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Habitat Preference of Black Bass Species in Lakes in Kentucky

by

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ABSTRACT

Relationships between black bass standing crop and harvest estimates to abiotic and biotic variables in lakes in Kentucky were studied. Particular emphasis was placed on the relationship of these two variables to nutrient levels (chlorophyll-a). Largemouth bass abundance was found to be positively correlated to the percent of the drainage area of a lake in agricultural use, chlorophyll-a, total alkalinity, and panfish standing crops. A negative correlation was found between largemouth bass and the percent of drainage area of a lake that was in silviculture. The harvest of largemouth bass was found to have a strong positive relationship to nutrient levels. Because of this response, mesotrophic and eutrophic lakes can support and sustain a larger amount of fishing pressure and harvest. Slot limits on black bass, particularly on largemouth bass, would have the most application in mesotrophic and eutrophic lakes where there are sufficient numbers of intermediate-size largemouth bass. In oligotrophic lakes where intermediate numbers of largemouth bass are generally low, slot limits will likely result in the harvest of too many intermediate-size fish, resulting in either no improvement or deterioration in the age structure of largemouth bass due to poor recruitment. In oligotrophic lakes and other lakes where intermediate numbers of bass are low or where fishing pressure is high, a minimum size limit would have more application than a slot limit. No distinct relationship was found between spotted bass standing crop and nutrient levels. Spotted bass standing crop was positively correlated to largemouth bass, storage ratio, and water level and were negatively correlated to total phosphorus and drainage areas. Although the percent contribution of this species to the total standing crop of black bass decreased as nutrient levels increased, the biomass was similar in all trophic states of lakes. The decrease in percent contribution was a result of the increased standing crops of largemouth bass as nutrient levels increased. The contribution to the creel of spotted bass was relatively low in all lake types under a 12-inch minimum size limit. This is due to their slow growth rates and short life span; few spotted bass grow fast enough or live long enough to reach 12 inches. The standing crop and harvest of smallmouth bass showed a negative response to nutrient levels. Characteristics of smallmouth bass habitat in lakes in Kentucky was described as a lake larger than 100 acres, either oligotrophic or mesotrophic, drainage area in silviculture $\geq$55%, mean depth $\geq$26 ft, exchange rate $\geq$0.28 year, MEI $\geq$20, thermocline depth $\geq$15 ft, and oxygenated water ($\geq$4.0 mg/l) at the preferred (68.5-70.3F) or acceptable (70.3-74.3F) temperature range from July through September. A smallmouth bass habitat index was developed to identify suitable habitat in Kentucky. As a result, seven lakes were identified where smallmouth bass habitat exists. A stocking program has been initiated in these lakes in an attempt to establish self-sustaining smallmouth bass fisheries. The relative contribution of smallmouth bass to the black bass population in these lakes has been projected from the smallmouth bass habitat index. Multiple regression equations were developed for predicting standing crop and harvest for black bass species in lakes.

INTRODUCTION

There are a great number of articles in the literature in recent years on the subject of interpreting and predicting fish yields and standing crops from abiotic and biotic variables associated with lakes. The morphoedaphic index (MEI) is one simplistic model developed by Ryder (1965) as a predictor of fish yield in lakes within the U.S. and Canada. Since then, the MEI model has been used to describe fish populations in reservoirs in the U.S. (Jenkins 1968) and other parts of the world. The MEI model (total dissolved solids, mg/l, divided by mean depth in meters) was originally developed to describe the standing crop and fish yield in natural lakes. The MEI model, however, has also been used successfully to describe fish yields and standing crops in reservoirs (Jenkins 1968). As Jenkins (1982) pointed out, reservoirs vary not only in their capacity to produce fish, but also in available habitat. Compared to natural lakes in North America, reservoirs have a higher exchange rate, greater shoreline development, a longer growing season, and they eutrophy faster. Eutrophication, which comes from both agricultural runoff and effluents from domestic sewage, is very important. The amounts of nutrient loading from these sources, which vary from lake to lake, not only drastically influence the standing crop of fish but fish harvest as well.

Use of the MEI model was just the beginning to using abiotic and biotic variables as predictors of fish yield and standing crop. Other variables used include phosphorus, nitrogen, particle size, gross photosynthesis, and summer standing crops of phytoplankton (Jenkins 1982). Fish production and yield were also correlated to climatic data (Schesinger and Regier 1982). Jones and Hayer (1982) found a strong linear correlation between fish yield and summer time chlorophyll-a values obtained from both natural and artificial lakes in Missouri and Iowa. They found a stronger correlation between fish yield and chlorophyll-a than with total phosphorus, alkalinity, and MEI. As they stated, the stronger correlation between chlorophyll-a and yield was to be expected because the lakes used in the analysis were affected by cultural eutrophication. This nutrient loading can affect productivity of a lake without affecting the concentration of dissolved materials in a lake (Jones and Hayer 1982). As a result, total dissolved solids, alkalinity, or conductivity may not be the best indicators of a lake's productivity (Ryder et al. 1974).

