Habitat of Adult Smallmouth Bass in a Tennessee River Reservoir

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Habitat of Adult Smallmouth Bass in a Tennessee River Reservoir[1]

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Abstract

Over four seasons the movement and distribution of radio-tagged smallmouth bass (*Micropterus dolomieui*) were evaluated relative to water temperature, current velocity, turbidity, surface light intensity, reservoir elevation, bottom contours, substrate, and cover. Water temperatures always were within the range of tolerance by smallmouth bass, but late summer temperatures of 31 C probably reduced movement. Fluctuations in water velocity and reservoir elevation influenced depth distribution and movement of individual fish. Bottom relief was a major variable governing distribution and movement patterns of smallmouth bass. Dropoffs of 30–45° slope from the overbank into the original river channel or inundated creek channels were preferred. Bottom contours influenced both the shape of residence areas and movement pathways outside of residence areas. Smallmouth bass utilized all forms of submerged cover—rocks, stumps, sunken trees, and crevices in hard clay banks—without apparent preference for one type.

The purposes of this study were to examine one important species, the smallmouth bass (*Micropterus dolomieui* Lacépède) in a large impoundment, to define specific physical elements of its habitat, and to relate these findings to management practices. Management of smallmouth bass generally has involved stocking and fishing regulations. The possibility of manipulating the physical habitat and the importance of preserving existing habitat may be important to smallmouth bass management, but their value has not been assessed. Identifying physical elements of the reservoir environment associated with an established smallmouth bass population could facilitate habitat evaluation and manipulation as management techniques. Further, it would help ensure that existing smallmouth bass habitat is not destroyed because of an incorrect assessment of its importance.

The Tennessee Valley forms the southern edge of the natural smallmouth bass range. Two of the Tennessee River's nine mainstream reservoirs, Pickwick and Wilson, support nationally recognized smallmouth bass fisheries. Three and one-half years of creel survey data (Tennessee Valley Authority, unpublished report) from the uppermost 52 km (6,800 hectare) of Pickwick Reservoir indicate that smallmouth bass live in both riverine and reservoir portions of the impoundment. These smallmouth bass grow rapidly compared to those in other localities in the species' range (Hubert 1975).

Study Area

Pickwick Reservoir, a 17,400-hectare mainstream Tennessee River reservoir bordered by Alabama, Mississippi, and Tennessee, was impounded in 1938. Its upstream boundary is Wilson Dam, located at Florence, Alabama, which discharges a mean annual flow of 1,000 m³/second. The Tennessee River flows within its original banks and is distinctly riverine for 20 km below Wilson Dam. Beyond this point the river inundates overbank areas and the cur-

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rent velocity decreases. The original river channel is 600–800 m wide. An abrupt dropoff (generally a 30–45° slope) from the overbank region into the old river channel occurs over much of the reservoir (Fig. 1).

This investigation was confined to one portion of the reservoir, a transition area where the riverine Wilson Dam tailwater changes to a more lentic or reservoirlike habitat and where a range of habitat types occurs. Smallmouth bass were released at ten predetermined sites from 29 to 38 km downstream from Wilson Dam.

Methods

Based on previous water temperature records, four seasons were defined beginning April 15 (spring, rising temperatures), July 20 (summer, maximum temperatures), October 25 (autumn, falling temperatures), and February 5 (winter, minimum temperatures). Smallmouth bass equal to or greater than 350 mm total length were collected by electrofishing just below Wilson Dam. Only female fish were tagged during the spring period to avoid possible sexual differences in behavior. Sex was not determined during the other seasons because stress associated with determining sex could seriously affect survival.

Paraffin-coated ultrasonic transmitters (21 mm × 98 mm; 51 g in air) were surgically implanted into the peritoneal cavity by the procedures of Hart and Summerfelt (1975) within 24 hours of capture. Following surgery, fish were held 2–24 hours to assure recovery. Telemetry equipment (Smith-Root, Incorporated, Vancouver, Washington) included the Model TA-60 ultrasonic receiver, Model PC-74 digital pulse counter, and Model SR-70-H submersible hydrophone. The ultrasonic transmitters, Model SR 69A, had a frequency of 74 kHz. Pulse rates from 0.6 to 8.0/second distinguished individual fish. Data from the first 2 days of tracking each fish were excluded from analysis as postsurgical behavior may be abnormal during this time (Shepherd 1973; Hart 1974; Prince 1976).

