Walleye Movement, Distribution, and Habitat Use in Laurel River Lake, Kentucky

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Abstract: Movement, distribution, and habitat use of walleyes *(Stizostedion vitreum)* in Laurel River Lake, Kentucky were determined by radio-tracking 35 walleyes for 605 days (mean = 249 days) from March 1994 through November 1995. The goal of this study was to increase the angler utilization of walleyes in Laurel River Lake by educating anglers on walleye movement patterns, habitat usage, and distribution within the lake. Walleye movement (as measured in distance between weekly locations) was highest during the spring (median = 120 m/day) and lowest during the summer (median = 53 m/day). During the summer, most walleyes confined their activities to specific areas of the lake and were often located in the same area during consecutive weeks. Activity areas ranged from 2 to 590 ha with 75% of walleyes utilizing areas <300 ha. Walleyes were widely distributed throughout the lake during each season, although only 2 walleyes remained in the upper Laurel River arm during July and August. Walleyes predominately oriented to standing (flooded) timber located only in coves on an annual basis (53%) and even more (59%) in the summer. Walleyes moved deeper as summer progressed, which coincided with an increase in the median depth of the thermocline. During summer stratification, walleyes selected water temperatures averaging 23.0 C (mean depth 6.1 m). Walleyes were most active at night, with mean peak movements occurring at 0200 hours (396 m/hour) in the spring, 2200 hours (174 m/hour) in the summer, and 0400 hours (198 m/hour) in the fall. Walleyes typically moved out of the timbered coves at night and either traveled along the shoreline, suspended at the edge of timber near the mouth of the cove, or suspended in open water in the main lake. Walleyes usually returned to the same cove by morning, although they occasionally returned to a nearby cove. Information gained from this study should improve walleye angler success in Laurel River Lake and perhaps in other southern reservoirs. Walleye harvest is expected to increase in Laurel River Lake as anglers use the information gained from this study.

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Numerous telemetry studies have been conducted on walleyes. However, most have dealt with movements in river systems (Bahr 1977, McConville and Fossum 1981, Holzer and Von Ruden 1982, Kingery and Muncy 1988, Paragamian 1989), in northern lakes and reservoirs (Holt et al. 1977, Einhouse 1981, Hall 1982, Heidinger and Tetzlaff 1989), or midwestern reservoirs (Summers 1979, Prophet et al. 1989, Parks and Kraai 1991). Few studies have been conducted on deep, clear, southern reservoirs such as Laurel River Lake in Kentucky, and little is known about the behavior of walleyes in such systems. Ager (1976) tracked 29 walleyes in Center Hill Reservoir, Tennessee, but tracking times for individual fish were typically <60 days because of equipment limitations. Schultz (1992) tracked 12 walleyes in Dale Hollow Reservoir, Tennessee, for over 1year, but his findings were general in scope. Wilson (1997) tracked 25 walleyes in Paintsville Lake, Kentucky.

This study was conducted on Laurel River Lake in southeastern Kentucky from March 1994 through November 1995. The goal of this study was to increase the exploitation of walleyes in Laurel River Lake by informing anglers about walleye movement patterns, habitat usage, and distribution within the lake. The specific objectives of the Laurel River Lake telemetry study were to 1) determine the seasonal distribution of walleyes, 2) determine the daily and seasonal movement patterns of walleyes, and 3) determine the habitat usage (including temperature and depth selection) of walleyes.

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Methods

Laurel River Lake is a 2,452-ha (maximum power pool) reservoir located in Laurel and Whitley counties, Kentucky. This lake is divided into 2 major arms, Laurel River and Craig's Creek, and has a mean depth of 21.9 m and a maximum depth of 76 m. Most of the watershed is forested (71%). The shoreline is relatively steep-sided and composed of mixtures of rock and sand with limited clay. Secchi disk readings are typically 2.5–4.0 m. The lake is highly dissected and contains numerous coves, most of which contain standing (flooded) timber. A trophic gradient exists in Laurel River Lake ranging from oligotrophic in the lower lake and Craig's Creek arm (2,019 ha), to mesotrophic in the midregion of the lake (305 ha), to highly eutrophic in the headwaters (128 ha) of the Laurel River arm (Ky. Div. Water 1984). Laurel River Lake is a warm, monomictic lake that is thermostratified between April–November. During the summer (Jun–Aug), epilimnetic water temperatures are typically 27–30 C. The upper Laurel River arm experiences oxygen depletion (< 4 mg/liter) below the thermocline in water < 25 C during late summer. However, most of the lake maintains oxygen concentrations > 4 mg/liter in water < 25 C during summer stratification (Jun–Aug).