All variables used by researchers seem to have applications in predicting fish standing crop and yield in lakes and reservoirs. The only question remaining is which variables are most applicable under a given set of circumstances. The purpose of this paper was to examine some of these abiotic and biotic variables, nutrient levels in particular, and relate them to bass standing crop and harvest in Kentucky's lakes.

METHODS

A large amount of historical data exists on the standing crop and harvest of fish from Kentucky's lakes. Standing crop data determined by standard cove-rotenone techniques have been collected on all major reservoirs in the state, while creel surveys have been used to collect harvest data from most of the reservoirs. For consistency and making the data used in the analysis similar as possible, only standing crop and harvest data collected from 1978-1985 were used to estimate standing crops and harvest of black bass. Multiple regression equations for predicting these two variables were then formulated. During 1978-1985, black bass were under a 12-inch minimum size limit in lakes from which data were obtained. Changes in the size limit could result in different standing crops and harvest of black bass in lakes irrespective to nutrient levels. All historical data, however, was used in the calculation of the Pearson's correlation coefficients.

The abiotic and biotic variables used in the analysis were collected by the Corps of Engineers, Division of Water, Department of Fish and Wildlife, and other sources. Only those variables found to be associated with black bass are given in this report. The trophic status of lakes was assigned using the Carlson Trophic State Index for chlorophyll-a (Division of Water 1984); chlorophyll-a values are as follows for four trophic categories: oligotrophic (0-40), mesotrophic (41-50), eutrophic (51-69), and hypereutrophic (70-100). All uses of chlorophyll-a made in this report are in reference to the above index. All statistical analyses, regression equations, and Pearson correlation coefficients were performed by Aquatic Ecosystem Analysts personnel.

Standing Crop

The nutrient levels (expressed by chloraphyll-a values) present in a body of water have a very important and dramatic affect on both the biomass of fish that a body of water can support and the amount of fish that is harvested. For example, oligotrophic lakes in Kentucky (Table 1) from 1978-1984 had an average total standing crop of 118 lb/acre. At lakes where nutrient levels were in the mesotrophic range, the standing crop of fish more than double at 296 lb/acre. In eutrophic lakes, the mean standing crop of all fish was nearly double again at 517 lb/acre.

Nutrient levels, as stated above, show a positive relationship to the total standing crop of all fish in lakes in Kentucky. They also affect the total standing crop and harvest of black bass and species of black bass in these lakes.

As nutrient levels increased in lakes, the total biomass of black bass increased (Table 1). Black bass in oligotrophic lakes in Kentucky accounted for an average of 6.3 lb/acre. In mesotrophic lakes, black bass biomass was nearly double at 12.4 lb/acre. Although the standing crop of black bass did not double again in eutrophic lakes, their biomass did increase to an average of 16.0 lb/acre or 2.5 times the black bass standing crop in oligotrophic lakes.

Largemouth bass abundance showed a very strong and positive response to increased nutrient levels. In oligotrophic lakes, the mean standing crop of largemouth bass was only 3.4 lb/acre compared to 8.6 lb/acre in mesotrophic lakes and 13.8 lb/acre in eutrophic lakes (Table 1). Eutrophic lakes in Kentucky contained, on the average, over four times the standing crop of largemouth bass than did oligotrophic lakes.

Similar results were observed when the numbers of largemouth bass per acre were compared in the different lake types (Table 2). In the three lake types, numbers of largemouth bass fingerlings (0-4 inch group) per acre or young-of-year fish varied drastically. This illustrates the fact that the abundance of largemouth bass fingerlings is extremely variable, being lowest in oligotrophic lakes at an average of 77 fish/acre. The number per acre of intermediate-size fish (5-11 inch group), or primarily age 1 and 2 fish, demonstrated the importance of nutrient levels to largemouth bass. Numbers of intermediates increased from 10.2 fish/acre in oligotrophic lakes to 19.2 fish/acre in mesotrophic lakes and to 39.2 fish/acre in eutrophic lakes. There were 3.8 times more intermediate-size largemouth bass per acre at eutrophic lakes than at oligotrophic lakes. The number of harvestable-size ($\geq$12.0 inches) largemouth bass per acre also showed a similar increase with increased trophic levels. Only 0.9 harvestable largemouth bass was collected per acre in oligotrophic lakes compared to 2.4 fish/acre in mesotrophic lakes and 5.6 fish/acre in eutrophic lakes. Eutrophic lakes had 6.2 times more harvestable-size largemouth bass per acre than did oligotrophic lakes, based on standing crop data.

Pearson correlation coefficients showed that largemouth bass in lakes in Kentucky were significantly correlated to several abiotic and biotic variables (Table 3). Largemouth bass were positively correlated to the amount of drainage area of a lake tied up in agriculture. Their abundance was also positively correlated to chlorophyll-a, total alkalinity, and panfish (primarily bluegill) standing crops. A negative correlation was determined between largemouth bass and the amount of the drainage area in silviculture. These results again show the overall importance of nutrient levels to largemouth bass. An estimate of the standing crop of largemouth bass in lakes in Kentucky can be obtained using the regression equation given in Table 4.

