Derivation and Application of Parameter Values for White Bass Populations in Missouri's Large Reservoirs

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Abstract: A method of evaluating white bass *(Morone chrysops)* populations sampled with gill nets during fall in Missouri's large reservoirs was developed by establishing objectives for growth, size structure, and age structure parameters. Growth objectives were 300 and 350 mm mean total lengths for age-1 and -2 white bass in reservoirs where gizzard shad *(Dorosoma cepedianum)* are the primary prey, and 330 and 380 mm in reservoirs where threadfin shad *(D. petenense)* are the primary prey. Objectives for size and age structure were determined by modeling population structures of white bass with acceptable growth and intermediate total annual mortality rates (about 40%–50%). Objectives for size structure (percentages of white bass ≥age 1 that were also ≥300 mm and 380 mm) were 65%–85% and 5%–25% for gizzard shad prey reservoirs, and 80%–100% and 30%–50% for threadfin shad prey reservoirs. The objective for age structure (percentages of fish ≥ age 1 that were ≥ age 4) was 10%–20% for all reservoirs. Using these criteria and objectives, fishery managers can evaluate white bass populations and determine problem areas when populations consistently fail to meet objectives. Results of the evaluation can be used to implement specific management practices to correct problems, or to justify the need for more-detailed studies that will identify the causes of the problems.

Key words: white bass, population evaluation and objectives.

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A major goal for fishery managers is to improve and maintain quality fishing. Providing the right numbers and sizes of sport fish for anglers to catch and harvest is essential to achieving this goal. Consequently, fishery managers frequently set objectives for various aspects of a fishery (catch rates, size structures, etc.) so that they will know when a fish population is providing the desired benefits. Routine evaluations of fish populations, therefore, are necessary if managers are to determine whether populations are meeting established objectives. In Missouri, objectives have been established for sample parameters of white crappie *(Pomoxis annularis)* (Colvin and Vasey 1986) and largemouth bass *(Micropterus salmoides)* (Kruse 1988) in large reservoirs, but not for other important sport fishes.

An effective technique for evaluating fish population status should include measures of recruitment, growth, and mortality rates, which will be reflected in changes in sample catch rates and size structures (Colvin 2000). It should provide a consistent and objective way of evaluating fish populations, which will help managers identify problem areas when populations are not satisfactory. Finally, it should be relatively simple and easy to use, which will enhance communication about the population among managers, other biologists, fisheries administrators, and anglers.

White bass *(Morone chrysops)* are popular sport fish in Missouri's large reservoirs and are frequently the third or fourth most-sought species in many of them. However, objectives for sample parameters had not been established because standard sampling techniques had not been determined. Therefore, little was known about the characteristics of white bass populations. Colvin (2002a) concluded that experimental gill netting in reservoir areas during fall provided the most meaningful estimates of size and age structure of white bass populations. Using fall gill netting as the standard sampling method, Colvin (2002b) described the population and fishery characteristics of white bass in four large Missouri reservoirs and discussed management options. The objectives of this paper are to: determine appropriate parameters for evaluating white bass populations, derive objective values for these parameters, and evaluate white bass populations based upon these objectives.

Methods

Sampling

White bass were sampled with experimental, monofilament mesh gill nets during fall (mid-September–October) on four Missouri reservoirs (Colvin 2002a). Gill nets were 38 m long×1.8 m deep and had five panels of equal length with mesh sizes of 19-, 25-, 38-, 51-, and 64-mm bar measure. Even though gill nets are size selective (Willis et al. 1985, Wilde 1993), this method provided the best overall depiction of white bass size structure because both sexes were generally equally captured and age structures from gill-net samples corresponded to age structures from spring electrofishing (Colvin 2002a), which is another common method for sampling white bass (e.g., Webb and Moss 1968, Moen and Dewey 1980, Muoneke 1994, Lovell and Maceina 2002). Furthermore, in Texas reservoirs sampled with similar mesh sizes, no systematic differences or biases were detected between adjusted and unadjusted size structure indices, and slopes of regression equations comparing the two were not significantly different from one (Wilde 1993). The Missouri data used to derive objectives were from white bass sampled with gill nets during fall 1991–2000 in Pomme de Terre Lake (PDT), 1991–1999 in Niangua Arm of Lake of the Ozarks (LOZ), 1996–1999 in a mid-lake portion of Table Rock Lake (TBR), and 1998–2000 in Bull Shoals Lake (BSH).

