Fisheries Session

Electrofishing Catch of Largemouth Bass: Spatiotemporal Variation and Relation to Angler Catch

Robert K. Betsill, *Texas Parks and Wildlife Department, Heart of the Hills Research Station, HC07, Box 62, Ingram, TX 78025*

Abstract: I examined spring and fall electrofishing catch rates of largemouth bass (*Micropterus salmoides*) in 12 Texas reservoirs from 1986 to 1992 to assess the relative importance of spatial and temporal variation and to evaluate the relation between electrofishing catch rates and future angler catch. East Texas reservoirs were characterized by relatively greater temporal (i.e., annual) variation in electrofishing catch rates, whereas west Texas reservoirs tended to exhibit greater spatial variation. Reservoirs in east Texas shared a common temporal pattern in electrofishing catch rates. Conversely, there were marked differences in catch rates among west Texas reservoirs that remained relatively stable across years. The relation between electrofishing catch rate and angling success was poorer than expected. Spring electrofishing yielded most of the significant correlations with future angler catch, particularly in east Texas reservoirs. However, correlations were generally weak and of limited predictive value. Given that improving or increasing angler catch is often the goal of management actions, such actions should probably be assessed directly using creel surveys rather than electrofishing catch-per-unit-effort. Substantial regional (east vs. west Texas) differences in electrofishing catch-per-unit-effort, and in the relation to angler catch, suggested that a regional approach to largemouth bass management in Texas might be appropriate.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 50:1-11

The ability to forecast recruitment of sport fishes would be of considerable practical value to fishery managers. In marine fisheries, there has been some success at predicting recruitment or harvest using data on the abundance of spawners (e.g., Garrod 1967, Ricker 1975). The greater role of density-independent population regulation in freshwater systems has limited the use of stock-recruitment relations for predicting year-class strength in these systems (Van Den Avyle 1993). Instead, an index of year-class strength, measured close to the time of recruitment, is often used to forecast changes in the size of harvestable or catchable stocks in freshwater fisheries. This index is based on catch-per-unit effort (CPUE) of pre-recruits and has been used for striped bass (*Morone saxatilis*) (Goodyear 1985), crappies (*Pomoxis* spp.) (Mitzner 1981, 1991), and other freshwater fishes.

Biologists of the Texas Parks and Wildlife Department (TPWD) establish largemouth bass harvest regulations based, in part, on consideration of recruitment in the target populations. A common index of recruitment used by these biologists is CPUE from seasonal electrofishing surveys. The utility of such an index depends on the strength of its relation to future catchable stocks or angler harvest. This index is based on considerable institutional experience, but it lacks quantitative, statistical evaluation for Texas waters.

The objective of this study was to determine the relative importance of geographic and annual variation in electrofishing CPUE of largemouth bass and assess the statistical relation between electrofishing CPUE and angler catches in Texas reservoirs.

This study was funded by Federal Aid in Sport Fish Restoration Grant F-31-R. I thank R. Howells, R. Luebke, S. Peyton, V. Pitman, and J. Prentice for reviewing the manuscript. Data used in this study were collected by TPWD Inland Fisheries Division field staff.

Methods

General

The TPWD maintains a computerized database of electrofishing and creel survey data collected from Texas reservoirs. The data are collected during standardized, routine monitoring of the state's fishery resources. I selected 12 reservoirs for which electrofishing and creel survey data were available for most or all of the period between 1986 and 1992. These reservoirs provided good geographic coverage of the state and during the study period, a 356-mm minimum length limit was in effect for largemouth bass in each reservoir.

Electrofishing and creel surveys were conducted according to guidelines in the Texas Inland Fishery Assessment Procedures manual (TPWD, Austin, Texas). Electrofishing surveys consisted of 15-minute transects at 4–12 sites in each reservoir. Surveys were conducted at night in spring or fall (frequently both seasons). All largemouth bass were measured and counted. I calculated seasonal electrofishing catch rates (*N*/hour) of largemouth bass by averaging estimates from each of the sampling sites in each reservoir. Separate estimates were calculated for spring and fall of each year when data were available. Catch rates were calculated separately for 3 size classes of largemouth bass: <200 mm, 200–355 mm, and ≥356 mm. These size classes were chosen based upon general characteristics of catchability and harvestability. The smallest size class (i.e., <200 mm) was considered too small to be generally caught by anglers but capable of growing to catchable size within 1 year. Largemouth bass 200–355 mm could contribute greatly to angler catch rates, but under the regulations existing on the study reservoirs, they could not be harvested. Given the average growth rates of largemouth bass in Texas (see Prentice and Durocher 1978), these fish could be expected to grow into the harvestable size class (≥356 mm) within 1 year. The largest size class (i.e., ≥356 mm) contained fish large enough for anglers to harvest.