The estimated standing crops of spotted bass found in lakes in Kentucky differed from that of largemouth bass and showed no strong positive or negative relationship to nutrient levels; actual numbers do, however, increase slightly with increased nutrient levels. Spotted bass biomass in both oligotrophic and eutrophic lakes was 2.1 lb/acre (Table 1). Although spotted bass account for about the same amount of biomass in each of the lake types, they are more important to the overall black bass fishery in oligotrophic lakes. In these lakes, spotted bass accounted for 33% of the biomass and 57% of the number of black bass. This compares to 27% of the biomass and 40% of the number of bass in mesotrophic lakes. In eutrophic lakes, spotted bass accounted for only 13% of the biomass and 33% of the number of bass. This again illustrates that spotted bass are much more important to the overall black bass fishery and to management considerations in oligotrophic lakes due to their dominance even though their biomass is simmilar in all lake types with respect to nutrient levels. The apparent decrease in importance of spotted bass in more eutrophic lakes is due primarily to the increased abundance of largemouth bass in more fertile lakes.

Similar results can be seen when comparing the average numbers per acre of fingerling-, intermediate-, and harvestable-size spotted bass collected from rotenone studies (Table 2). For spotted bass, little difference is detected in the number of fingerlings per acre in lakes within the three trophic states. Even less of a difference can be seen in the numbers of intermediate- or harvestable-size spotted bass, with less than 1 harvestable-size spotted bass taken in all lakes. The importance of spotted bass to the total black bass fishery in less fertile lakes can again be seen by looking at the number of intermediate- and harvestable-size bass in these lakes. In oligotrophic lakes, these two size groups of spotted bass accounted for 39.7% of the number of black bass; in mesotrophic lakes, they comprised

35.5%. Their relative abundance in eutrophic lakes decreased to 24.2% of the total number of intermediate- and harvestable-sized black bass. Under a 12-inch minimum size limit, very few harvestable fish ($\geq$12.0 inches long) were collected in all three lake types. The major reason for this is their relatively short life span and slow growth rates in Kentucky. For example, in 1985, a total of 656 spotted bass were sampled in May at Cave Run Lake. Of these, only 52 fish or 8% of the total were in the 12-inch group or were larger. No fish were collected larger than within the 16-inch group. In 1985, 58 spotted bass were aged; the oldest fish collected was 7 years old and measured only 14.8 inches long.

Pearson correlation coefficients showed that spotted bass in lakes in Kentucky were significantly correlated to several abiotic and biotic variables (Table 3). Spotted bass were positively correlated to largemouth bass, storage ratio, and water level fluctuation and were negatively correlated to total phosphorus and drainage area. An estimate of the standing crop of spotted bass in lakes in Kentucky can be obtained using the regression equation given in Table 4.

The standing crop of smallmouth bass, unlike that for largemouth and spotted bass, showed a negative relationship to nutrient levels. In all oligotrophic lakes examined, smallmouth bass had a standing crop of 0.8 lb/acre (Table 1). Not all of the oligotrophic lakes currently contain viable smallmouth bass populations. Using only those oligotrophic lakes where viable smallmouth bass populations exist, this species accounted for 2.2 lb/acre. In oligotrophic lakes, where smallmouth bass habitat is present, this species can make up a significant portion of the overall black bass fishery. As nutrient levels increased to the mesotrophic level, smallmouth abundance decreased to 0.4 lb/acre. In eutrophic lakes, the smallmouth bass were essentially non-existent with only 0.1 lb/acre taken (Table 1). The only smallmouth bass found in eutrophic lakes were those that had been stocked in Herrington Lake in an attempt to re-establish this species in the lake. However, because of a lack of smallmouth habitat, this attempt failed (Buynak 1986).

Smallmouth bass fingerlings per acre showed a downward trend as nutrient levels increased (Table 2). Smallmouth bass shown in eutrophic lakes are those fish that were stocked in Herrington Lake. The number of smallmouth bass shown for oligotrophic lakes is misleading and does not show the overall importance of smallmouth in lakes with low nutrient levels. In oligotrophic lakes in Kentucky, where viable smallmouth bass fisheries currently exist (Dale Hollow Lake, Lake Cumberland, and Carr Fork Lake), this species accounts for a mean of 35.9% of the total biomass of black bass and an average of 11.8 fingerling-, 5.6 intermediate- and 0.3 harvestable-size fish per acre. This compares to smallmouth bass forming a mean of 12.7% of the biomass and an average of 4.0 fingerling-, 2.0 intermediate-, and 0.2 harvestable-size fish per acre in all oligotrophic lakes, including those that have no smallmouth bass (Table 2). This points out the importance of understanding the habitat requirements for smallmouth bass. If sufficient habitat is present in an oligotrophic lake that presently has no smallmouth bass, this species could be established and account for about 1/3 of the black bass standing crop in those lakes. As nutrient levels continue to increase, the number of fingerling-, intermediate-, and harvestable-size smallmouth bass decreases.

