Movement of Smallmouth Bass in Elkhorn Creek, Kentucky

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Abstract.—Movement patterns of 305–406-mm smallmouth bass *Micropterus dolomieu* were observed by use of radiotelemetry in main-stem Elkhorn Creek and the Kentucky River, Kentucky, in 2000 and 2001 to determine impacts of movement and homing ability on a special regulation area within the open-river system. Smallmouth bass are protected from harvest in main-stem Elkhorn Creek by a 305–406-mm protective slot limit, but can be harvested in the Kentucky River under a 305-mm minimum length limit. In 2000, 39 smallmouth bass radio-tagged in May and June after spawning were composed of migratory (69%) and sedentary (31%) groups, with 13% utilizing the Kentucky River. In 2001, 15 smallmouth bass radio-tagged in late March prior to spawning were year-round sedentary residents; 20% made limited movements out of their original capture pool. In addition, we displaced 15 smallmouth bass from Elkhorn Creek into the Kentucky River in March 2001 to observe and quantify homing; 60% of the fish returned to the creek from their displacement locations. Managers should consider movement patterns when developing special regulation areas, particularly as seasonal movements may affect the size and scope of the area necessary for adequate protection.

Smallmouth bass *Micropterus dolomieu* are highly prized sport fish in the USA and are managed in a variety of ways. Management options include special regulation areas, particularly areas subject to slot limits or minimum length limits (Smith and Kauffman 1991; Hayes et al. 1997; Slipke et al. 1998; Buynak and Mitchell 2002), sections closed to harvest (Johnson et al. 1999), and catch-and-release-only zones on a stretch of river or tributary. Sometimes, multiple regulations are used on the same water body or on connected water bodies.

Despite extensive research on the behavior of smallmouth bass, populations can be relatively sedentary (Gerking 1950, 1953, 1959; Larimore 1952) or highly migratory (Latta 1963; Langhurst and Schoenike 1990) in streams and rivers. Information on the potential impacts of smallmouth bass movement on special regulation areas within open river systems is lacking; therefore, special regulations do not always consider the impact of movements, thus compromising the effectiveness of the regulations.

The main goal of this study was to determine if movement patterns could decrease densities of smallmouth bass within a slot-limit protected area as a result of movement into an unprotected area. To accomplish this goal, we used radiotelemetry to characterize movement of smallmouth bass in a protected section of Elkhorn Creek, Kentucky, and determined the extent to which these fish utilized an unprotected portion of the Kentucky River.

Methods

Study area.—The study area was a 25.7-km reach of the main-stem Elkhorn Creek, a sixth-order tributary of the Kentucky River located in Franklin County, Kentucky (Figure 1). Main-stem Elkhorn Creek is a warmwater stream with a broad range of habitats (from class-III whitewater to long, slow-moving pools) and a gradient of 1.9 m/km. The fish fauna is dominated by smallmouth bass, channel catfish *Ictalurus punctatus*, rock bass *Ambloplites rupestris*, sunfish *Lepomis* spp., redhorse *Moxostoma* spp., and common carp *Cyprinus carpio*. Jim Beam Dam is an upstream barrier to fish movement in the creek.

Tagging and tracking.—A total of 39 smallmouth bass corresponding to the 305–406-mm slot limit (mean ± SE: 354 ± 4.0 mm; 603 ± 26.3 g) were collected by electrofishing from five Elkhorn Creek sites in May and June 2000 after spawning (Figure 1). Fish were anesthetized, weighed, measured, surgically implanted with radio transmitters (Advanced Telemetry Systems, Inc., Isanti, Minnesota), and released near the area of capture after they regained equilibrium and demonstrated normal swimming activity (procedures modified from Winter [1983]).

Smallmouth bass were located by kayaking Elkhorn Creek and using a scanning receiver and handheld loop antenna (Advanced Telemetry Systems, Inc.). Tracking in the Kentucky River was done primarily by boat, with one aerial helicopter flight used in fall 2000. Frequency of tracking de-