Determining Parameters and Deriving Objectives

When developing the white bass evaluation, I initially examined parameters used to evaluate white crappie populations in Missouri: recruitment, population abundance, growth, size structure, and age structure (Colvin and Vasey 1986). However, catch rates of white bass in experimental gill nets failed to detect typical changes in abundance (Colvin 2002c). Therefore, growth, size structure, and age structure were selected to evaluate white bass populations. Objectives for each parameter were derived using the general procedures described by Colvin (2000) which included population sampling, literature review, and population modeling.

Objectives for the three parameters were determined with a variety of methods. Growth objectives were subjectively determined by comparing Missouri data with large reservoir populations in other states. Size and age structure objectives were determined by modeling length frequencies similar to a method described by Reynolds and Babb (1978). In this procedure, I used data from white bass populations in Missouri and other states to subjectively determine desirable levels of total annual mortality (A). Length frequencies were then modeled using a variety of growth and total annual mortality rates. The resulting length and age frequencies provided the basis for setting objectives for size and age structure.

Growth. —Growth influences size structure, and white bass in the four Missouri reservoirs exhibited two distinct growth patterns. In the fall, age-1 and -2 white bass averaged about 300 and 350 mm total length (TL) in PDT and LOZ and about 330 and 380 mm TL in TBR and BSH (Colvin 2002b). These differences may be due to different prey species that dominate these reservoirs. Gizzard shad *(Dorosoma cepedianum)* is the primary prey species in PDT and LOZ, and threadfin shad *(D. petenense)* is primary in TBR and BSH. Growth in these Missouri reservoirs was similar to that in many other southern reservoirs where white bass grew to preferred sizes (300 mm TL, Gabelhouse 1984) in two growing seasons or less (Jenkins and Elkin 1957, Starrett and Fritz 1965, Webb and Moss 1968, Moen and Dewey 1980, Muoneke 1994, Guy et al. 2002, Lovell and Maceina 2002). These published growth rates were considered to be satisfactory or excellent by most authors. Using the preferred length as a guide, I set 300 mm as the objective mean TL for age-1 white bass captured in fall (2 growing seasons) in Missouri reservoirs where gizzard shad are the primary prey. Also, an objective mean TL of 350 mm was set for age-2 white bass (3 growing seasons), which was the age-1 objective plus the typical 50-mm length increment of age-2 fish (Colvin 2002b). However, in TBR and BSH where threadfin shad are the primary prey, white bass exhibited greater growth potential. Therefore, I set 330 and 380 mm as objective mean TL for age-1 and age-2 white bass for reservoirs where threadfin shad are the primary prey.

Size Structure. —Size structure is best represented by the sample length frequency. Typically, structural indices such as proportional and relative stock densities (PSD and RSD) have been used to describe key components of fish population size structures (Anderson 1978, Wege and Anderson 1978). Gabelhouse (1984) proposed the following minimum total lengths for calculating white bass structural indices: 150 mm (stock length), 230 mm (quality length), 300 mm (preferred length), 380 mm (memorable length), and 460 mm (trophy length). However, calculations of PSDs and RSDs from fall gill netting data in Missouri are not accurate because they are affected by the presence of age-0 white bass, which are not as vulnerable to netting as older fish and exceed the minimum stock length. Therefore, I omitted age-0 white bass from calculations of size structure and defined the size structure parameter as the percentages of fish ≥ age 1 that equaled or exceeded the preferred (300 mm TL) and memorable lengths (380 mm TL).

Table 1. Mean total lengths (mm) of ages 1–7 white bass used to model regular- and fast-growth length frequencies. The standard deviation was 15 mm for each age and growth rate.

Age	Regular growth	Fast growth
1	300	330
2	350	380
3	365	410
4	380	425
5	395	435
6	400	440
7	400	445

Determining a desirable length frequency or size structure for white bass populations is problematic, given that it reflects total annual mortality and growth rates that will produce acceptable sizes for anglers. Total annual mortality rates of white bass ranged from a low of about 35% in South Dakota glacial lakes (Willis et al. 2002) to over 90% in some Kansas and Texas reservoirs (Muoneke 1994, Schultz and Robinson 2002). Total annual mortality rates in Missouri and Alabama were intermediate—averaging about 40% for younger white bass and 80% for ages 5 and older in PDT and LOZ (Colvin 2002b) and about 50% for two Alabama reservoirs (Lovell and Maceina 2002). In addition, angler exploitation rates in Missouri were moderate and ranged from 13% to 23% in PDT and from 22% to 36% in LOZ (Colvin 2002b). Therefore, I assumed that intermediate total annual mortality rates represented a desirable condition, because they allowed for moderate angler exploitation yet yielded older and larger fish in the population.