Implantation of Transmitters

Radio transmitters (48 MHz) were surgically implanted into the body cavity of 47 walleyes (26 females, 19 males, 2 undetermined sex) during March 1994 (28 transmitters) and December 1994 through March 1995 (19 transmitters). Tagged male walleyes ranged from 48.8–67.3 cm TL (1.1–3.4 kg) and females ranged from 47.8–81.3 cm TL (1.1–6.4 kg). Four transmitter sizes (Advanced Telemetry Systems, Isanti, Minn., models 5, 5A, 6, and LTC30) based on fish size were used during the study. The smallest transmitter size (model 5) measured 54 mm x 18 mm and weighed 21 g and the largest transmitter size (model 5A) was 90 mm x 19 mm and weighed 45 g. Transmitter weight was < 2% of the fish's weight. Transmitter life expectancy ranged from 225–450 days, depending upon the model, and each transmitter was equipped with an external whip antenna to increase reception range. Each transmitter operated on a unique frequency that allowed recognition of individual walleyes. Forty-three of the 47 transmitters were temperature-sensitive and during lake thermal stratification, each walleye's depth could be determined by using a temperature profile of the lake at the walleye's location.

Surgical procedures occurred on the lakeshore following the collection of 1–4 walleyes. Most walleyes (44) were captured by electrofishing; 3 were captured by gillnets. Walleyes were captured throughout the lake, including headwater, mid-lake, and lower lake areas. Captured walleyes were sedated in a 100-mg/liter solution of tricaine methane sulfonate (MS-222), measured to the nearest 0.2 cm, and weighed to the nearest 0.4 kg. Walleyes were then transferred to a surgery hammock that consisted of seine netting draped over a metal frame. The walleyes were placed ventral side up in the surgery hammock with their head and gills immersed in fresh lake water and their abdomen exposed. Surgical equipment was sterilized in a 25% Virosand solution and then rinsed in sterile water to prevent tissue irritation. The incision site was sprayed with a topical antiseptic (Betadine) and 2 to 3 rows of scales were removed from the incision area. A 2-cm incision was made (with scalpel) just lateral to the midline of the belly and was lengthened to 3–4 cm using surgical scissors. The whip antenna was first inserted into the incision and threaded out of the body cavity (about 3 cm posterior to the incision) through a hypodermic needle. The transmitter was then inserted anteriorly into the body cavity and the incision was closed with 3-0 (Dermalon) nonabsorbable surgical sutures. Typically, 4 or 5 sutures were required to close the incision. Surgical gloves were worn during the surgery. The surgical process typically lasted 5–8 minutes and the walleyes were usually recovered from the anesthetic upon completion of the surgery. A Floy tag was inserted just behind the dorsal fin as an external marker to indicate a $20 reward for the transmitters. Walleyes were released near the capture area immediately upon recovery from the anesthetic.

Daytime Tracking

Walleyes were tracked by boat during daylight hours from March 1994 through November 1995. The tracking boat was equipped with a 4-element Yagi antenna connected to a programmable, scanning receiver (Challenger Model 2000, Advanced Telemetry Systems) that cycled through the transmitter frequencies. Tracking was usually conducted 1 or 2 times per week with an effort to locate each walleye at least once per week. The following information was recorded each time a walleye was located: habitat type (timbered cove, shoreline, point, open water, and other), water temperature at walleye depth (based on transmitter temperature), water depth at walleye location (Eagle Mach 2 paper graph, Lowrance, Inc.), distance from shore, and water clarity. Throughout the study period, water depth at walleye location was used to approximate walleye depth, even though walleyes could be shallower than the water depth. However, during summer stratification when walleyes were located in the metalimnion, I also determined walleye depth (to the nearest 0.1 m) and DO (YSI Model 54A) at walleye depth by comparing the temperature reading from the transmitter (based on pulse rate) to a temperature and oxygen profile recorded at the walleye's location.