Quarterly estimates of angler average catch rates were calculated from interviews of parties seeking largemouth bass. Numbers of fish harvested, numbers reported released, and total catch (harvested plus released fish) were converted to rates using estimates of effort for each party. Data from completed and incomplete trips were used.

Geographic and Annual Variation

Previous study of fish distribution among Texas reservoirs has shown a general east-to-west decrease in largemouth bass biomass (Miranda 1984) and abundance (Dolman 1990). Since this earlier work was based on 8–10 years of survey data, it was clear largescale regional differences (i.e., east vs. west Texas) overshadowed annual variability. Therefore, I examined geographic and annual variability within these 2 regions of Texas. I used the 97th meridian as the dividing line between regions. Choice of this meridian was arbitrary, although it approximates the western edge of the blackland prairie ecoregion. In a study of average ichthyomass among Texas reservoirs, Miranda (1984) found substantially lower biomass of black basses (*Micropterus* spp.) west of the blackland prairie ecoregion. This dividing line also corresponds approximately to the 76-cm rainfall isopleth. Reservoirs in the eastern region typically have stable water levels, abundant aquatic vegetation, low conductivity and salinity, and are neutral to acidic. Conversely, in western reservoirs, water levels fluctuate greatly, aquatic vegetation is scarce, conductivity is high and pH is more alkaline.

I averaged seasonal electrofishing CPUE across years to describe geographic patterns. Heterogeneity of reservoirs, within regions, was quantified using coefficients of variation among these reservoir long-term averages.

I used a 2-way analysis of variance to separate spatial and temporal components of variance in largemouth bass CPUE data following the rationale of Lewis (1978). The factors included in the analytical model were reservoir, year, an interaction term, and an error term. Each of the factors (= effects) in the model represents a source of variation. The reservoir effect represents differences among reservoirs that tend to be consistent from year to year (= fixed spatial variation). The year effect measures year-to-year fluctuations in CPUE that are common to all reservoirs (= temporal variation). The interaction term represents differences among reservoirs that change from year to year (= ephemeral spatial variation). Finally, the error term incorporates variation that cannot be attributed to spatial or temporal sources. Data were log-transformed and analyzed using the SAS VARCOMP procedure (SAS Inst. 1985).

Relation to Angler Catch

Correlation analysis was used to examine the relation between electrofishing CPUE and various measures of angler catch. Again, separate analyses were conducted for eastern and western portions of the state. In this case, the rationale for separate regional analyses stems from substantially higher water conductivity in western reservoirs (Miranda and Durocher 1986). Efficiency of electrofishing surveys is greatly influenced by water conductivity (Snyder 1992) such that relations between electrofishing CPUE and largemouth bass abundance can be expected to vary with regional limnological conditions (Hall 1986, Hill and Willis 1994).

Initially, spring and fall electrofishing CPUE's were compared with harvest rate, release rate, and total catch rate during the same season. For this analysis, electrofishing CPUE of catchable fish (i.e., 200–355 mm and ≥ 356 mm) was used. CPUE of subharvestable fish was compared with angler average release rates and overall catch rates. I tested the relation between CPUE of largemouth bass ≥356 mm and angler harvest rate and total catch rate.

I considered only those comparisons that could reasonably be expected to be related to either angler harvest, release, or total catch rates. For example, for comparison of electrofishing and creel surveys within the same season, CPUE of subharvestable fish would likely be related to angler release rates and CPUE of harvestable fish would be expected to be related to angler harvest rates. Either of these size classes of fish could contribute to angler total catch, though the relative strength of these correlations would depend on the relative abundance of each size class in the group of reservoirs. CPUE of subharvestable fish was not compared with angler harvest rates in the same season based on the assumption that anglers complied with harvest regulations.

