level of aquatic plant coverage (Figure 4). Largemouth bass anglers were the only group in which more than 5% of the respondents preferred to see more aquatic plant coverage in Lake Seminole.

A difference in plant abundance preference was not evident between home-owner or non home-owner largemouth bass anglers ($\chi^2 = 3.92$; $P = 0.14$; Figure 5). However, only 17% of bass anglers who owned a home preferred more vegetation, while 36% of non home-owners who fished for largemouth preferred more vegetation. The percentage of all non-largemouth bass anglers preferring fewer aquatic plants was significantly greater than the percentage preferring the same or more aquatic plants ($\chi^2 = 12.99$; $P < 0.01$).

Categorical regression modeling showed that angler type (i.e., bass or non-bass) was the strongest determinant ($\chi^2 = 61.52$; $P < 0.0001$) of plant preference. Whether or not an angler owned a home was not as strong a determinant as angler type, but still was highly influential ($\chi^2 = 10.43$; $P < 0.01$) in predicting plant preference. Finally, after accounting for the effects of angler type and home or non-home ownership in the model, the interaction between these two categorical terms was non-significant ($\chi^2 = 0.07$; $P = 0.80$).

Possible responses from the categorical model ranged from 1.00, which conferred complete preference for fewer aquatic plants, to 3.00, which indicated complete preference for more plant coverage. A value of 2.00 conferred a preference for the same level of aquatic plant coverage. The model predicted values of 1.27 for non-bass home owners, 1.50 for non-bass non-home owners, 1.86 for bass home owners, and 2.14 for bass non-home owners. Thus, those non-bass anglers who owned a home showed a strong preference for fewer plants, while bass anglers who owned or did not own homes desired to maintain the same level of vegetation in Lake Seminole.

Lake Seminole home-owners and non home-owners targeted different fish species ($\chi^2 = 28.26$; $P < 0.01$). Most anglers who did not own homes on Lake Seminole fished for largemouth bass, whereas Lake Seminole home-owners fished primarily for sunfish and crappie.

DISCUSSION

The decline in total angling effort observed between 1978-79 and 1985 continued into 1996. The 33% decline in total effort between 1978-79 and 1985 was followed by a 52% decline between 1985 and 1996. The observed decline in angler use at Lake Seminole occurred at a time of increasing hydrilla coverage. Colle et al. (1987) documented a similar decline in angler use at a Florida lake under conditions of extensive hydrilla coverage. The dramatic decline in fishing effort at Lake Seminole, particularly for largemouth bass, was likely the result of reduced catch rates of largemouth

TABLE 2. ESTIMATES OF THE NUMBER OF FISH CAUGHT (N), NUMBER CAUGHT PER UNIT AREA (N/HA), BIOMASS HARVESTED (KG), AND BIOMASS HARVESTED PER UNIT AREA (KG/HA) FOR SELECTED SPECIES GROUPS IN LAKE SEMINOLE. ESTIMATES ARE FOR FEBRUARY THROUGH JUNE, 1985 AND 1996.

		Catch		Harvest	
Year	Species	N	N/ha	kg	kg/ha
1985	Largemouth bass	54,300	4.31	40,000	3.18
	Sunfish	89,400	7.10	6,600	0.52
	Crappie	26,700	2.12	11,600	0.92
	Catfish	26,500	2.11	6,000	0.48
1996	Largemouth bass	19,000	1.51	3,200	0.25
	Sunfish	72,400	5.75	5,400	0.43
	Crappie	14,300	1.13	3,200	0.26
	Catfish	18,700	1.49	1,400	0.11

TABLE 3. ESTIMATES OF MEAN ANGLER CATCH RATES (N/H) FOR SELECTED SPECIES GROUPS FROM LAKE SEMINOLE. ESTIMATES ARE FOR ANGLERS TARGETING EACH PARTICULAR SPECIES GROUP.