Desirable size structures were simulated by modeling length frequencies of ages 1 and older white bass with uniform recruitment, four total annual mortality rates, and regular (gizzard shad prey reservoirs) and fast (threadfin shad prey reservoirs) growth scenarios (Table 1). Total annual mortality rates consisted of one high rate (85% for ages 1 and older) and three intermediate rates: 40% for ages 1–4 and 80% thereafter, and 50% and 40% for ages 1 and older. Percentages of white bass ≥ age 1 that were also ≥ 300 and 380 mm TL were then calculated from these model length frequencies (Fig. 1, Table 2). Objective ranges for size structure were then derived from the values calculated from the intermediate total annual mortality rates and the two growth scenarios. I set objective ranges of 20% for size structure at approximately ±10% of the values calculated from the model length frequencies. Objective ranges for the regular-growth scenarios were 65%–85% and 5%–25% for white bass ≥ 300 mm and 380 mm TL. For fast-growth scenarios, objective ranges were 80%–100% and 30%–50% for the two sizes, respectively.

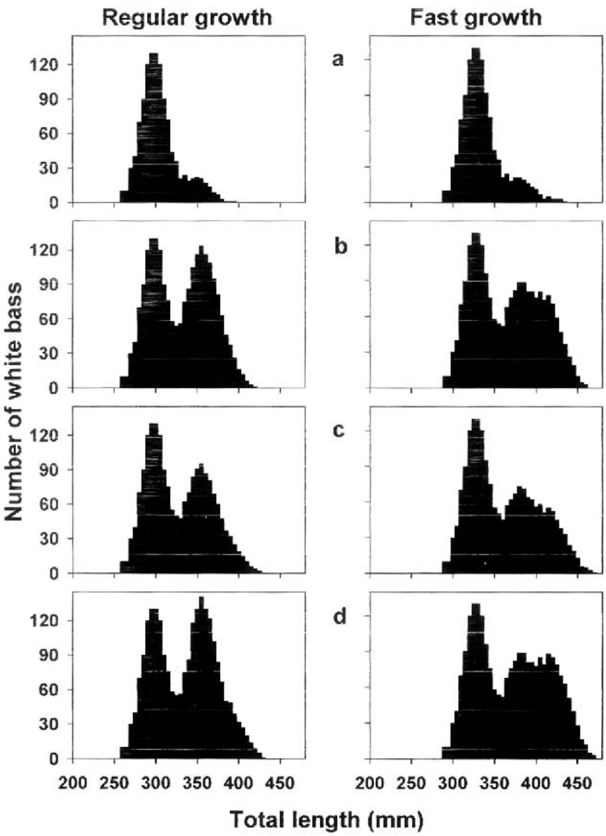

Figure 1. Simulated length frequencies of ages 1 and older white bass from regular- and fast-growth models with four total annual mortality scenarios and per 1,000 age-1 recruits. The four total annual mortality rates were: a) 85% for ages 1 and older, b) 40% for ages 1–4 then 80% thereafter, c) 50% for ages 1 and older, and d) 40% for ages 1 and older. These length frequencies were used to calculate the parameter values in Table 2.

Age structure. —Age structure gives an indication of the magnitude of total annual mortality in a population. Colvin and Vasey (1986) used the percentage of white crappies ≥ age 1 that were also ≥ age 4 in the fall as the measure of age structure for crappie populations. This parameter seemed reasonable for white bass as well, because few fish would live longer if total annual mortality was high. Additionally, age-4 white bass in Missouri reservoirs attained about 90% of the maximum length determined from von Bertalanffy growth equations (Colvin 2002b), indicating that fish in this category are in the upper end of sample length frequencies.

The population models were also used to determine desirable age structure. The percentages of white bass ≥ age 1 that were also ≥ age 4 ranged from <1 for the high mortality model to 19% when total annual mortality was 40%, and the range for all intermediate mortality models was 12%–19% (Table 2). Therefore, I set 10%–20% as the objective range for white bass, regardless of the growth rate.