To determine if electrofishing CPUE could be used to predict trends in future angler catch, I examined the relation between electrofishing CPUE and angler catch rates during each of the 4 subsequent seasons. For example, spring electrofishing surveys were compared to creel survey results for the following summer, fall, winter, and spring. For this analysis, growth of subharvestable fish could be expected to make these fish vulnerable to angling during the time period for which the comparison was made. Therefore, I included electrofishing CPUE of largemouth bass <200 mm and comparisons of subharvestable fish abundance with future harvest rates. Specific comparisons included: 1) CPUE of largemouth bass ≥356 mm vs. harvest and total catch rates, 2) CPUE of largemouth bass 200–355 mm vs. harvest, release, and total catch rates, and 3) CPUE of largemouth bass <200 mm vs. release and total catch rates. Because of the inherent variability associated with creel and electrofishing survey data, and because the primary purpose of this study was to identify general patterns, I used a significance level of 0.10 for all statistical tests.

Results and Discussion

Geographic and Annual Variation

East Texas reservoirs generally had higher CPUE of all sizes of largemouth bass in both spring and fall surveys (Figs. 1, 2). Regional differences were most pronounced for subharvestable largemouth bass (i.e., <200 mm and 200–355 mm). In fall, variation among eastern reservoirs was relatively low (CV = 30% and 14% for <200-mm and 200- to 355-mm size classes) while reservoirs in the west were more heterogeneous (CV = 83% and 81% for <200-mm and 200- to 355-mm size classes) and tended to display a north-to-south gradient of increasing CPUE. Spring CPUE

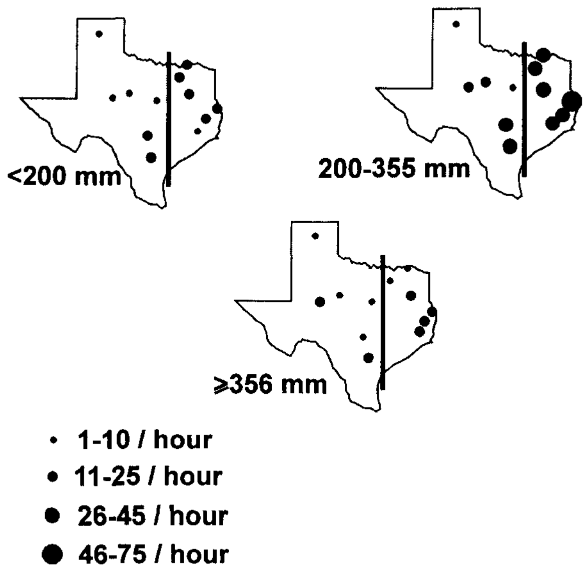

Figure 1. Catch-per-unit-effort (*N*/hour) of 3 size classes of largemouth bass in spring electrofishing surveys of 12 Texas reservoirs. Each estimate is the average of all available yearly surveys for the period 1986–1992. The vertical reference line represents the 97th meridian used to separate reservoirs into regions.

of subharvestable fish was generally lower than in fall, but again there was substantial variation among western reservoirs (CV = 93% and 67% for <200-mm and 200- to 355-mm size classes), and a north-to-south gradient in CPUE was apparent. CPUE of harvestable largemouth bass was uniformly lower in all reservoirs during spring and fall surveys, and differences between regions were less apparent.

The importance of spatial and temporal components of variance differed between regions, and in eastern reservoirs, between seasons (Table 1). In east Texas reservoirs, explained variation in spring electrofishing catch rates was fairly evenly divided among reservoir, year, and interaction effects. Year and interaction effects were most important in fall surveys. The temporal component indicates east Texas reservoirs tend to share a common pattern of annual variation in fall catch rates. For example, in years when fall CPUE was high, it tended to be high in all reservoirs. The importance of the interaction effect indicates the reservoirs with the highest (or lowest) CPUE changed from year to year. These patterns suggest influence of fall catch rates by factors that change over time but act on a regional basis. Climate or other abiotic factors could explain the observed patterns in fall catch rates. In contrast, spring catch rates showed no clear pattern of dominance by regional influences or fixed differences among reservoirs.