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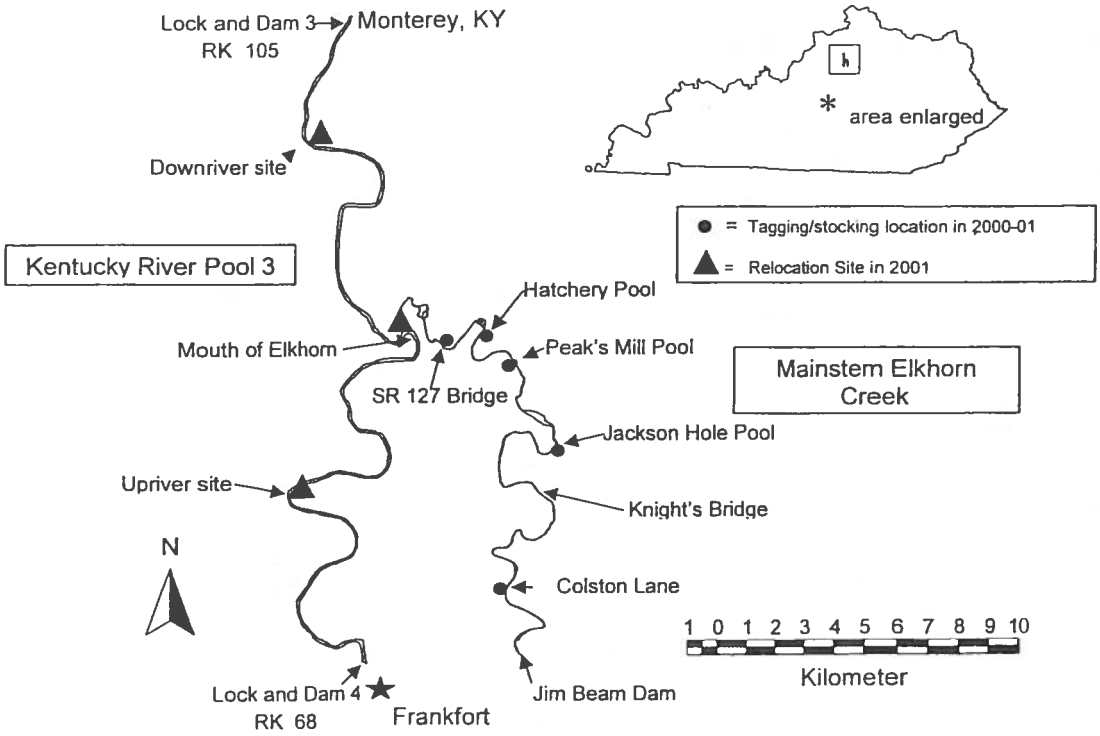

FIGURE 1.—Elkhorn Creek and Pool 3 of the Kentucky River, Kentucky, where the movements of radio-tagged smallmouth bass were monitored in 2000 and 2001.

pended on the season, as defined by water temperature (Todd and Rabeni 1989). During spring and fall, surveys were conducted weekly; in summer and winter, surveys were conducted once every 2 weeks.

By October 2000, only 23 of the original 39 radio-tagged fish were located in the study area. An extensive search was conducted by boat and by helicopter over Elkhorn Creek and the Kentucky River to determine if the fish had migrated out of the study area, but none were found. Electrofishing in the creek produced tagged smallmouth bass with nonfunctioning transmitters. Due to tag malfunction, 30 additional fish averaging 355 mm (SE = 4.3 mm) and 622 g (SE = 27.6 g) were collected in March 2001 before spawning, from the same collection areas used in 2000. Fifteen of these fish were released near their areas of capture and the other 15 were moved to the Kentucky River (upriver: river kilometer [RK] 93.5, downriver: RK 72.7, and at the mouth of Elkhorn Creek: RK 83.1) (Figure 1) in order to observe and evaluate homing ability.

Data analysis.—Locations, recorded as Global Positioning System readings, were downloaded into Waypoint+ version 1.7.17 software and into ArcView (Environmental Systems Research Institute, Inc., Redlands, California) mapping software. Individuals were classified as sedentary, upstream, downstream, or complex (both upstream and downstream) movers. Fish exhibiting no movement outside of the original capture pool were classified as sedentary. Individual fish movements were measured relative to the previous recorded location. Maximum distance moved was calculated as the greatest distance a fish moved from the original capture pool (Fajen 1962). Seasonal mean movement for each fish tagged in 2000 was calculated as the mean of individual movements. Seasonal mean movement for all fish was calculated as the grand mean for all fish combined within each season. Therefore, sample sizes for all statistical tests were the number of fish rather than the number of individual movements. Movement data collected for fish tagged in 2000 were analyzed with Statistical Analysis System (SAS Institute 1988) software. The NPAR1WAY procedure run together with the Kruskal–Wallis test was used to test for differences in mean fish movement among seasons and release sites in Elkhorn Creek.