Species	1978-79	1985	1996
Largemouth bass	0.42	0.28	0.28
Bass >305 mm	—	0.28	0.16
Bass <305 mm	—	0.00	0.12
Sunfish	4.43	3.93	2.10
Crappie	1.54	0.98	1.11
Catfish	2.00	2.09	1.97

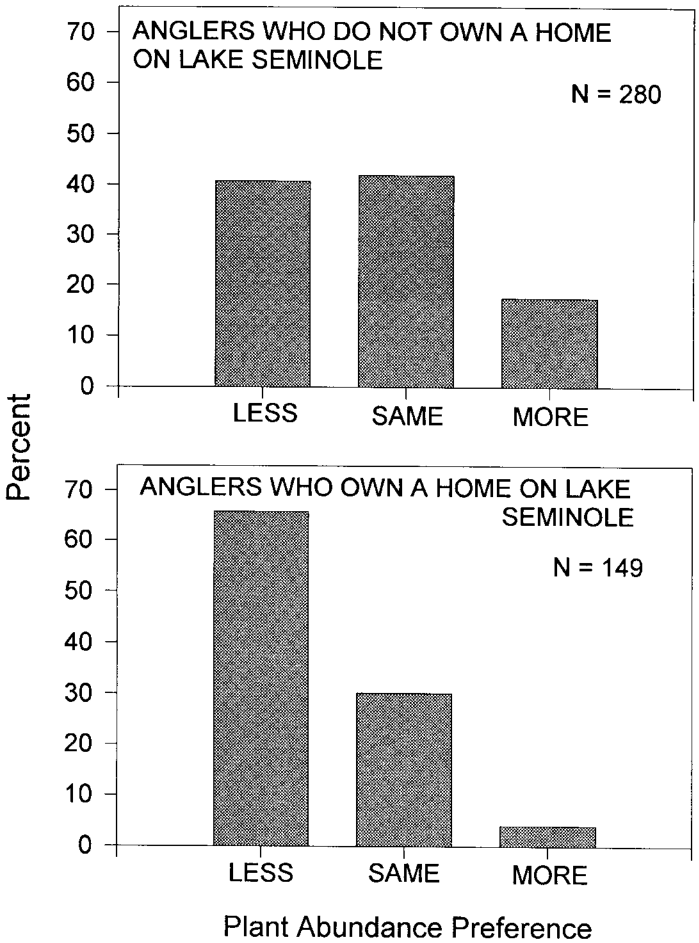

Figure 3. Responses regarding the preferred abundance of aquatic plants in Lake Seminole, partitioned by anglers who did or did not own a home on Lake Seminole in 1996.

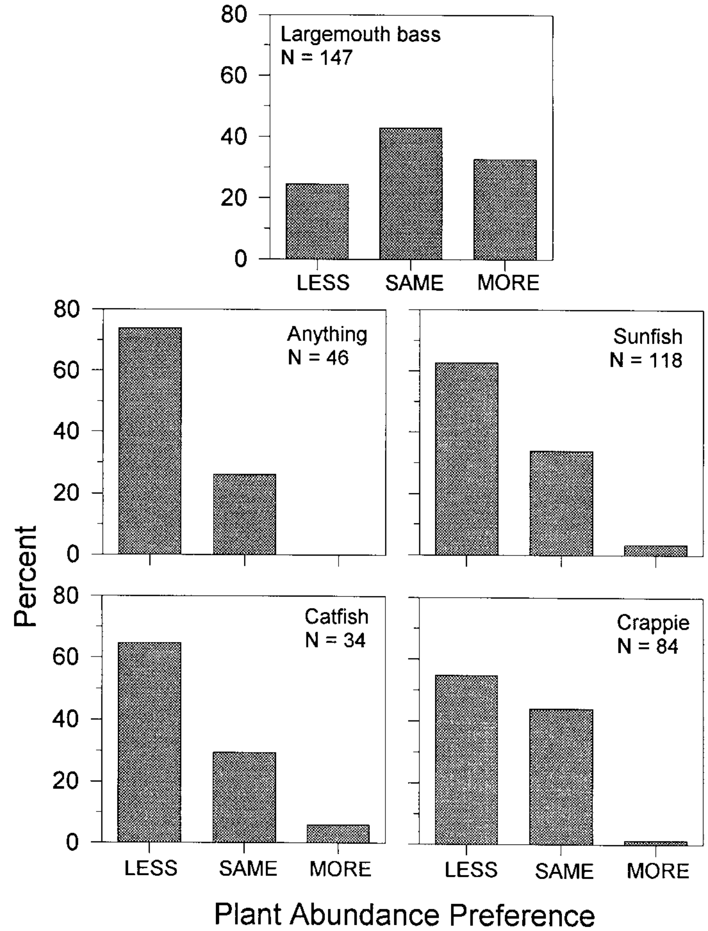

Figure 4. Responses regarding the preferred abundance of aquatic plants in Lake Seminole in 1996, partitioned by the species for which anglers fished.

bass ≥305 mm TL, which declined from 0.28/h in 1985 to 0.16/h in 1996. We speculate that many largemouth bass anglers decided not to fish Lake Seminole or fish less often because catch rates were low. However, reduced angler access to hydrilla infested areas likely contributed to the overall decline in fishing effort.