Table 2. Age-and size-structure values for white bass that were calculated for each total annual mortality rate (A) and growth rate from the population models. Values are the percentages of fish ≥age 1 that were ≥age 4 for both growth rates, and the percentages of fish ≥age 1 that were ≥300 and 380 mm TL for each growth rate.

		Regular growth		Fast growth	
A	% ≥age 4	% ≥300 mm	%≥380 mm	% ≥300 mm	% ≥380 mm
85%	<1	57	<1	98	9
40% for ages 1–4; 80% thereafter	12	77	10	99	41
50%	12	74	10	99	37
40%	19	79	13	99	46

Table 3. Summary of objectives for three population parameters used to evaluate white bass populations sampled with gill nets in fall in Missouri's large reservoirs. Growth and size-structure objectives were determined for regular growth (giz zard shad prey) and fast growth (threadfin shad prey) scenarios.

	Objective	
Unit of measure	Regular growth	Fast growth
Growth		
Mean TL of age-1 white bass	300 mm	330 mm
Mean TL of age-2 white bass	350 mm	380 mm
Size structure		
% ≥age 1 that are ≥300 mm TL	65–85	80–100
% ≥age 1 that are ≥380 mm TL	5–25	30–50
Age structure		
% ≥age 1 that are ≥age 4	10–20	10–20

Evaluations of Missouri Reservoirs

Objectives for each parameter (Table 3) were compared to 28 reservoir-years of data for the four study reservoirs. For growth, PDT met the objective mean lengths for age-1 and age-2 white bass in 19 of 22 comparisons, LOZ in 10 of 18, TBR in 5 of 8, and BSH in 6 of 6. Values for size and age structure parameters fluctuated above and below objective ranges for most reservoirs (Fig. 2). A major epizootic of white bass in PDT in 1995 (Colvin 2002b) caused age structures to be below the objective ranges for several years.

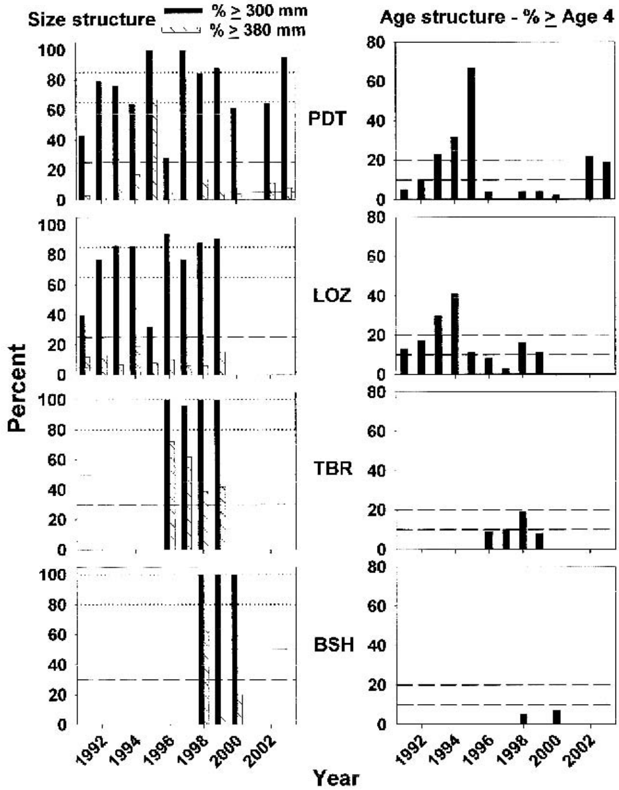

Figure 2. Size structure (percentages of fish ≥age 1 that are ≥300 and 380 mm TL) and age structure (percent ≥age 1 that are ≥age 4) evaluations of white bass from Pomme de Terre Lake (PDT), Lake of the Ozarks (LOZ), Table Rock Lake (TBR), and Bull Shoals Lake (BSH), Missouri. Horizontal dotted lines bound the objectives for percent ≥300 mm TL, and the horizontal dashed lines bound the objectives for percent ≥380 mm TL and for age structure. No sample was taken in PDT in 2001.

Discussion and Management Implications

This procedure of evaluating white bass populations enables biologists to consistently compare samples to objectives for growth, size structure, and age structure. Comparing sample values to objectives makes it easy to determine when growth and mortality rates are desirable. Therefore, problem areas with populations can be identified if some parameters consistently miss objectives. Results of the evaluation can be used to implement specific management practices to correct problems, or to justify the need for more-detailed studies that will identify the causes of the problems. For instance, if age structure values are consistently below the objective, high total annual mortality is the likely cause, thereby indicating the need for restrictive regulations (if angler exploitation is known to be high) or studies to determine the cause of the high mortality.