Smallmouth Bass Habitat Index

The smallmouth bass has recently been given a great deal of management consideration in Kentucky. This interest first began with an attempt at re-establishing this species in Herrington Lake through stocking of large numbers of smallmouth bass fingerlings for 4 years. Unfortunately, this attempt was not successful since a viable smallmouth bass fishery did not result. One of the reasons believed responsible for the elimination of smallmouth bass from the lake in the 1950's and the cause of failure at re-establishing this species was the eutrophication of Herrington Lake. Eutrophication resulted in the elimination of the smallmouth bass habitat in the lake (Buynak 1986). An apparent successful introduction of smallmouth bass has occurred in the 248-acre Cannon creek Lake, an oligotrophic lake located in eastern Kentucky. Smallmouth bass fingerlings were stocked in this lake for 3 years, in the fourth year, a natural year class of smallmouth bass was produced in the lake. After 4 years, this species currently accounts for an estimated 21.5% of the standing crop of black bass in the lake.

The failure at Herrington Lake and the apparent success at Cannon creek Lake has led to an attempt to better define the abiotic and biotic variables associated with smallmouth bass habitat in lakes in Kentucky. Data from these two lakes, in addition to data collected at lakes where viable smallmouth bass populations currently exist, was used to determine the habitat requirements of this species and identify other lakes where this species can likely be established.

Characteristics of lakes in Kentucky with smallmouth bass habitat was based on the presence of deep, cool, oxygenated water during the critical time of July through September. The critical time refers to the period of thermal stratification when oxygen levels become depleted or fall below 4.0 mg/l in water at or near the field-observed preferred temperature (Table 5) of 68.5-70.3F (Ferguson 1958). If a lake had oxygenated water ($\geq$4.0 mg/l) throughout the critical time at the preferred temperature, the lake was said to have preferred smallmouth bass habitat (Table 6). Acceptable (versus preferred) habitat (Table 6) was determined to exist in a lake where water contained $\geq$4.0 mg/l oxygen at a temperature of 70.3-74.3F. This temperature range was arbitrarily set but is that range of temperatures above the field-observed preferred temperature of smallmouth bass and less than the field-observed preferred temperature of spotted bass (Table 5). Dissolved oxygen/temperature profiles taken over several years were checked to determine if preferred or acceptable smallmouth bass habitat was present during the critical time. A habitat index was then obtained for each lake (Tables 6, 7). A habitat index of 2.0 was obtained for Dale Hollow Lake where smallmouth bass accounted for an estimated 59% of the black bass harvested (Table 8) and 42% of the standing crop of black bass (Table 9). In contrast, Herrington Lake had a habitat index of 0.0. Smallmouth bass at this lake, primarily those stocked, accounted for <0.5% of the standing crop of black bass and 1% of the black bass harvested from 1978-1984. For purposes of deciding the best lakes to try establishing smallmouth bass, where they currently do not exist, it was decided that for the program to be successful, smallmouth bass should account for at least 10% of both the standing crop and harvest of black bass in those lakes. A habitat index of at least 0.5 was considered necessary to achieve this management goal. A habitat index of 0.5 was obtained for Green River Lake where smallmouth bass accounted for 15% of the pounds of black bass harvested (Table 9) and 13% of the standing crop of black bass (Table 8). The habitat index was then applied to water quality data taken on other lakes in Kentucky. As a result, seven additional lakes were recognized as having the potential to support a viable smallmouth bass fishery. Stocking of smallmouth bass fingerlings into these lakes has begun with a stocking rate of about 20 fingerlings/acre for 3 years. The Dale Hollow Lake form of smallmouth bass is being reared for stocking. Each lake will be monitored to determine the success of this stocking program in establishing a self-sustaining fishery.

Using the habitat index and data obtained from lakes where smallmouth bass currently exist in Kentucky, a flow chart showing the characteristics common to lakes having preferred or acceptable smallmouth bass habitat is shown in Figure 1. The minimum lake size was taken from Hubbs and Bailey (1938) who described the best smallmouth bass lakes as being over 100 acres. The other characteristics listed in figure 1 are those which were found to be in common with all lakes having smallmouth bass habitat in Kentucky. The trophic state of these lakes were primarily oligotrophic; however, several mesotrophic lakes were found to have smallmouth bass habitat present. The amount of the drainage area in silviculture at these lakes was always greater than or equal to 55%. This also means that the amount of drainage area in agriculture was less than or equal to 45%. A greater percentage of agricultural land in the drainage area resulted in lakes becoming more eutrophic as a result of increased nutrient levels entering the lake through runoff.

Lakes having smallmouth bass habitat were also relatively deep lakes with a mean depth ≥ 26 feet. In addition to being deep lakes, these lakes also had relatively long exchange rates (≥ 0.28 year) resulting in the lake retaining cold winter-stored water for a longer period of time. These characteristics result in these lakes having deep-cool-oxygenated water throughout the critical months of July-September during the period of thermal stratification. Pearson correlation coefficients show that smallmouth bass are positively correlated with storage ratio and the amount of drainage area in silviculture and negatively correlated to chlorophyll-a, amount of drainage area in agriculture, and largemouth bass standing crops (Table 3). An estimate of the standing crops of smallmouth bass in lakes in Kentucky can be obtained using the regression equation given in Table 4.