Location was recorded in Universal Transverse Mercator (UTM) coordinates based on a grid system (50 m x 50 m) superimposed on a map of the lake (1:24,000). Movement distances (m/day) were determined by plotting successive weekly locations on the map and dividing the distance by the number of elapsed days. This movement rate was an underestimate since walleyes could move extensively and return to the same place; however, it was useful for comparing monthly and seasonal movements. Median values were used for movement data, water depth at walleye location, and distance from shore measurements to reduce the effect of outliers. Movement data was analyzed for differences between seasons by non-parametric methods (Kruskal-Wallis test, Rosner 1986).

Size of activity areas calculated by the minimum area polygon method (Winter 1977) was determined for 27 walleyes tracked more than 180 days. Activity area (home area) was defined as an area normally traversed by walleyes during the monitoring period, excluding wanderings and spawning movements. Certain locations within the activity areas that received heavy daytime use were termed "rest areas" (Pitlo 1978). Spearman's rank correlation analysis was used to test the relation between activity area size (dependent variable) and weight of tagged fish, number of days tracked, and number of fixes (independent variables) (Rosner 1986).

Twenty-four Hour Tracking

Daily activity patterns were determined by continuous 24-hour tracking of individual walleyes in each season except winter (Dec–Feb). Twenty-four hour tracking sessions were conducted on 11 separate occasions. During these tracks, 2 or 3 walleyes were selected and located approximately once per hour during a 24-hour period. Tracking typically began about mid-day and continued for 24 hours. Twenty-four hour tracking sessions were conducted throughout the lake, except the upper Laurel River arm. Walleyes were selected for tracking based on their proximity to each other to facilitate tracking. Most fish (74%) selected for tracking were located in timbered coves at the beginning of the tracking session. Hourly movement rates for each fish were determined by plotting successive hourly locations on a map and dividing the distance by the elapsed time. The midpoint of the time interval (rounded to the nearest hour) was used to plot the movement rate against time. Mean values were used to compare hourly movement rates.

Results

Tracking was accomplished on 41 of the 47 tagged walleyes; 6 walleyes were not located after release. Six of the remaining 41 walleyes died or expelled their tags, thereby reducing the study cohort to 35 fish. Eight of these walleyes were caught by anglers during the study period. Thirty-one walleyes were tracked ≥100 days, 24 were tracked for ≥200 days, and 10 walleyes were tracked at least 300 days. A total of 886 daytime fixes on 35 walleyes was made during the study period.

Twenty-seven tracks on 17 walleyes were conducted during the 24-hour tracking sessions. Most 24-hour tracking sessions were during the summer (15 tracks), followed by the fall (Sep–Nov, 7 tracks) and spring (Mar–May, 5 tracks). No 24-hour tracks were conducted during the winter period due to inclement weather. Of the 17 walleyes tracked, 11 were tracked once, 2 were tracked on 2 separate occasions and 4 were tracked on 3 separate occasions.

Distribution and Movement

Walleyes were widely distributed throughout the lake during each season, although only 2 walleyes remained in the upper Laurel River arm during July and August. The scarcity of walleyes in the upper Laurel River arm during late summer was probably due to the low oxygen concentrations (<4.0 mg/liter) below the thermocline in water <25 C in that part of the reservoir.

During the summer, most walleyes established an activity area and stayed in the same general area of the lake, often in the same location for several consecutive weeks. Similarly, the movement rate of walleye during the summer was lower than any other season (median = 53 m/day). Statistical analysis of movement data indicated that walleye movement was significantly lower (Kruskal-Wallis test, $P < 0.05$) during the summer than during the spring (median = 120 m/day) and winter (median = 105 m/day).

Walleye movement increased (median = 93 m/day) during declining water temperatures in the fall as some walleyes abandoned their summertime activity areas and began to frequent more areas of the lake. October was the beginning of this trend, as indicated by the higher movement rates (Fig. 1).