Determining when biologists should implement corrective management practices or further studies because sample values consistently miss objectives is problematic and depends on the importance of white bass in a particular system, the degree of variation from the desired objective, and the variability characteristic of gill-net sampling. For instance, after correcting for mesh selectivity, Wilde (1993) found that adjusted PSDs and RSDs differed on average about 6% from unadjusted values for white bass captured with experimental gill nets in Texas. He surmised that with an objective range of 30% (e.g. 40%–70%), even populations with desirable PSDs and RSDs would fall outside of the objective in one of every five years. After weighing the importance of the other factors, I surmise that sample values should miss objectives in about three of every four years to warrant consideration for further management action.

I established growth and size structure objectives based upon the growth potential of white bass in different reservoirs. This was reasonable, because white bass growth in Missouri seemed to be related to the primary prey in each reservoir. Because threadfin shad do not survive in more northern areas of Missouri, it would be unreasonable to establish the same growth and size-structure objectives for reservoirs that cannot support threadfin shad (e.g., PDT and LOZ). In addition and on a larger scale, growing season also affects white bass growth potential (Wilde and Muoneke 2001), indicating that growth and size structure objectives for white bass in more northern states should be different than in states with similar latitudes as Missouri.

Applying the evaluation procedure to 28 reservoir-years of white bass data in four Missouri reservoirs indicated that growth, size structure, and age structure did not consistently miss objectives in most reservoirs. Mean lengths of age-1 and age-2 white bass were not consistently below objectives in any reservoir, indicating that growth was not a problem requiring management attention. Similarly, size- and age-structure values frequently ranged from below to above objective ranges when sampling was conducted for consecutive years, indicating that total annual mortality was probably consistently within the intermediate ranges that were deemed desirable. Two exceptions were PDT where age structures were below objectives for six years after the epizootic and BSH where it was below the objective during the three years that were sampled (Fig. 2). Total annual mortality may be high and further management action appropriate in BSH. Variations in recruitment also cause wide fluctuations in size and age structures. In Missouri, therefore, the annual evaluations also indicate the need for studies to determine if recruitment levels could be stabilized.

Portions of this procedure could be applied to spring electrofishing in stream spawning areas, which is another common sampling method for white bass. Size structures should not be evaluated, because electrofishing captures primarily males which are smaller than females of the same age (Forney and Taylor 1963, Webb and Moss 1968, Ruelle 1971, Colvin 2002a, Guy et al. 2002, Lovell and Maceina 2002). However, age structures could be evaluated, because age structures between fall gill netting and spring electrofishing were similar (Colvin 2002b). If spring electrofishing is used to evaluate age structure, one year should be added to the corresponding fall criteria, because 31 December has been accepted as the standard year class age increment (e.g. age 1 in fall = age 2 the following spring). Therefore, the age structure parameter would be the percentage of white bass ≥age 2 that are also ≥age 5.

Results of the evaluation confirm Colvin's (2002b) conclusions that restrictive regulations (e.g., minimum size limits and reduced daily creel limits) would not be effective in the Missouri reservoirs examined. Both exploitation and total annual mortality in Missouri reservoirs appear to be intermediate. Therefore, restrictive regulations designed to change the mortality structure and increase the number of older (and therefore larger) fish would only be marginally successful, a conclusion also made by Lovell and Maceina (2002) and Schultz and Robinson (2002).

In addition to the Missouri reservoirs I examined, white bass in other reservoirs should be sampled to determine if they meet established objectives. Even though the objective values for the three parameters were derived from both empirical and modeling data, few reservoirs have been fully evaluated because of a paucity of published size and age structure data from fall gill netting. Consequently, the reservoirs I evaluated were the same ones used to help establish objective values. Therefore, more trials are needed to establish the effectiveness and reliability of this procedure.

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Literature Cited

Anderson, R. O. 1978. New approaches to recreational fishery management. Pages 73–78 *in* G. Novinger and J. Dillard, editors. New approaches to the management of small impoundments. American Fisheries Society, North Central Division Special Publication 5, Bethesda, Maryland.