Harvest

The amount of black bass harvested at lakes shows a strong positive relationship to the amount of nutrient levels in a body of water. In oligotrophic lakes, 0.9 lb/acre of all black bass were harvested (Table 10). Numbers of bass harvested at these lakes were 0.8 fish/acre, while the harvest rate was 0.1 fish/hour. The numbers and pounds per acre of black bass harvested essentially doubled at mesotrophic lakes. The harvest rates, however, remained similar to that at oligotrophic lakes with 0.1 fish/hour. A large increase in harvest was observed in eutrophic lakes, with 7.7 lb/acre and 6.3 fish/acre being harvested. Black bass catch rates, however, increased to 0.3 fish/acre. The reason for the increased harvest of black bass in eutrophic lakes was due to greater availability of largemouth bass and increased fishing pressure on bass. Black bass fishing pressure increased drastically from 5.9 man-hours/acre at both oligotrophic and mesotrophic lakes to 23.2 man-hours/acre at eutrophic lakes. The increase in catch rate in eutrophic lakes was largely due to the increased availability of largemouth bass. Improved success also promoted greater fishing pressure at these lakes.

The contribution to the creel differed for each species of black bass in relationship to nutrient levels (Table 8). At oligotrophic lakes (Dale Hollow Lake, Lake Cumberland, and Carr Fork Lake), largemouth bass accounted for 47.7% (range = 29-73%) of the pounds of black bass harvested. Smallmouth bass at these lakes made up 14-59% ($\bar{x}$ = 44.0%) of the pounds of bass harvested, while spotted bass accounted for a range of 0-13% ($\bar{x}$ = 8.3%). The contribution of largemouth bass to the black bass creel was significantly greater at mesotrophic lakes (Green River, Barren River, and Kentucky lakes), ranging from 77-98% ($\bar{x}$ = 87.7%). Largemouth bass dominated the black bass yield in eutrophic lakes (Barkley and Herrington lakes) ($\bar{x}$ = 97%). Smallmouth bass decreased in importance to the total bass harvest as nutrient levels increased, contributing 15% to the creel at Green River, only 2% at Barren River and Kentucky lakes, and 1% at Herrington Lake. Spotted bass also showed a decrease in contribution to the bass yield at more fertile lakes as they made up 8% of the yield at Green River Lake and only 4% at Herrington Lake and <1% at Barren River Lake. Although the percent contribution of spotted bass to the black bass yield decreased as did actual yield as nutrient levels increased, their abundance did not decrease. As stated above, the standing crops of spotted bass are nearly the same at all three trophic types of lakes. The reason for the decrease in contribution to the creel by spotted bass is mainly due to largemouth bass becoming much more abundant in more fertile lakes. In addition, under a 12-inch minimum size limit, few spotted bass are subject to harvest because of their slow growth rate and short life span. Multiple regression equations for predicting harvest statistics of all black bass, each species of black bass, and the total number and pounds of all fish are given in Table 11.

CONCLUSIONS

The standing crops and harvest of largemouth bass at lakes showed a positive relationship to nutrient levels. Although a slight positive response was seen for spotted bass biomass in relation to nutrient levels, the biomass of this species was similar in all lakes. The standing crop and harvest of smallmouth bass showed a negative response to nutrient levels.

Certain management implications must be kept in mind pertaining to managing a smallmouth bass fishery. To maintain current levels of smallmouth bass in a lake, the amount of watershed in silviculture should be protected from reduction as much as possible. The percent of watershed in silviculture at lakes being managed for smallmouth bass should remain greater than 55% of the total acreage. Also, the percent of watershed in agriculture should be kept below 45%. Lakes having preferred habitat for smallmouth bass have these watershed characteristics. As agricultural lands increase in the drainage area, increased nutrient loading will occur from agricultural runoff. Increased nutrient loading from agriculture or domestic sewage could result in the eutrophication of the lake and a reduction or elimination of smallmouth bass. Increased nutrient loading, however, would have a positive effect on the abundance and harvest of largemouth bass and essentially have no affect on spotted bass. Because of the strong positive response of largemouth bass to nutrient levels, mesotrophic and eutrophic lakes can support and sustain a larger amount of fishing pressure and harvest due to greater fish production.

Slot limits on black bass, particularly on largemouth bass, would have the most application in mesotrophic and eutrophic lakes where there are sufficient numbers of intermediate-size largemouth bass. In oligotrophic lakes where intermediate numbers of largemouth bass are generally low, slot limits will likely result in the over-harvest of intermediate-size fish, resulting in either no improvement in the harvest or deterioration in the size structure of largemouth bass due to poor recruitment. In oligotrophic lakes and other lakes where intermediate numbers of bass are low or where fishing pressure is high, a minimum size limit would have more application than a slot limit. The minimum size limit would allow for the protection of intermediate-size fish, resulting in an increase in numbers of quality-size (≥12 inches long) bass for catch and release in addition to a larger size for harvest.