Activity Areas

Activity areas were established by early June and ranged in size from 2 to 590 ha. Most (75%) were <300 ha. Within the activity areas, walleyes were typically found in 1–3 smaller daytime resting areas, usually within timbered coves. Activity area size was not significantly correlated with either length of period tracked (r = 0.30, P = 0.12) or the number of contacts (r = 0.28, P = 0.16). However, there was a significant positive correlation between activity area size and weight of fish (r = 0.53, P = 0.004), which suggested that larger fish used larger activity areas.

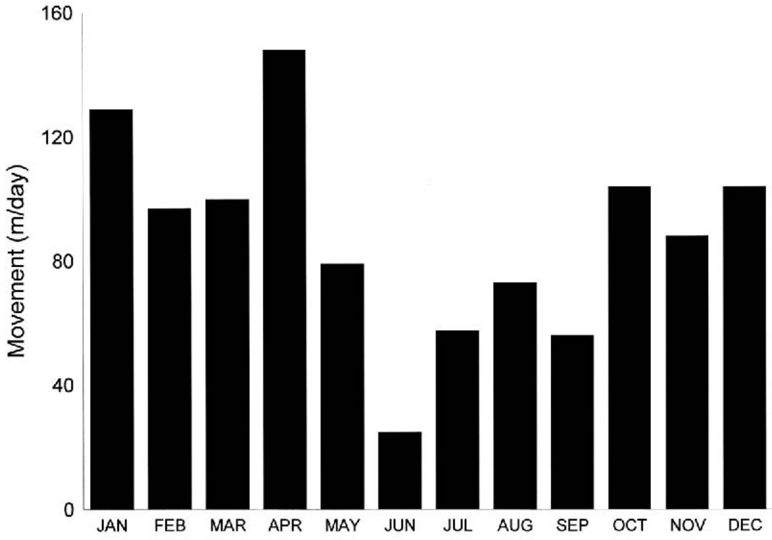

Figure 1. Median daily movement (m/day) by month of walleyes in Laurel River Lake, Kentucky, March 1994–November 1995.

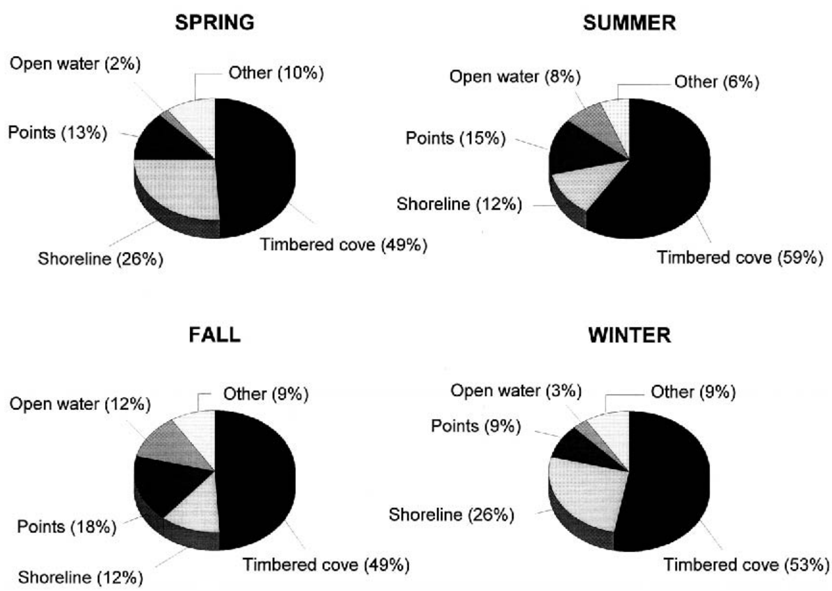

Figure 2. Seasonal habitat use by walleyes in Laurel River Lake, Kentucky, March 1994–November 1995.

Habitat Use

Timbered coves were the dominant habitat type used by walleyes during the study (Fig. 2). Timbered coves comprise only about 6% of the surface area of Laurel River Lake, yet over half (53%) of the walleyes were located in timbered coves during the daytime. Use of timbered coves was similar between sexes. Male walleyes were found in timbered coves 56% of the time while females used timbered coves 51% of the time. Timbered cove use was very similar among seasons, with highest use during the summer (59%), particularly in June (70%) and July (62%).