Individual smallmouth bass were located once each day, weather permitting, from the day of release until the batteries failed or the fish could no longer be found. Daily monitoring began between 0600 and 1000 hours. As each fish was located, its position was fixed (1–5 m

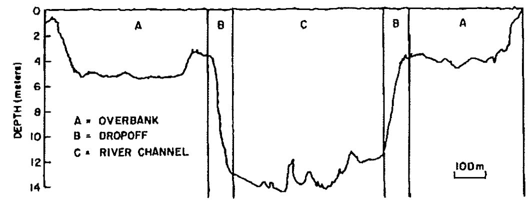

FIGURE 1.—*Transect of Pickwick Reservoir at Tennessee River kilometer 381 showing depth distributions.*

accuracy depending on depth) by triangulation and measurement of distance from permanent reference points. The location was plotted directly on navigation maps superimposed with a 100-m × 100-m grid system. The position was marked with a buoy, and its distance from the previous day's fix was calculated in the field or later from grid maps.

At the point of each fix, the following were measured: time of fix; water depth at fix; current velocity at 30 cm depth; water temperature (1 m, bottom, and 5-m intervals between surface and bottom); surface light intensity; turbidity; observable structure. Water depth, current velocity, and water temperature were measured by standard instruments. Light intensity was measured with a photographic light meter, turbidity with a Jackson turbidometer. Cover was anything that could provide shelter or visual orientation and that could be seen from the boat or sensed by the depth recorder.

Fix displacement, the linear distance between two consecutive fixes, was used as a measure of movement. Fix displacement was categorized into two general types: (1) displacement within a residence area, and (2) displacement outside an established residence area. Residence areas were defined as locations where fish remained for 3 consecutive days or more before displacement from the area by more than 100 m. Two 50-m transects were established through each residence area perpendicular to the current, and two scuba divers evaluated the substrate in 5-m intervals along each. Seven substrate types were identified: silt-clay; sand; gravel (5–50 mm diameter); rubble (50–250 mm diameter); boulders (>251 mm diameter); bedrock; and mollusk shells. Contours of the residence areas were measured with a depth recorder. Cover was observed from the surface or by scuba divers at a later date, or indicated on the depth recorder.

TABLE 1.—*Summary of smallmouth bass released with ultrasonic transmitters, Pickwick Reservoir, April 1977 to February 1978.*

Season	Total length (mm)	Weight (g)	Date of release	Days tracked	Number of daily fixes
Spring 1977	510	2,450	1 Apr	32	25
	425	1,130	5 Apr	4	4
	419	1,100	15 Apr	36	32
	508	840	15 Apr	48	47
	413	430	15 Apr	27	18
	397	390	15 Apr	39	39
	517	980	15 Apr	47	42
	413	480	15 Apr	46	40
	413	850	16 Apr	42	37
Summer 1977	406	980	23 Jul	30	29
	421	1,100	23 Jul	3	3
	457	2,130	23 Jul	30	26
	350	590	25 Jul	28	27
	483	1,820	25 Jul	41	35
	553	2,320	25 Jul	3	3
	353	680	26 Jul	5	5
	432	1,270	26 Jul	41	39
	381	800	1 Aug	31	26
	439	1,250	1 Aug	29	24
Autumn 1977	495	2,050	28 Oct	23	19
	450	820	28 Oct	53	37
	435	1,450	28 Oct	53	42
	480	2,000	30 Oct	51	31
	390	500	30 Oct	47	31
	465	840	30 Oct	45	34
	400	480	30 Oct	51	36
	500	1,600	31 Oct	51	35
	425	1,130	31 Oct	5	5
Winter 1978	425	1,120	7 Feb	41	28
	445	1,300	7 Feb	32	23
	455	1,390	8 Feb	10	9
	388	850	16 Feb	32	18
	370	730	16 Feb	33	23
	400	930	16 Feb	25	16

Daily data on discharge from Wilson and Pickwick dams, surface elevation of Pickwick Reservoir, and rainfall were obtained from the Tennessee Valley Authority Hydraulic Data Branch, for use in determining possible relations with measured variables.