Because of the relatively slow growth rates and short life span of spotted bass, this species has contributed very little to the creel under a 12-inch minimum size limit; most die of natural mortality before reaching the 12-inch minimum length. Depending on angler acceptance, the removal of the size limit on spotted bass should be considered at all lakes. This is especially true at oligotrophic lakes where spotted bass make up a large percentage of the black bass population.

Lakes having preferred or acceptable smallmouth bass habitat have the following characteristics: larger than 100 acres in size, either oligotrophic or mesotrophic, drainage area in silviculture ≥55%, mean depth ≥26 ft, exchange rate ≥0.28 year, MEI ≤20, thermocline depth ≥15 ft, and oxygenated water (≥4.0 mg/l) at the preferred (68.5-70.3F) or acceptable (70.3-74.3F) temperature range from July through September. Habitat characteristics have been measured in lakes to determine if preferred and acceptable smallmouth bass habitat is present. Where smallmouth bass habitat is present, smallmouth bass, 1.5-2.0 inches long, should be stocked for 3 years at 20 fish/acre to establish this species and provide a significant contribution to the black bass fishery. Based on lakes in Kentucky that have an established smallmouth population and a habitat index of at least 0.5, this species can expect to make up at least 10% of the black bass biomass and yield in other lakes having a habitat index of at least 0.5. The following lakes were identified as having a habitat index of ≥0.5 and having the characteristics shown in Figure 1; these lakes will be stocked with smallmouth bass as recommended: Cannon Creek Lake, Cave Run Lake, Laurel Lake, Greenbo Lake, Cranks Creek Lake, Beulah Lake, and Wood Creek Lake.

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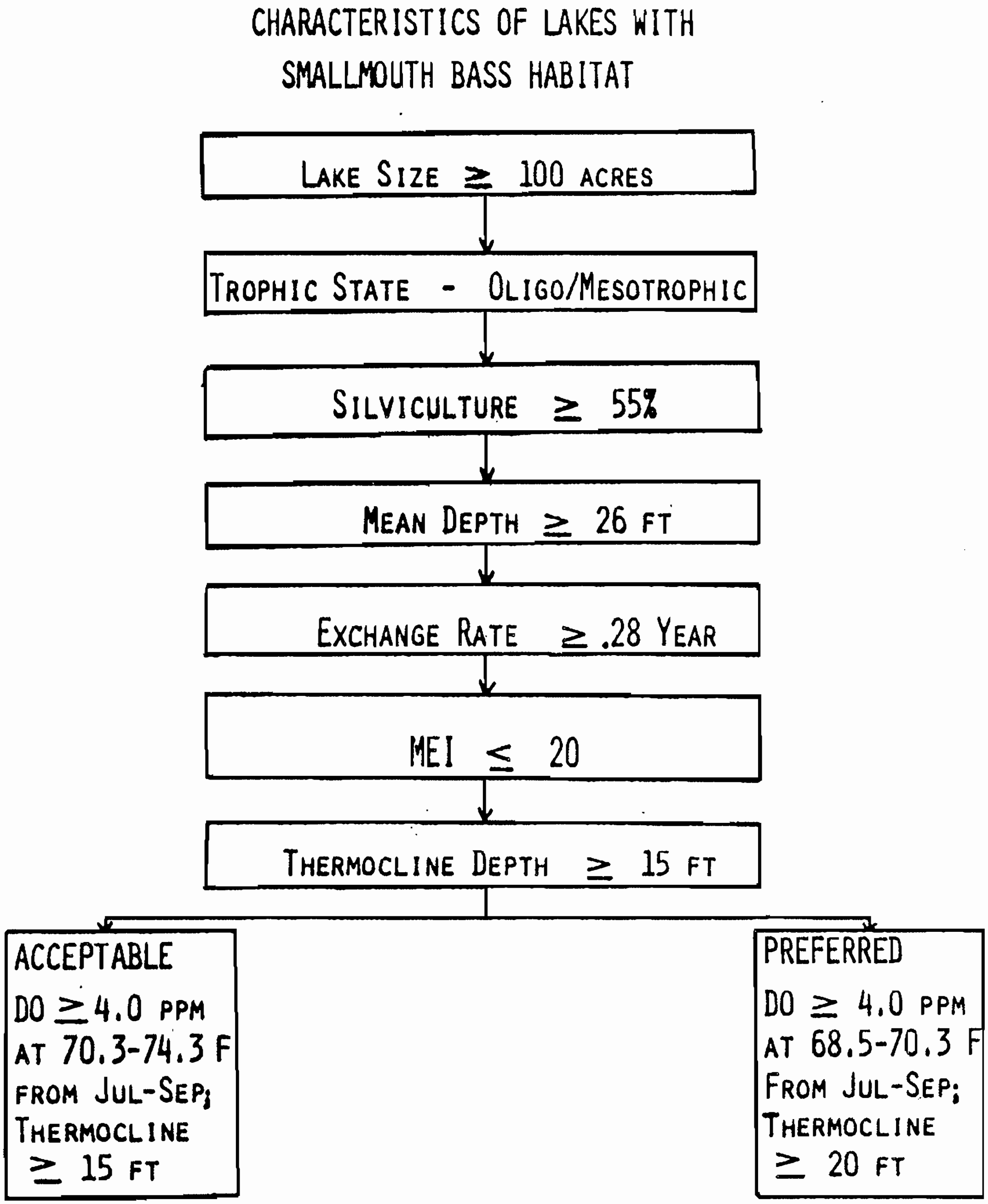

Figure 1. A flow chart showing characteristics of lakes in Kentucky with smallmouth bass habitat.