Among western reservoirs there was a substantial reservoir effect, especially for

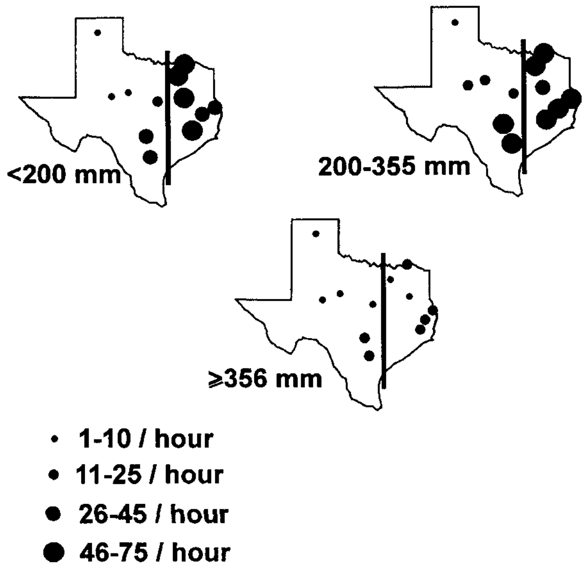

Figure 2. Catch-per-unit-effort (*N*/hour) of 3 size classes of largemouth bass in fall electrofishing surveys of 12 Texas reservoirs. Each estimate is the average of all available yearly surveys for the period 1986–1992. The vertical reference line represents the 97th meridian used to separate reservoirs into regions.

subharvestable fish. This fixed spatial variation indicates differences among reservoirs are relatively stable across years. The relatively minor contribution of temporal and ephemeral spatial variation indicate annual changes in CPUE of subharvestable fish in 1 reservoir are unlikely to be mirrored by others in the region. This suggests factors that lead to high CPUE of pre-recruits are acting at the local (i.e., reservoir) rather than regional level.

The smaller total variance in CPUE of harvestable fish reflects greater uniformity among reservoirs in catch rates of this size class. This resulted from a proportionally greater reduction in catch rates of harvestable fish (compared to catches of 200- to 355-mm fish) in the southernmost west Texas reservoirs. Another aspect of the variation in CPUE of harvestable fish is the reduced contribution of fixed spatial variation and concomitant increase in unexplained variation. These patterns could reflect differences among reservoirs in electrofishing efficiency, possibly related to habitat. However, if electrofishing catch rates reflect true population density, a hypothesis consistent with these trends is that total mortality of harvestable fish increases in a southerly direction within this region.

Relation to Angler Catch

Correlations between electrofishing CPUE and angler catch during the same season varied markedly between regions (Table 2). For east Texas reservoirs, the

Table 1. Total variance of log-transformed largemouth bass catch-per-unit-effort in spring and fall electrofishing in 12 Texas reservoirs from 2 regions, 1986–1992, and components of variance. The reservoir term reflects spatial differences that were consistent over years. Temporal variation, common to all reservoirs, is reflected by the year term. The interaction term represents ephemeral spatial variation.

Fish size (mm)	Total variance	Percent of variance			
		Reservoir	Year	Interaction	Unexplained
		East			
Spring					
<200	0.370	4	0	16	80
200–355	0.261	13	11	9	67
≥356	0.259	15	11	7	67
Fall					
<200	0.379	0	14	24	62
200–355	0.265	0	18	17	65
≥356	0.280	5	12	21	62
		West			
Spring					
<200	0.417	54	0	12	34
200–355	0.290	43	1	7	49
≥356	0.279	16	5	11	68
Fall					
<200	0.364	37	4	3	56
200–355	0.367	43	3	13	41
≥356	0.270	28	5	10	57

Table 2. Simple correlation coefficients for comparisons of seasonal electrofishing catch rates (CPUE) of various size classes of largemouth bass with angler harvest, release, and catch rates during the same season in 12 Texas reservoirs. NS indicates non-significant coefficients (i.e., $P > 0.10$).

Creel period	East		West	
	Spring	Fall	Spring	Fall
CPUE largemouth bass ≥356 mm vs. Angler harvest rate (*N*/hour)				
spring	0.53		NS	
fall		NS		0.67
CPUE largemouth bass 200–355 mm vs. Angler release rate (*N*/hour)				
spring	NS		0.31	
fall		NS		NS
CPUE largemouth bass 200–355 mm vs. Angler catch rate (*N*/hour)				
spring	NS		0.34	
fall		NS		NS

only significant relation was between spring electrofishing CPUE of largemouth bass ≥356 mm and spring angler harvest rate. None of the measures of abundance from fall electrofishing were significantly correlated with angler catch. For west Texas reservoirs, there was a significant correlation between angler harvest rate and electrofishing CPUE of largemouth bass ≥356 mm in fall but not in spring. However, among west Texas reservoirs, spring electrofishing CPUE of fish 200–355 mm was correlated with angler release rate and total catch rate in spring.