Depth and Distance from Shore; Temperatures Occupied

Tagged walleyes were usually located in water less than 10 meters deep and within 30 meters of shore (Fig. 3). Walleyes were typically the most shallow and closest to shore during the winter and spring. They exhibited a general trend of inhabiting deeper water from spring through summer. Most walleyes moved toward the shore into water shallower than 8 m during late September, while a few remained offshore in 8–12 m deep water. Although the general fall trend was movement into shallower water, depths occupied by individual fish varied widely and walleyes did not appear to concentrate at a particular depth.

During summer stratification, depth of the walleyes was determined during 263 observations. Mean depth from all combined observations was 6.1 m (mean range 4.2–7.6 m) during thermal stratification. Walleyes gradually moved deeper as summer progressed. Mean depth was 4.5 m (mean range 2.8–6.7 m) in June ($N = 72$), 6.2 m (mean range 3.8–7.9 m) in July ($N = 91$), and 7.1 m (mean range 4.0–8.3 m) in August ($N = 101$).

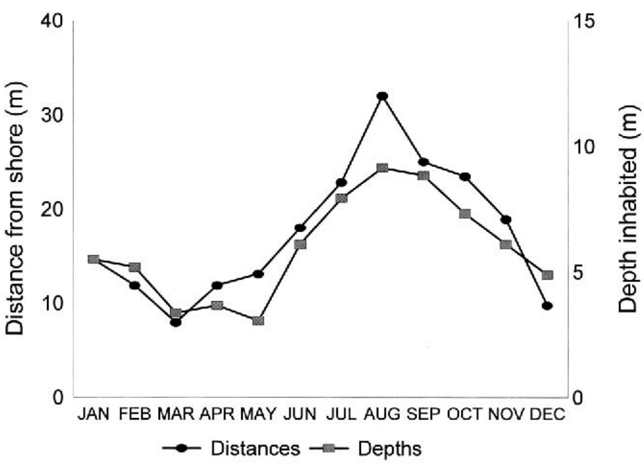

Figure 3. Median monthly distance from shore (m) and depth inhabited (m) by walleyes in Laurel River Lake, Kentucky, March 1994–November 1995.

Although the mean depth occupied by walleyes increased during the summer months, mean temperature occupied remained nearly identical. Walleyes mean temperature occupied was 23.2 C ($N = 79$) in June, 23.1 C ($N = 91$) in July, and 22.8 C ($N = 101$) in August. Mean temperature occupied during summer stratification (June–August) for all observations combined was 23.0 C (individual mean range 19.4–26.3 C, $N = 271$ observations) with 77% of the walleye mean temperatures between 21–25 C.

Diel Activity; Twenty-four Hour Tracks

Walleyes were most active at night with maximum movement rates occurring between 2000–0800 hours for 85% of the walleyes (Fig. 4). Nighttime movement rates were higher than daytime rates and peak movement rates occurred at different times each season. In the spring, walleyes movement rate averaged 39 m/hour in daytime movement rates, but nighttime movement rates averaged 169 m/hour with peak values at 0200 hours (396 m/hour). Walleyes movement rate in the summer months averaged 26 m/hour in daytime movement rates, but nighttime movement rates averaged 119 m/hour with peak values at 2200 hours (174 m/hour). Movement rate of walleyes in the fall averaged 26 m/hour in daytime movement rates, but nighttime movement rates averaged 83 m/hour with peak values at 0400 hours (198 m/hour).

Discussion

Walleyes utilized most major sections of Laurel River Lake throughout the year, with some limited distribution during the summer months. Similar wide range use by walleyes has been reported for Center Hill Reservoir, Tennessee (Ager 1976), Lake Okoboji, Iowa (Pitlo 1978), and Chautauqua Lake, New York (Einhouse 1981). Only 2 walleyes remained in the upper Laurel River arm during midsummer. These 2 fish remained in 25–27 C water temperatures, which exceeded reported preferred temperatures of 20.6–23.2 C but was below their lethal temperature of 31.6 C (Hokanson 1977).