Table 1. Mean standing crop of fish under a 12-inch minimum black bass size limit as determined from cove-rotenone samples collected from 1978-1984.

			Mean standing crop (lb/acre)			
Lake type	No. of lakes	Total	Largemouth bass	Smallmouth bass	Spotted bass	Black bass
Oligotrophic[a]	9	118	3.4	0.8	2.1	6.3
Mesotrphic[b]	5	296	8.6	0.4	3.4	12.4
Eutrophic[c]	2	517	13.8	0.1	2.1	16.0

[a] Oligotrophic lakes: Laurel, Grayson, Fishtrap, Dewey, Dale Hollow, Cumberland, Cave Run, Carr Fork, Buckhorn.

[b] Mesotrophic lakes: Kentucky, Green River, Nolin, Rough River, Barren River.

[c] Eutrophic lakes: Barkley, Herrington.

Table 2. Number of fingerling (f), intermediate (I), and harvestable (H) black bass per acre as determined from cove-rotenone samples from 1978-1984 in lakes under a 12-inch minimum size limit on black bass.

Lake type	No. of lakes	Largemouth bass			Smallmouth bass			Spotted bass			Black bass		
		F	I	H	F	I	H	F	I	H	F	I	H
Oligotrophic[a]	9	77.0	10.2	0.9	4.0	2.0	0.2	117.7	8.2	0.3	198.7	20.4	1.4
Mesotrophic[b]	5	246.0	19.2	2.4	3.5	0.8	0.1	169.6	12.1	0.3	419.1	32.1	2.8
Eutrophic[b]	2	176.0	39.2	5.6	1.7	0.8	0.1	97.7	13.9	0.8	275.4	53.9	6.5

[a] Oligotrophic lakes: Laurel, Grayson, Fishtrap, Dewey, Dale Hollow, Cumberland, Cave Run, Carr Fork, Buckhorn.

[b] Mesotrphic lakes: Kentucky, Green River, Nolin, Rough River and Barren River.

[c] Eutrophic lakes: Barkley, Herrington.

Table 3. Pearson correlation coefficients, based on all historical cove-rotenone data, that relate to physical and biological characteristics of lakes to smallmouth, largemouth, and spotted bass; r = correlation coefficient, and dt = degrees of freedom. Probability: *** = α 0.001, ** = α 0.01, and * = α .05. Based on all historical cove-rotenone data.

Smallmouth bass	storage ratio*** r = 0.38807 DF = 153	Chlorophyll-a* r = -0.19341 DF = 153	Silviculture* r = 0.18091 DF = 153	Agriculture* r = 0.17300 DF = 153	Largemouth bass* r = -0.17180 DF = 153
Largemouth bass	Agriculture*** r = 0.60396 DF = 177	Silviculture*** r = -0.56733 DF = 177	Chlorophyll-a*** r = 0.49358 DF = 177	Total alkalinity*** r = 0.47590 DF = 177	Sunfish*** r = 0.44774 DF = 177
Spotted bass	Largemouth bass*** r = 0.27527 DF = 173	Total phosphorus r = -0.26304 DF = 173	Storage ratio** r = 0.24037 DF = 173	Fluctuation** r = 0.24498 DF = 173	Drainage area** r = -0.22691 DF = 173

Table 4. Multiple regression equations for predicting standing crops of each species of black bass in Kentucky reservoirs, using cove-rotenone data samples collected between 1978 and 1985.

Log_{10} (largemouth bass in lb/acre) = -5.75799 + 0.42164 (Log_{10} total dissolved solids) + 3.52718 (Log_{10} chloraphyll-a).

R^2 = 0.59, No. observations = 46

Log_{10} (spotted bass in lb/acre) = -1.82668 + 0.69965 (Log_{10} storage ratio) -0.43792 (Log_{10} outlet depth) + 2.07254 (Log_{10} chlorophyll-a).

R^2 = 0.38, No. observations = 46

Log_{10} (smallmouth bass in lb/acre) = -2.06955 + 1.07401 (Log_{10} area) - 2.19639 (Log_{10} shoreline development)

R^2 = 0.27, No. observations = 24

Table 5. Field observed preferred temperature (F) range for each species of bass as determined by Ferguson 1958.

Species	Temperature
Largemouth bass	79.8 - 81.9
Spotted bass	74.3 - 75.9
Smallmouth bass	68.5 - 70.3

Table 6. Criteria used to assign a numerical value to the dissolved oxygen/temperature profile data obtained during the critical months of July-September in lakes.