Relations between electrofishing CPUE and angler catch in subsequent seasons were most often significant using spring electrofishing in east Texas reservoirs (Table 3). Spring measures of abundance of fish 200–355 mm were correlated with angler harvest rate the following summer, fall, winter, and spring in these reservoirs. Spring electrofishing CPUE of fish ≥356 mm was correlated with angler harvest rate during the following summer, winter, and fall. Few significant relations were identified in fall surveys, however, electrofishing CPUE of largemouth bass 200–355 mm and ≥356 mm were correlated with harvest rates the following summer. There was no significant relation between electrofishing CPUE and release rates or total catch rates in fall.

Among west Texas reservoirs, there were only a few correlations between spring electrofishing CPUE and future angler catch (Table 3). The most consistent relations were between electrofishing CPUE measures that included subharvestable fish (i.e., <200 mm and 200–355 mm) and angler release rates the following summer. Spring electrofishing CPUE of largemouth bass ≥356 mm was significantly correlated with harvest rate and total catch rate the following fall. Fall electrofishing CPUE was not correlated with future angler harvest, release, or total catch rates in western reservoirs.

Management Implications

Electrofishing is perhaps the primary assessment tool of fisheries managers in Texas. It is a relatively fast and efficient means of sampling fish populations and fishery managers routinely use electrofishing catch rates as an index of largemouth bass population abundance and size structure. This use of electrofishing has been substantiated by empirical study (e.g., Hall 1986, McInerny and Degan 1993). However, electrofishing CPUE is also used to justify management actions and evaluate effectiveness of those actions (e.g., Boxrucker 1986, Terre and Zerr 1992, Moyer et al. 1995). Used in this manner, there is an implied general relation between electrofishing catch rates and availability of fish to anglers that, while intuitive, lacks empirical support. In this study, the relation between electrofishing CPUE and angling success was poorer than expected. Relatively few comparisons were statistically significant, and these were generally weak correlations. Given that improving or increasing angler catch is frequently cited as the goal of management action, such actions would be better evaluated by direct assessment of angling success (e.g., creel surveys).

Despite limitations, electrofishing will continue to be an important tool of fisheries managers. Regional differences in the importance of spatial and temporal variation in CPUE can be useful in determining optimal sampling frequency and allocation of

Table 3. Correlation coefficients for comparisons of seasonal electrofishing catch rates (CPUE) of various size classes of largemouth bass with angler catch rates during subsequent seasons in 12 Texas reservoirs. NS indicates non-significant correlations (i.e., $P > 0.10$).

	East		West	
Creel period	Spring	Fall	Spring	Fall
CPUE largemouth bass 200–355 mm vs. Angler harvest rate (*N*/hour)				
winter	0.60	NS	NS	NS
spring	0.44	NS	NS	NS
summer	0.31	0.38	NS	NS
fall	0.45	NS	NS	NS
CPUE largemouth bass ≥ 356 mm vs. Angler harvest rate (*N*/hour)				
winter	0.47	0.33	NS	NS
spring	NS	NS	NS	NS
summer	0.32	0.40	NS	NS
fall	0.29	NS	0.56	NS
CPUE largemouth bass <200 mm vs. Angler release rate (*N*/hour)				
winter	NS	NS	NS	NS
spring	NS	NS	NS	NS
summer	NS	NS	0.37	NS
fall	NS	NS	NS	NS
CPUE largemouth bass 200–355 mm vs. Angler release rate (*N*/hour)				
winter	0.36	NS	NS	NS
spring	NS	NS	NS	NS
summer	NS	NS	0.43	NS
fall	NS	NS	NS	NS
CPUE largemouth bass <200 mm vs. Angler catch rate (*N*/hour)				
winter	NS	NS	NS	NS
spring	NS	NS	NS	NS
summer	NS	NS	NS	NS
fall	NS	NS	NS	NS
CPUE largemouth bass 200–355 mm vs. Angler catch rate (*N*/hour)				
winter	0.47	NS	NS	NS
spring	NS	NS	NS	NS
summer	0.34	NS	NS	NS
fall	NS	NS	NS	NS
CPUE largemouth bass ≥356 mm vs. Angler catch rate (*N*/hour)				
winter	0.32	NS	NS	NS
spring	NS	NS	NS	NS
summer	NS	NS	NS	NS
fall	NS	NS	0.40	NS

effort among reservoirs. For example, a strong temporal component in CPUE variability (e.g., fall surveys in east Texas) suggests that a sample of reservoirs could be used as an index of the region. Increased frequency of sampling for a relatively small group of reservoirs may be more cost effective. However, in west Texas there were substantial, fixed differences among reservoirs indicating the possible need for sampling more reservoirs.