Annual walleye movement patterns in Laurel River Lake were similar to patterns reported in the literature with highest walleye movement during the cool water seasons (fall-winter-spring). Both Ney (1978) and Holt et al. (1977) found walleyes more active in the spring and fall, possibly due to lower food availability. Similarly, in Laurel River Lake, the primary prey (gizzard and threadfin shad) abundance was likely highest in the summer when walleye movement was lowest.

Most tagged walleyes in Laurel River Lake confined their activities to specific areas of the lake and were typically found in the same areas in consecutive weeks during the summer and early fall. These activity areas were usually associated with a group of timbered coves. The use of specific areas by walleyes has been documented in several biotelemetry studies (Ager 1976, Pitlo 1978, Einhouse 1981, Wilson 1997).

Laurel River Lake walleyes exhibited characteristic nighttime movement patterns generally associated with feeding. Ryder (1977) noted that most feeding by

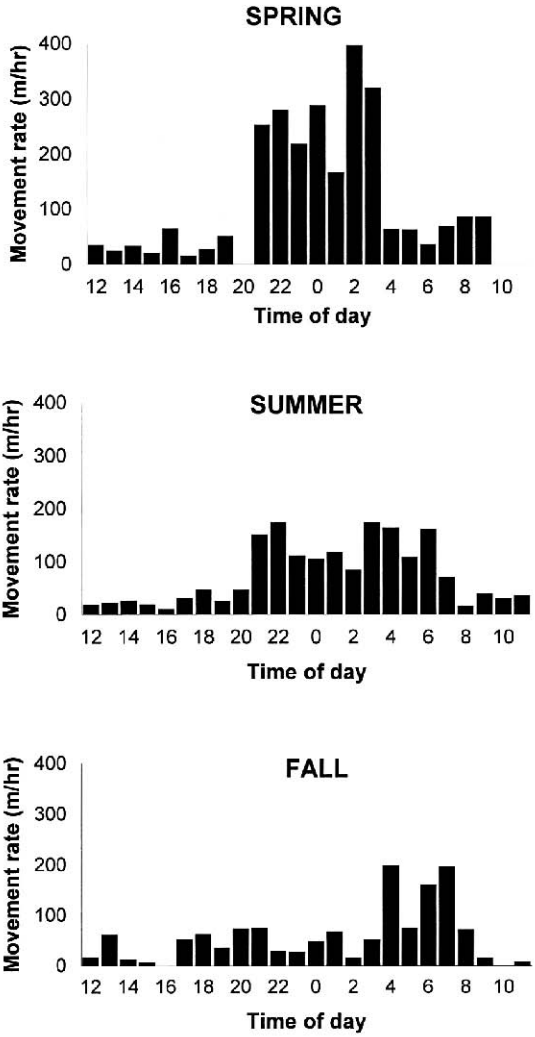

Figure 4. Mean hourly movement (m/hour) for walleyes during 24-hour tracks at Laurel River Lake, Kentucky, 1994 and 1995.

walleyes in clear lakes was either crepuscular or nocturnal. Laurel River Lake walleyes were typically found inactive in timbered coves during the daytime. Movement typically began at dark as walleyes exited the standing timber and either traveled along the shoreline or suspended near the mouth of the cove or in open water. Walleyes tended to suspend in open water more in late summer and fall than during the spring, possibly due to the presumed increase in shad availability during that time. Sonar recordings indicated suspended walleyes were often found with schools of baitfish (presumably shad). Walleyes also were commonly found suspended within the submerged timber at night, especially in late summer. Mean movement rates remained high during the night with peaks after midnight and near dawn. Other investigators have reported similar findings, with reported peak activity occurring near dusk and dawn (Carlander and Cleary 1949, Fossum 1975, Kelso 1976, Holt et al. 1977, Pitlo 1978, Einhouse 1981, McConville and Fossum 1981, Wilson 1997). Bahr (1977) reported four distinct modes of activity—at 0230 hours, 0630 hours, 1130 hours, and 1830 hours, with the maximum movement peak occurring after midnight (at 0230 hours).