The decrease in angler effort at Lake Seminole undoubtedly impacted the local economy. Wrenn et al. (1996) documented a decline in angling expenditures of $1.4 million between 1991 and 1993 at Lake Guntersville, Alabama, concurrent with a 63% reduction in fishing effort. In their study, Wrenn et al. (1996) identified reduced catch rates of largemouth bass as the probable cause for the decline in fishing effort. Although declining largemouth bass catch rates were associated with a decrease in submersed macrophyte coverage in Lake Guntersville between 1990 and 1993, macrophyte coverage never exceeded 12% during the period. In contrast, submersed macrophyte coverage in Lake Seminole never fell below 40% between 1985 and 1996, suggesting that largemouth bass catch rates might be greatest under conditions of moderate macrophyte coverage.

Anglers fishing for largemouth bass accounted for most of the total effort expended for all survey years. The increased popularity of bass fishing in the 1980's was reflected by an increase in the percent of total effort attributable to anglers targeting that species in 1985 (73%). However, that percentage decreased to 53% in 1996. Also in 1996, bass anglers tended to expend more effort fishing the Spring Creek Arm (section C; highest plant coverage), compared to other less vegetated sections of the reservoir. Conversely, the opposite trend was observed in Lake Guntersville, Alabama where the section of highest plant coverage accounted for the lowest targeted largemouth bass effort (Wrenn et al. 1996).

The number of fish caught during the 1996 survey period on Lake Seminole was 36% less than the number caught during the same time period in 1985 for all species groups combined. Catch rates, however, were similar between the two survey years for all species groups except sunfish. Thus, the decline in total catch was primarily a result of the decreased angler effort between the 1985 and 1996. Total biomass harvested also decreased substantially between 1985 and 1996. Largemouth bass accounted for the greatest percentage of biomass harvested in 1985, whereas sunfish made up the bulk of the harvest in 1996.

The apparent negative relationship between macrophyte coverage and mean weight of harvested largemouth bass, while not statistically significant due to limited observations, is consistent with previous research. The mean weight of harvested largemouth bass was negatively correlated with macro-

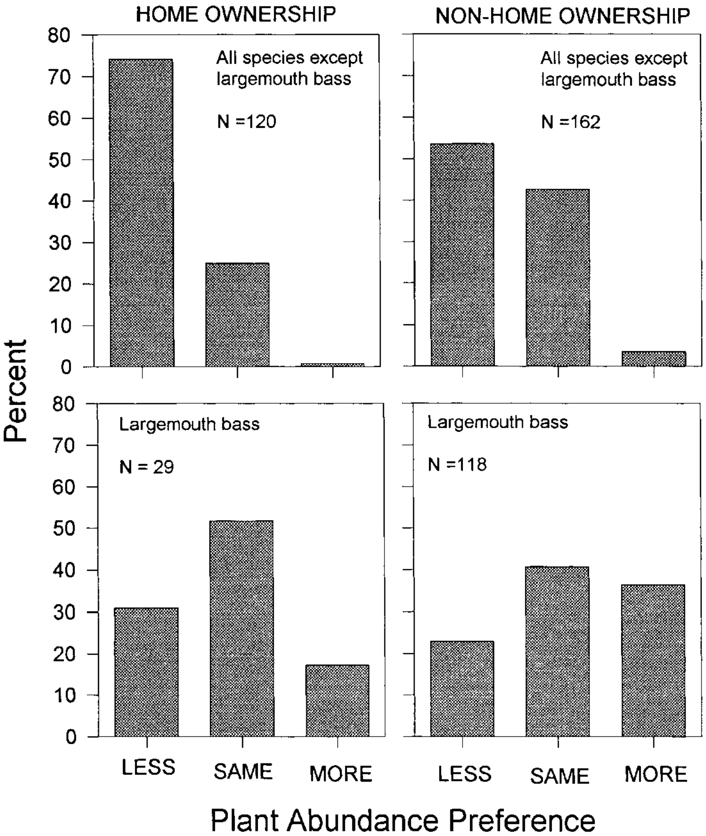

Figure 5. Responses regarding the preferred abundance of aquatic plants in Lake Seminole in 1996, partitioned by anglers who did or did not own a home on Lake Seminole and whether or not they fished for largemouth bass.