Statistical Analysis

Frequency distributions of measured values were analyzed with chi-square contingency tables. The null hypothesis was that two modes of classification were independent, or that there was no association between individual fish or fish grouped by season and the observed frequency distributions. Kendall's coefficient of rank correlation was used to evaluate relationships between measured variables. The null hypothesis was that no association existed between measured variables (Sokal and Rohlf 1969). Null hypotheses were rejected at $P \leq 0.1$.

Results

Tracking Success

The 34 study fish were 350–553 mm total length (TL) and weighed 390–2,450 g (Table 1). Five fish were tracked for 5 days or less and were eliminated from analysis. The other 29 were tracked for an average of 38 days (range: 10–53 days).

Physical Variables

The daily water temperature between a depth of 1 m and the bottom did not differ by more than 1.5 C, except at the location of one fish, and there was no thermal stratification in the study area. The minimum bottom temperature measured at the site of a fix was 2.5 C on March 8, 1978; the maximum was 31.5 C on August 31, 1977.

Current velocities at fix sites varied from 0 to 82 cm/second, but were in excess of 50 cm/second at only 3.6% of the fixes. Seasonal means were 20.4 cm/second in spring, 10.9 cm/second in summer, 32.0 cm/second in autumn, and 19.2 cm/second in winter; they were significantly associated (product-moment correlation coefficient = 0.99) with the mean daily discharge from Wilson Dam. Throughout the study, individual fish tended to experience moderate current velocities on a daily basis.

Throughout the study, turbidity was low; 92% of the measurements were less than or equal to 25 Jackson Turbidity Units (JTU), and only five measurements were greater than 75 JTU.

Fish Distributions

The 1,490-hectare study area had four general types of habitat: cove, overbank, dropoff from overbank into the original river channel, and original river channel. Smallmouth bass preferred dropoffs. The distributions of habitat area and number of fixes were as follows: cove 8% of study area, 4% of fixes; overbank 49% of study area, 17% of fixes; dropoffs 7% of study area, 69% of fixes; channel 36% of study area, 10% of fixes. Only one fish was located in a cove and this was during the summer.

TABLE 2.—*Number of ultrasonic-tagged smallmouth bass for which there were significant associations ($P \leq 0.1$; Kendall rank coefficient) between water depth at fix and physical variables, Pickwick Reservoir, 1977–1978. + denotes direct (same arithmetic sign) correlation; − denotes inverse (opposite) correlation.*

Variable	Spring (8 fish)		Summer (7 fish)		Autumn (8 fish)		Winter (6 fish)		All seasons (29 fish)	
	+	−	+	−	+	−	+	−	+	−
Current velocity	3	0	3	0	4	0	2	0	12	0
Bottom temperature	2	2	2	0	0	3	1	2	5	7
Surface light intensity	2	0	0	0	1	1	1	0	4	1
Time of fix	1	0	0	0	0	0	0	0	1	0
24-hour Wilson Dam flow	1	0	1	0	4	0	0	1	6	1
24-hour mean Florence elevation	0	0	0	1	2	0	1	1	3	2
24-hour mean Pickwick Dam elevation	0	1	0	1	1	0	1	1	2	3
24-hour change in flow at Wilson Dam	2	0	0	0	2	1	0	0	4	1
24-hour change in elevation at Florence	0	0	0	0	1	1	0	0	1	1
24-hour change in elevation at Pickwick Dam	0	0	1	0	0	0	0	0	1	0
24-hour rainfall at Wilson Dam	0	0	0	1	0	0	0	0	0	1

Smallmouth bass occurred in water depths of 10 m or more during warmer periods, but frequented more shallow areas during colder times. The fraction of fixes at depths between 0.5 and 5 m were spring 58%, summer 54%, autumn 71%, and winter 93%.

Twelve study fish moved to and from sites of deeper water when current velocities increased or decreased, respectively (Table 2). All fish showing this association were in the dropoff habitat. Ten other physical variables were statistically associated with depth at fix for some fish, but coefficients were both positive and negative.

Residence Areas

A residence area was defined as a specific locality in which a fish was observed 3 consecutive days or longer before displacement from the area by more than 100 m. The 29 study fish established 41 residence areas and spent up to 41 days in them. Thirteen fish spent greater than 50% of their tracking days in residence areas. The proportion of tracking days spent in residence areas varied by season: spring 37%, summer 71%, autumn 37%, and winter 79%. Mean duration of stay in residence areas was spring 11.2 days, summer 15.9 days, autumn 10.6 days, and winter 22.8 days.