Laurel River Lake walleyes used the timbered coves as daytime rest areas and they typically returned to the same cove or a nearby cove after foraging at night. Wilson (1997) also found walleyes resting in timbered coves during the daytime in Paintsville Lake, Kentucky. He reported that fish exited their rest area (timbered cove) at or after dusk, presumably foraged, and then returned to a timbered cove during the night or shortly after dawn. Similarly, Pitlo (1978) noted that study fish in West Lake Okoboji, Iowa, were usually found stationary in smaller rest areas during the daytime period and moved toward or within a larger foraging area during the nighttime period. Use of smaller rest areas within activity areas has also been noted by Einhouse (1981) and Prophet et al. (1989).

Walleye depth distribution in Laurel River Lake varied seasonally and was influenced by water temperature, oxygen concentrations, and possibly water clarity. Walleyes moved deeper during the summer months as the thermocline moved deeper except for the 2 walleyes in the Laurel River arm headwaters. These 2 walleyes were limited to shallow depths because of oxygen depletion in the thermocline. They typically occupied the coolest water that contained DO concentrations greater than 4.0 mg/liter. Walleyes in nearby Tennessee reservoirs behaved similarly—they moved deeper with the thermocline unless forced to remain shallow by oxygen depletion (Dendy 1948, Ager 1976, Fitz and Holbrook 1978). Light penetration may have influenced walleye depth selection in certain systems. Ryder (1977) stated that in clear lakes, light was most important variable affecting depth distribution. Kelso (1978) also found that light rather than temperature regulated depth in walleyes; however, these findings were in northern water bodies where epilimnetic water temperatures remained cool (<23 C). During the summer in Laurel River Lake, temperature appears to influence depth distribution more than light penetration, since walleyes moved deeper during the summer to remain in water temperatures near 23 C. Also, many walleyes moved to shallower water in late September (when epilimnetic water temperatures cooled) even though water clarity increased. Although water temperature appeared to have the greatest influence on walleye depth selection in Laurel River Lake, light penetration may also have been a factor. Walleyes have been shown to optimize daytime light levels by using some form of cover to reduce light intensities (Ryder 1977, Pitlo 1978). Likewise, Laurel River Lake walleyes may have used areas around timber for the same reason.

Mean temperatures occupied by walleyes during the summer in Laurel River

Lake were similar to findings in nearby reservoirs. Schultz (1992) reported that the mean temperature occupied during summer stratification by walleyes in Dale Hollow Lake, Tennessee, was 23.9 C. Similarly, 4 of the 5 walleyes tracked during the warm water months (May–Sep) in Center Hill Reservoir, Tennessee, occupied mean temperatures of 23.7–25.2 C (Ager 1976). Dendy (1946), using gill nets, found that 21–26 C was the preferred summer temperature range of walleyes in Norris Reservoir, Tennessee. Mean temperatures occupied by walleyes in Laurel River Lake were very close to the physiological optimum (22.6 C) reported by Hokanson (1977). The similarity of the mean temperature occupied during each summer month (mean range 22.8–23.2 C), suggested that walleyes preferred temperatures near 23.0 C.

The goal of the walleye telemetry study on Laurel River Lake was to increase the angler utilization of walleyes in Laurel River Lake by informing anglers on their distribution, movement patterns, and habitat use. I believe anglers can improve their success at Laurel River Lake by focusing on 2 key findings. First, anglers should fish in or near timbered coves, especially at night or during low light periods. The nocturnal movement pattern exhibited by Laurel River Lake walleyes is likely related to feeding activity. Anglers fishing at dark near the timber edge at the mouth of the coves could intercept walleyes as they exit the timbered coves to feed. Second, anglers should key on 23 C water temperatures during summer stratification. Thermal stratification concentrates walleyes within a relatively narrow depth range during the summer months and anglers could benefit by fishing in water temperatures near 23 C.

Angler interest in this study was high throughout the study period and many anglers improved their catches of walleyes by using the information relayed to them while the study was ongoing. Although a 1997 daytime creel survey did not show an increase in fishing success for walleyes at Laurel River Lake, the survey design did not include nighttime anglers, when walleye harvest was likely the highest. Information gained from this study could be applicable to other clear, southern reservoirs, particularly those containing timbered coves.

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