phyte coverage in Lake Conroe, Texas, where submersed macrophyte coverage, primarily hydrilla, ranged from 0 to 44% of the surface area.[5] A negative relationship between macrophyte coverage and mean weight of harvested largemouth bass also was observed in Lake Guntersville, Alabama, where submersed macrophyte coverage, primarily Eurasion milfoil (*Myriophyllum spicatum* Lacepede), ranged from 7 to 28% of the surface area (Maceina and reeves 1996).

A positive correlation between largemouth bass angler catch rates and macrophyte coverage also was evident from these two previous studies. However, no significant relationship between catch rates of largemouth bass and macrophyte coverage at Lake Seminole was observed during this study, although the highest largemouth bass catch rate (0.38 fish/h) did occur in section C (highest macrophyte coverage). The trend of lower sunfish catch rates from 1978-79 through 1996 is consistent with previous research. Colle et al. (1987) found that sunfish catch rates declined substantially once hydrilla became well established and exceeded 50% coverage, and they speculated that the decline was due to reduced growth of sunfish caused by insufficient cropping by predators.

Anglers varied in their response to the question regarding their preference of aquatic plant abundance. Anglers who owned a home on Lake Seminole generally preferred fewer aquatic plants, while non home-owners were more evenly divided concerning a preference for a particular level of macrophyte coverage. As a group, non-largemouth bass anglers clearly preferred less or the same level of coverage, whereas largemouth bass anglers were more evenly distributed in their responses toward varying levels of aquatic plant coverage and accounted for the largest percentage of respondents that preferred more plant coverage. These results are similar to those of Wilde et al. (1992), who found that largemouth bass anglers indicated the greatest opposition to aquatic vegetation control, whereas crappie and catfish anglers indicated the least opposition.

The relation between submersed macrophyte coverage, largemouth bass catch rates, and the decline in angler visitation appears spurious. Although largemouth bass catch rates and angler effort decreased during a period of increased macrophyte coverage, angler catch rates of largemouth bass in 1996 were highest in section C (highest macrophyte coverage). Therefore, we conclude that on a lake-wide scale, angler catch rates of largemouth bass were influenced more by largemouth bass recruitment than by catchability under various levels of macrophyte coverage. Future research in this area should focus on the population dynamics (recruitment, growth, and mortality) of largemouth bass under varying levels of aquatic macrophyte coverage.

In conclusion, the management of aquatic macrophytes in large multi-use reservoirs like Lake Seminole is a complicated issue, and one not easily resolved. Managers must consider not only the different needs of various user groups (angling, swimming, navigation, power generation, etc.), but also the preference for aquatic plant abundance within user groups. Largemouth bass anglers tend to want more vegetation, whereas some other anglers consider abundant vegetation to be a nuisance. Anglers who own homes on the reservoir are more passionate about vegetation control than are anglers who do not own homes on the reservoir. Managers should use sound scientific data to assist in complex decision making processes regarding the levels of aquatic vegetation coverage that maximize benefits for all users.

ACKNOWLEDGMENTS

Funding for this project was provided by the Mobile District Corps of Engineers through the Alabama Cooperative Fish and Wildlife Research Unit (cooperative agreement 14-45-0009-1550, number 56). The Unit is sponsored by the National Biological Service, the Game and Fish Division of the Alabama Department of Conservation and Natural Resources, the Wildlife Management Institute, and Auburn University (Alabama Agricultural Experiment Station, Department of Fisheries and Allied Aquacultures, Department of Zoology and Wildlife Science). We thank D. Bayne, C. Webber, R. Wright and three anonymous reviewers for providing comments that improved this manuscript. Partial funding was also provided by the Georgia Department of

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