Pronounced topographic relief occurred in 39 of 41 residence areas. Some of it involved inundated creek channels or large rock formations, but 32 residence areas were along steep (30–45°) dropoffs to the river channel. Residence areas were linear in most cases, ranging to 405 m along the dropoffs. There was no seasonal difference in residence locality among the four general habitat areas (cove, overbank, dropoff, river channel). Nor was there any relationship between duration of stay in a residence area and current velocity.

Substrate types in 39 residence areas were evaluated. Clay-silt dominated in all the residence areas. Rubble and gravel each occurred in 70% of residence areas and composed a substantial portion of the substrate in several. Many residence areas were completely or almost completely void of rock substrate. No associations were observed between the duration of stay in particular residence areas and the presence or abundance of specific substrate types.

Cover in 38 residence areas took the form of rocks (26 areas), stumps (23), sunken trees (16), and crevices in hard clay banks (4). Rocks or stumps were found, separately or together, in all 38 residence areas. Cover occurred over a range of depths where vertical relief was present. Its most common pattern within residence areas was stumps near the top of a dropoff and rubble, boulders, or sunken trees near the bottom. In several cases, rubble and boulders occurred over the entire vertical reach of the residence area. Some of this rock cover was manmade, the remnants of a 19th century canal system inundated by Pickwick Reservoir.

Homing was observed for seven study fish. Three spring and four autumn fish established a residence area, moved away for a period, and subsequently returned to reestablish residence

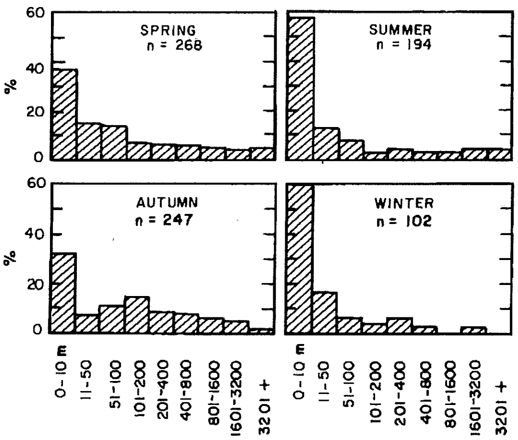

FIGURE 2.—*Frequency distribution of distances between successive daily fixes for ultrasonic-tagged smallmouth bass, Pickwick Reservoir.*

at the site. For example, one spring fish maintained a residence area for 23 days, moved 5,800 m upstream, returned to the residence area 9 days later, and stayed there during the last 4 days it was tracked.

Fish Movement

Seasonal trends were noticed in the movement tendencies (Fig. 2). The greatest fix displacement occurred in autumn and spring when 49 and 38%, respectively, of the distances between daily fixes exceeded 100 m. In winter and summer, 17 and 21% of the distances, respectively, were greater than 100 m.

There also were differences in the movement tendencies of individual fish within a season. If greater than 75% of the fix displacements fell within the 0–100-m range, the fish was arbitrarily defined as sedentary; three spring fish, four summer fish, and two winter fish could be classified as sedentary. If greater than 50% of the observed displacements were in excess of 100 m, the fish was defined as mobile; two spring fish, two summer fish, and five autumn fish were designated mobile. There was a distinct mode of displacements in the 0–50 m range for seven summer fish, five winter, and one spring fish. There was no statistical association between upstream or downstream displacements and season. Associations between fix-displacement magnitudes and eight physical variables occurred, but not consistently (Table 3).

Discussion

Smallmouth bass in this mainstream impoundment encountered only minor temperature changes with vertical movement. The vertical distribution of Pickwick Reservoir smallmouth bass is not influenced by temperature stratification as in most lakes and storage reservoirs.