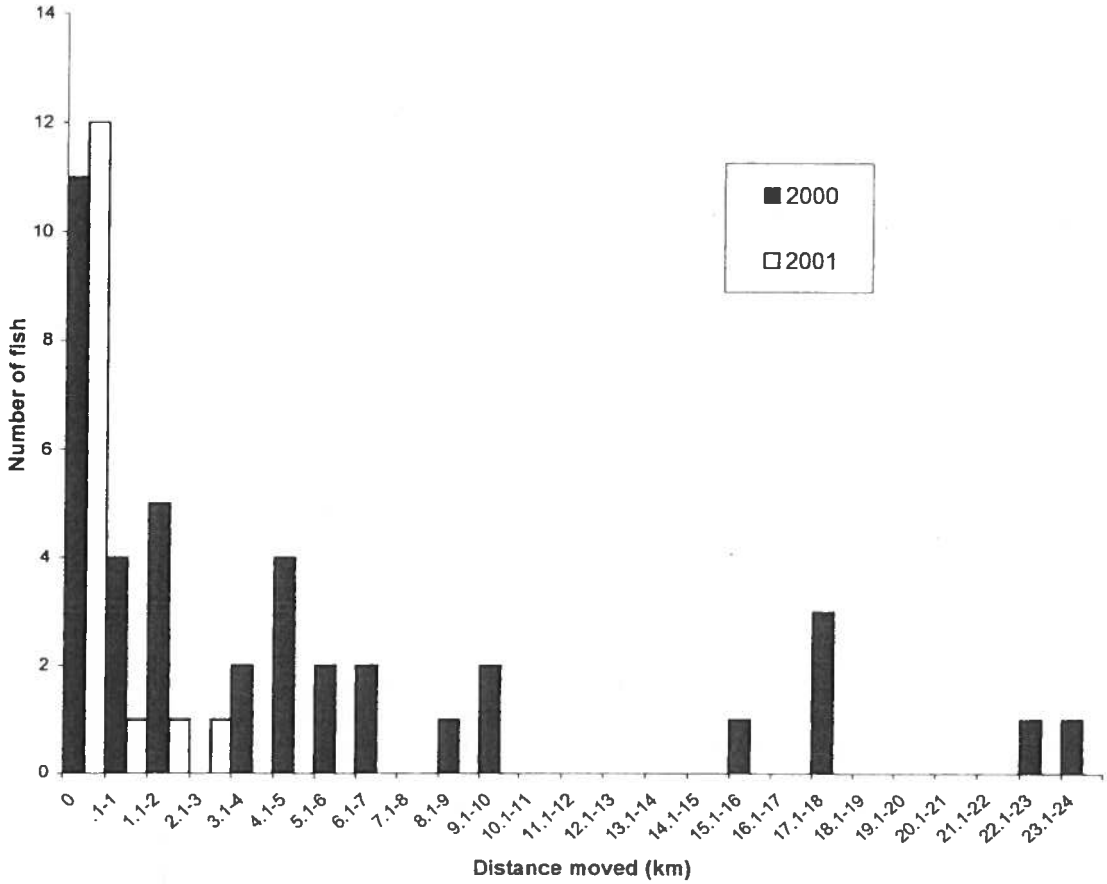

FIGURE 2.—Distances moved (km) from the original capture pool by smallmouth bass radio-tagged in Elkhorn Creek, Kentucky, during 2000 and 2001. Distances are to the furthest points, upstream or downstream, at which fish were located.

Wilcoxon's rank-sum test was used to test for differences in mean movement between males and females and between upstream and downstream movement in Elkhorn Creek. A significance level of 0.05 was used for all analyses. Fish tagged in 2001 and released in the creek exhibited little movement; therefore, movement was expressed only as a mean. Homing ability of smallmouth bass displaced into the Kentucky River was summarized by calculating, for each release site, the percentage of fish that returned to the creek, did not return to the creek, or disappeared, and the amount of time it took for the fish to move or return.

Results

In 2000, radio-tagged smallmouth bass exhibited two patterns of movement: 69% were migratory (n = 28) and 31% were sedentary (n = 11; Figure 2). Of the 28 migratory individuals, 36% (n = 11) moved in complex patterns, 15% (n = 4) moved upstream, 30% (n = 8) moved downstream, and 19% (n = 5) moved into the Kentucky River. Movement into the Kentucky River by two females and three males occurred from late-May to mid-June 2000. These fish exhibited variable movement patterns, including remaining in the river, returning to the creek, or a combination of the two. The mean total distance moved from the capture pool by all fish combined was 5.3 km (SE = 1.1, range = 0–23.4 km). Downstream movements (mean ± SE = 4.0 ± 0.62 km) occurred more frequently (57%) than upstream movements (2.0 ± 0.24 km) and covered significantly greater distances (S = 1,038.5, Z = −2.1, P = 0.04, where S is the sum of ranks for pairs with a positive difference in Wilcoxon's rank sum test). Mean seasonal movement distance differed significantly among seasons (χ^2 = 14.9, df = 4, P = 0.01) and was highest in summer 2000. Mean movement by male (4.7 ± 1.2 km) and female (7.4 ± 2.8 km)

smallmouth bass did not differ significantly (S = 202.0, Z = 0.59, P = 0.6). Mean movement originating from the five release sites in Elkhorn Creek did not differ significantly among sites (χ^2 = 3.7, df = 4, P = 0.5).