Colvin, M. A. 2000. Criteria and procedures for evaluating the quality of fish populations in reservoirs. Environmental Science and Policy 3 (Supplement 1):S127–S132.

_____. 2002a. A comparison of gill netting and electrofishing as sampling techniques for white bass in Missouri's large reservoirs. North American Journal of Fisheries Management 22: 690–702.

_____. 2002b. Population and fishery characteristics of white bass in four large Missouri reservoirs. North American Journal of Fisheries Management 22:677–689.

_____. 2002c. Assessment and management of white bass in Missouri's large reservoirs.. Missouri Department of Conservation, Sport Fish Restoration Project F-1-R-50, Study I-31, Jobs 4 and 5, Final Report, Jefferson City, Missouri.

_____ and F. W. Vasey. 1986. A method of qualitatively assessing white crappie populations in Missouri reservoirs. Pages 79–85 *in* G. Hall and M. Van Den Avyle, editors. Reservoir fisheries management: strategies for the 80's. American Fisheries Society, Southern Division, Reservoir Committee, Bethesda, Maryland.

Forney, J. L. and C. P. Taylor. 1963. Age and growth of white bass in Oneida Lake, New York. New York Fish and Game Journal 10:194–200.

Gabelhouse, D. W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273–285.

Guy, C. S., R. D. Schultz, and C. A. Cox. 2002. Variation in gonad development, growth, and condition of white bass in Fall River Reservoir, Kansas. North American Journal of Fisheries Management 22:643–651.

Jenkins, R. M. and R. E. Elkin. 1957. Growth of white bass in Oklahoma. Oklahoma Fisheries Research Laboratory Report Number 60, Norman.

Kruse, M. S. 1988. Guidelines for assessing largemouth bass fisheries in large impoundments. Missouri Department of Conservation, Sport Fish Restoration project F-1-R-37, Study I-25, Final Report, Jefferson City, Missouri.

Lovell, R. G. and M. J. Maceina. 2002. Population assessment and minimum length limit evaluations for white bass in four Alabama reservoirs. North American Journal of Fisheries Management 22:609–619.

Moen, T. E. and M. R. Dewey. 1980. Growth and year-class composition of white bass *(Morone chrysops)* in Degray Lake, Arkansas. Proceedings of the Arkansas Academy of Science 34:125–126.

Muoneke, M. I. 1994. Dynamics of a heavily exploited Texas white bass population. North American Journal of Fisheries Management 14:415–422.

Reynolds, J. B. and L. R. Babb. 1978. Structure and dynamics of largemouth bass populations. Pages 50–61 *in* G. Novinger and J. Dillard, editors. New approaches to the management of small impoundments. American Fisheries Society, North Central Division Special Publication 5, Bethesda, Maryland.

Ruelle, R. R. 1971. Factors influencing growth of white bass in Lewis and Clark Lake. Pages 411–423 *in* G. Hall, editor. Reservoir fisheries and limnology. American Fisheries Society, Special Publication 8, Bethesda, Maryland.

Schultz, R. D. and D. A. Robinson, Jr. 2002. Exploitation and mortality rates of white bass in Kansas reservoirs. North American Journal of Fisheries Management 22:652–658.

Starrett, W. C. and A. W. Fritz. 1965. A biological investigation of the fishes of Lake Chautauqua, Illinois. Illinois Natural History Survey Bulletin 29:1–104.

Webb, J. F. and D. D. Moss. 1968. Spawning behavior and age and growth of white bass in Center Hill Reservoir, Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 21:343–357.

Wege, G. J. and R. O. Anderson. 1978. Relative weight (W_r); a new index of condition for largemouth bass. Pages 79–91 *in* G. D. Novinger and J. G. Dillard, editors. New approaches to the management of small impoundments. American Fisheries Society, North Central Division, Special Publication Number 5, Bethesda, Maryland.

Wilde, G. R. 1993. Gill net selectivity and size structure in white bass. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 45:470–476.

_____ and M. I. Muoneke. 2001. Climate-related and morphoedaphic correlates of growth in white bass. Journal of Fish Biology 58:453–461.

Willis, D. W., K. D. McCloskey, and D. W. Gabelhouse. 1985. Calculation of stock density based on adjustments for efficiency of gill-net mesh size. North American Journal of Fisheries Management 5:126–137.

_____, C. P. Paukert, and B. G. Blackwell. 2002. Biology of white bass in eastern South Dakota glacial lakes. North American Journal of Fisheries Management 22:627–636.