Habitat Index

P = 2 = Preferred temperature of 68.5 - 70.3F available from July-September with $\geq$4.0 ppm O_2.

A = 1 = Acceptable temperature of 70.3 - 74.3F available from July - September with $\geq$4.0 ppm O_2.

N = 0 = No preferred or acceptable temperature available.

Table 8. Estimated total pounds and percentage of total pounds of each species of black bass harvested as determined from creel survey data.

			Black bass harvest					
			Largemouth bass		Smallmouth bass		Spotted bass	
Lake	Survey years[a]	Quality index	Lb/acre	%	Lb/acre	%	Lb/acre	%
Dale Hollow	1969-73	2.0	0.83	29	1.70	59	0.37	12
Carr Fork	1983	1.3	0.90	41	1.30	59	0	0
Cumberland	1982-83	0.7	0.70	73	0.14	14	0.13	13
Green River	1979-82	0.5	0.91	77	0.18	15	0.10	8
Barren River	1979-80	0.1	2.76	98	0.02	2	0.01	t
Kentucky Lake	1978-80	0.0	1.06	88	0.03	2	0.12	10
Barkley Lake	1978-80	0.0	4.20	97	0.09	2	0.60	1
Herrington Lake	1981-84	0.0	8.80	97	0.08	1	0.19	2

t < 0.05%.

[a] Years creel data was collected.

Table 9. Standing crop estimates (lb/acre) and percent of total black bass yield for each species of black bass obtained from cove-rotenone data.

			Black bass standing crop					
			Largemouth bass		Smallmouth bass		Spotted bass	
Lake	Sample years	Quality index	lb/acre	%	Lb/acre	%	Lb/acre	%
Dale Hollow	1983-84	2.0	3.8	43	3.7	42	1.4	15
Carr Fork[a]	1978-80	1.3	0.1	5	2.0	95	0	0
Cumberland	1978-83	0.7	3.9	59	0.8	12	2.6	29
Green River	1979-81	0.5	6.8	58	1.5	13	3.5	29
Kentucky[b]	1978-84	0.0	7.2	77	0.2	2	2.0	21
Barren	1978-82	0.1	11.2	78	0.4	3	2.8	19
Barkley	1979-82	0.0	10.3	95	0.0	0	0.6	5
Herrington	1978-84	0.0	17.4	82	0.1	t	3.7	18

t < 0.05%.

[a] Standing crop estimates during pre-fertilization.

[b] In 1984, when a large cove was sampled in the LBL side for the first time (area of major smallmouth bass habitat), percentage of each black bass species was largemouth = 84%, smallmouth = 6%, spotted = 10%.

Table 10. Black bass harvest statistics derived from creel surveys on lakes with a 12-inch minimum size limit on black bass from 1978-84.

Lake type	No. of lakes	Man-hours /acre	Fishing trips/acre	Pounds harvested/acre	Number harvested/acre	Number harvested/hour
Oligotrophic[a]	6	5.9	2.5	0.9	0.8	0.1
Mesotrophic[b]	3	5.9	1.9	1.9	1.6	0.1
Eutrophic[c]	2	23.2	9.3	7.7	6.3	0.3

[a] Oligotrophic lakes: Laurel, Grayson, Fishtrap, Dewey, Cumberland, Cave Run.

[b] Mesotrophic lakes: Kentucky, Green River, Barren River.

[c] Eutrophic lakes: Barkley, Herrington.

Table 11. Multiple regression equations for predicting harvest statistics in Kentucky reservoirs, using cove-rotenone data collected between 1978 and 1985.

Log_{10} (black bass in lb/acre) = 0.12206 - 0.22545 (Log_{10} age) - 0.31233 (Log_{10} storage ratio) + 0.87467 (Log_{10} maximum depth) - 0.85887 (Log_{10} silviculture)

$R^2 = 0.35$ No. observations = 101

Log_{10} (spotted bass in lb/acre) = 11.63130 - 0.80555 (Log_{10} fluctuation) - 7.32733 (Log_{10} chlorophyll-a)

$R^2 = 0.67$ No. observations = 23

Log_{10} (largemouth bass in lb/acre) = 3.57175 - 0.70852 (Log_{10} shoreline development) - 1.50297 (Log_{10} silviculture)

$R^2 = 0.42$ No. observations = 25

Log_{10} (smallmouth bass in lb/acre)= -0.29969 + 0.83953 (Log_{10} storage ratio)

$R^2 = 0.54$ No. observations = 20

Log_{10} (total pounds of fish/acre)= -3.31957 - 0.55192 (Log_{10} storage ratio) + 1.05534 (Log_{10} maximum depth) - 0.31703 (Log_{10} thermocline depth) + 1.38853 (Log_{10} chlorophyll-a)

$R^2 = 0.40$ No. observations = 102

Log_{10} (total no. of fish/acre) = -0.70177 - 0.40882 (Log_{10} area) + 0.3802 (Log_{10} shoreline development) - 0.64907 (Log_{10} total dissolved solids) + 2.78460 (Log_{10} chlorophyll-a)

$R^2 = 0.48$ No. observations = 102