Of the 15 bass radio-tagged and released at their original site of capture in 2001, 80% (n = 12) were sedentary and 20% (n = 3) moved downstream (mean = 2.2 km) (Figure 2). Mean movement was 0.4 km (SE = 0.3, range = 0–3.5 km). No smallmouth bass moved into the Kentucky River in 2001. Of all fish tagged and released in 2000 and 2001 in Elkhorn Creek, 57% were migratory (n = 31) and 42% were sedentary (n = 23), with a mean total movement value of 3.7 km (SE = 0.8) (Figure 2).

Movement and homing behavior of the 15 smallmouth bass displaced into the Kentucky River in 2001 differed by area of release and began about 1 week after release. Four of the five fish released at the mouth of Elkhorn Creek returned to their original site of capture (creek kilometer 6.5 [from the mouth of the creek]) within 3–12 weeks (mean ± SE = 5.7 ± 2.1 weeks), and one fish returned to a different site in the creek. Of the fish released at both upstream and downstream locations in the river, 40% (n = 4 of 10) returned to the creek, while the others roamed about the river or disappeared altogether.

Discussion

Smallmouth bass radio-tagged after spawning in 2000 exhibited both migratory and sedentary behavior, similar to findings in Missouri streams (Funk 1955). In contrast, fish tagged before spawning in 2001 were relatively sedentary. After observing postspawning downstream movement in 2000, we hypothesized that pre-spawning smallmouth bass tagged in 2001 would move upstream, followed by a subsequent downstream movement. This was not the case, and the reasons are unclear. The difference in movement behavior between the two groups may have been due to a number of factors, including an absence of migratory individuals in our small sample or in the population of the creek early in 2001, annual variation in movement patterns, or possible alteration of spawning behavior by the surgery. Knights and Lasee (1996) found that bluegills and other laterally compressed fish might be adversely affected by implantation of transmitters.

Movement of smallmouth bass tagged in summer 2000 gives evidence of distinct use of summer and overwintering locations, as well as specific spawning locations. Movement between these locations can involve both Elkhorn Creek and the Kentucky River. Movement of smallmouth bass between connecting river systems was also examined on the Embarrass and Wolf rivers in Wisconsin (Langhurst and Schoenike 1990). Fish made extensive migrations downstream from the Embarrass River in the fall into the larger Wolf River for the winter and then returned upstream in May. Seasonal density changes have also been described by Webster (1954), Hayes et al. (1997), and Pezold et al. (1997). Langhurst and Schoenike (1990) stated that managers of smallmouth bass populations should consider the possibility of migration before applying special regulations to streams, and that such regulations would not be effective if winter habitat for large fish were unavailable. Hayes et al. (1997), in a study of smallmouth bass on the Zumbro River, Minnesota, found that stream lengths of less than 3 km may adequately function as special regulation zones where fishing pressure is concentrated in the summer. However, the smallmouth bass season in Minnesota is closed statewide from September through May to protect the fish during the winter and during spawning. The area of migration of smallmouth bass we observed in Elkhorn Creek, where there is no closed season for smallmouth bass, extended from a single pool to the full length of the creek and up to a 20-km reach of Pool 3 of the Kentucky River. Our findings indicate that an area of 2 linear kilometers would include the migratory range of only 55% of the 305–406-mm smallmouth bass, whereas 7 kilometers would include 75%, and 18 km would include 95%. The size of the area must be considered carefully to ensure that it encompasses all habitat for spawning, summer, and overwintering, which may require the protected area to be larger, depending on habitat types available.

Based on our findings and on previous work regarding smallmouth bass home ranges (Larimore 1952; Funk 1955; Forney 1961; Ridgeway and Shuter 1996), nest sites (Langhurst and Schoenike 1990; Ridgeway et al. 1991), and overwintering sites (Webster 1954; Langhurst and Schoenike 1990), we recommend that special regulation areas should encompass the entire migratory range of the species to achieve maximum benefits in an open river system. Managers of similar systems should have a full understanding of seasonal movement and habitat use before making management recommendations that include the use of special regulation areas. Managers also need to

consider that population surveys conducted late in the spring or in the fall may reflect density changes based upon seasonal movement and habitat preferences. Changes in population density due to movement and seasonal habitat preferences may require sampling efforts aimed at estimating populations to be consistent in timing from year to year and to cover a variety of habitats throughout the entire river or stream.

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