The maximum summer temperature associated with smallmouth bass populations is 31–33 C (Barans and Tubbs 1973; Wrenn 1974; Peterson 1975). Reservoir smallmouth bass were tracked in 31.0–31.5 C water for a week during late August and early September. Water temperatures exceeded 28 C for most of the summer tracking period. Seasonal changes in water temperature were correlated with movement tendencies and depth distributions of smallmouth bass in Pickwick Reservoir, a pattern generally observed in other reservoir bass studies (Peterson 1975; Warden and Lorio 1975). However, the shallow winter depth (<5 m) fre-

TABLE 3.—*Number of ultrasonic-tagged smallmouth bass for which there were significant associations (P ≤ 0.1; Kendall rank coefficient) between displacement since previous fix and physical variables, Pickwick Reservoir, 1977–1978. + denotes direct (same arithmetic sign) correlation; − denotes inverse (opposite correlation).*

	Spring (8 fish)		Summer (7 fish)		Autumn (8 fish)		Winter (6 fish)		All seasons (29 fish)	
Variable	+	−	+	−	+	−	+	−	+	−
Bottom temperature	1	0	0	1	1	0	2	0	4	1
24-hour Wilson Dam flow	0	1	1	1	2	0	1	0	4	2
24-hour mean Florence elevation	1	0	0	1	4	0	1	0	6	1
24-hour mean Pickwick Dam elevation	0	1	0	0	3	0	2	0	5	1
24-hour change in flow at Wilson Dam	0	0	0	0	1	1	1	0	2	1
24-hour change in elevation at Florence	0	0	1	0	1	1	0	1	2	2
24-hour change in elevation at Pickwick Dam	1	0	0	0	1	0	1	0	3	0
24-hour rainfall at Wilson Dam	0	0	0	0	0	1	1	0	1	1

quented by Pickwick smallmouth bass is inconsistent with the winter depth distribution generally described for this species or for largemouth bass (Hasler and Wisby 1958; Lewis and Flickinger 1967; Munther 1970; Prince 1976).

Smallmouth bass in Pickwick Reservoir generally were in areas exposed to moderate surface current velocities (10–40 cm/second). The association of smallmouth bass with regions of moderate current velocity in both streams and lakes has been previously observed (Coble 1975). The Pickwick study fish tended to move into deeper water as current velocities increased. Currents may have been reduced near dropoffs or the fish may have sought more protective cover.

Smallmouth bass in Pickwick Reservoir exhibited a strong association with steep dropoffs; such areas of relief are known to be preferred smallmouth bass habitat (Webster 1954; Watt 1959; Johnson and Hale 1977). Movement within, as well as between, residence areas generally followed the contour of dropoffs. As a result, residence areas were linearly shaped, ranging to 405 m in length. Fajen (1962) noted that the home range of stream smallmouth bass included several pools up to 800 m apart.

All residence areas of smallmouth bass in Pickwick Reservoir had cover of some type, but rocky cover was not a particular requisite. Other studies in natural lakes and streams have generally described the substrate associated with smallmouth bass to be almost exclusively rubble, boulders, and broken rock strata (Belding 1926; Hubbs and Bailey 1938; Westman and Westman 1949; Webster 1954; Stone et al. 1954; Watt 1959; Reynolds 1965; Munther 1970; Johnson et al. 1977; Johnson and Hale 1977). Paragamian (1976) observed that the standing stock of smallmouth bass in segments of a Wisconsin stream was strongly correlated with the quantity of rock substrate in the segments. Watt (1959), Munther (1970), and Johnson and Hale (1977) have suggested that this is due to the dietary preference of smallmouth bass for crayfish (*Orconectes* spp.). In Pickwick Reservoir, crayfish make up 48% of the food volume of 100–199-mm smallmouth bass, but less than 15% of the volume of smallmouth bass over 300 mm long (Hubert 1977). These larger fish, which the tracking study utilized, eat primarily shad (*Dorosoma petenense* and *D. cepedianum*), which may account for their relatively low requirement for rocky substrate.

Management Implications

The habitat of adult smallmouth bass contains quantifiable physical variables which can be evaluated for management purposes. Bottom relief and cover influence the distribution and movement of smallmouth bass. Certain elements of the habitat deteriorate over time, especially the stumps and sunken trees utilized as cover along dropoffs, and these may have to be replaced occasionally.

The Pickwick Reservoir study suggests that adult smallmouth bass habitat can be manipulated or enhanced by fisheries managers to increase yield from an existing population. Insufficient information exists on the physical elements of the habitat during spawning and early life phases to suggest that smallmouth bass populations can be created where they currently do not exist.

Acknowledgments

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