Substantial regional differences were observed in this study, suggesting a regional approach to largemouth bass management in Texas might be appropriate. There currently may be some dissatisfaction with statewide harvest regulations, but at the same time, reservoir-specific regulations are viewed as cumbersome by some anglers and law enforcement personnel. A regional approach would be a compromise and appears justified.

No attempt was made to verify a relation between electrofishing CPUE and largemouth bass abundance in this study. Such a relation was assumed on the basis of study in other states. If this assumption is valid, then the patterns observed in this study are the result of environmental and biological processes acting on survival of largemouth bass. However, variation in electrofishing efficiency in different areas of Texas cannot be ruled out. Strong inferences about the causes of CPUE variability would require verification of CPUE as an index of largemouth bass abundance in each region of Texas.

Literature Cited

Boxrucker, J. 1986. Evaluation of supplemental stocking of largemouth bass as a management tool in small impoundments. North Am. J. Fish. Manage. 6:391–400.

Dolman, W. B. 1990. Classification of Texas reservoirs in relation to limnology and fish community associations. Trans. Am. Fish. Soc. 119:511–520.

Garrod, D. J. 1967. Population dynamics of the arcto-Norwegian cod. J. Fish. Res. Board Can. 24:145–190.

Goodyear, C. P. 1985. Relationship between reported commercial landings and abundance of young striped bass in Chesapeake Bay, Maryland. Trans. Am. Fish. Soc. 114:92–96.

Hall, T. J. 1986. Electrofishing catch per hour as an indicator of largemouth bass density in Ohio impoundments. North Am. J. Fish. Manage. 6:397–400.

Hill, T. D. and D. W. Willis. 1994. Influence of water conductivity on pulsed AC and pulsed DC electrofishing catch rates for largemouth bass. North Am. J. Fish. Manage. 14:202–207.

Lewis, W. M., Jr. 1978. Comparison of temporal and spatial variation in the zooplankton of a lake by means of variance components. Ecology 59:666–671.

McInerny, M. C., and D. J. Degan. 1993. Electrofishing catch rates as an index of largemouth bass population density in two large reservoirs. North Am. J. Fish. Manage. 13:223–228.

Miranda, L. E. 1984. Average ichthyomasses in Texas large impoundments. Annu. Proc. Texas Chap., Am. Fish. Soc. 6:58–67.

——— and P. P. Durocher. 1986. Effects of environmental factors on growth of largemouth bass in Texas reservoirs. Pages 115–121 *in* G. E. Hall and M. J. Van Den Avyle, eds. Reservoir fisheries management: strategies for the 80's. Reservoir Comm., South. Div. Am. Fish. Soc., Bethesda, Md.

Mitzner, L. 1981. Influence of floodwater storage on abundance of juvenile crappie and subsequent harvest at Lake Rathbun, Iowa. North Am. J. Fish. Manage. 1:46–50.

———. 1991. Effect of environmental variables upon crappie young, year-class strength, and the sport fishery. North Am. J. Fish. Manage. 11:534–542.

Moyer, E. J., M. W. Hulon, J. J. Sweatman, R. S. Butler, and V. P. Williams. 1995. Fishery responses to habitat restoration in Lake Tohopekaliga, Florida. North Am. J. Fish. Manage. 15:591–595.

Prentice, J. A. and P. P. Durocher. 1978. Average growth rates for largemouth bass in Texas. Annu. Proc. Texas Chap., Am. Fish. Soc. 1:49–57.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board of Can. Bul. 191, Ottawa. 382pp.

SAS Institute, Inc. 1985. SAS user's guide: statistics, version 5 edition. SAS Inst., Inc., Cary, N.C. 956pp.

Snyder, D. E. 1992. Impacts of electrofishing on fish. Contrib. 50 Larval Fish Lab., Colo. State Univ., Fort Collins. 214pp.

Terre, D. R. and R. W. Zerr. 1992. Effects of a 356-mm statewide minimum length limit on abundance of adult largemouth bass in Texas. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 46:368–376.

Van Den Avyle, M. J. 1993. Dynamics of exploited fish populations. Pages 105–135 *in* C. C. Kohler and W. A. Hubert, eds. Inland fisheries management in North America. Am. Fish. Soc., Bethesda, Md.