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Habitat Selection and Movement of Walleye in Paintsville Lake, Kentucky

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Abstract. Twenty-five walleye were tagged and tracked with radio telemetry equipment in Paintsville Lake, Kentucky in 1993-94 to improve walleye harvest. Flooded timber was the most frequently utilized habitat during all months except March. Walleye preferred littoral areas of the lake during all seasons except summer. Seasonal movement was greatest during early spring and fall, with the least movement occurring during the summer. Diel movement was the greatest between dusk and dawn. Seasonal movement was greatest during early spring and fall, with the least movement occurring during the summer. All but one walleye established home ranges varying in size from 6 to 133 hectares. Several walleye established additional activity areas during the summer months. One headwater arm and a rip rap area near the dam were identified spawning areas. However, most walleye were not observed outside of their home range during the spawning period. Most walleye were located in less than 6.5 m of water, but depth selection appeared to be dependent on several factors including water temperature, dissolved oxygen content, habitat, and water clarity. Information from this study was provided to anglers that improved their success. The walleye harvest increased from 125 fish in 1988 to 1,091 fish in 1994.

A walleye *Stizostedion vitreum* population was established at Paintsville Lake as a result of a stocking program initiated by the Kentucky Department of Fish and Wildlife Resources (KDFWR) in 1984. Approximately 65,000 fingerling walleye, averaging 35 mm long, have been stocked annually since 1984. Sampling efforts conducted by the KDFWR show a good population of walleye had developed by 1989. Results from a creel survey conducted during the day and night periods in 1988 estimated anglers harvested only 125 walleye. Information regarding walleye movement and habitat selection was needed to assist anglers in catching more walleye.

Various authors have used biotelemetry techniques to describe seasonal and diel movements, habitat selection, or spawning behavior of walleye (Wolfert and Van Meter 1978; McConville and Fossum 1981; Paragamian 1989). However, most walleye studies have been conducted in their native waters or in reservoirs supporting good coolwater habitat. Information on seasonal habits, habitat utilization, and responses to restricted coolwater habitat in the Southeast is limited.

STUDY AREA

Paintsville Lake is a 461-hectare US Army Corps of Engineer reservoir located in eastern Kentucky. This reservoir was impounded in 1984, is 35 km in length and contains 92 km of shoreline. The average depth is 11.6 m, with a maximum depth of 32 m. The lake experiences less than a 1-m drawdown during the winter months.

Paintsville Lake is an extremely narrow reservoir, winding through mountainous terrain where silviculture is the predominant land use within the watershed. This lake is classified as oligotrophic (Kentucky Division of Water, 1996). The shoreline is very steep, providing a small littoral zone with little aquatic vegetation. Rock cliffs, rubble, and mud banks are scattered along the shoreline. Paintsville Lake has 22 coves of which 16 contain flooded timber (Figure 1). All three headwater embayments contain flooded timber.

Thermal stratification and dissolved oxygen (DO) levels less than 1 mg/l occur in the hypolimnion in approximately 85% of the reservoir during the summer. The hypolimnion is sufficiently oxygenated (>4 mg/l) to support fish in the lower 15% of the lake. For reference purposes in this report, the area of the lake with low DO was termed "upper end" and the remaining area near the dam that maintained good oxygenated water at all depths is termed "lower end" (Figure 1).

METHODS

Twenty-five walleye received radio transmitters between 1 March and 6 April 1993. Four additional walleye received transmitters on 20 December 1993. Walleye were collected by electrofishing along the shoreline and in coves containing flooded timber. No walleye were collected or tagged in the headwater tributary arms of the lake. There was no attempt made to collect walleye from deep water to determine if some walleye spend most of their time at depths greater than those collected near the surface. After capture, each fish was sedated, measured, and weighed. Radio transmitters were then inserted into the abdominal cavity. Each tagged fish was released at the same location it was captured. Each transmitter was equipped with an internal antennae and emitted a different frequency ranging from 48-50 kHz, with a life expectancy of at least 10 months. A $25 reward along with KDFWR 's address and phone number were imprinted on each transmitter. No external tags were attached to any of the walleye. Information regarding this study was posted at boat ramps, the marina, and local bait and tackle stores. A public information program was used to inform anglers about the study and its findings.

Diurnal tracking began by boat on 25 March 1993 and continued weekly through early December 1993. Ice covering the reservoir through the winter delayed tracking until February 1994, when 10 diurnal tracking surveys were completed through August 1994. Diurnal tracking typically began in the morning and was completed the same day when all fish were located one time or when the entire reservoir was traversed. Each time a walleye was located, the following data was recorded when possible: location, fish number, time, surface temperature, temperature at fish depth, distance from bank, and habitat type. Habitat at the location of each fix was determined by visual inspection and from information acquired from sonar.

Four nocturnal surveys were conducted during the months of June and August. Four to eight walleye were tracked during each nocturnal survey. Nocturnal surveys focused on movement and no habitat parameters were recorded. Tracking began either at or prior to dusk and continued to at least dawn. Each time a walleye was fixed, the location was plotted on a map. A cycle was conducted at regular intervals and the cycle length was dependent on the number of fish tracked, how far they moved, and weather conditions. On 11 August 1994, heavy fog prevented any tracking from midnight till dawn.

Home ranges and activity areas were calculated only from diurnal data collected throughout the year. All walleye with an estimated home range size were tracked a minimum of 6 months. Fish and Savitz (1983) described a primary occupation area as an area within each home range that excludes any location greater than 61 meters from any other location. Home ranges were estimated using a grid square method (Winter 1977) and a minimum of 90% of all locations for each fish, excluding the spawning period. Winter also suggested that obvious wandering should be excluded from home range calculations. Summer home ranges were identified for four walleye that moved away from their home ranges during the summer, all of these fish left their summer range only after surface water temperatures exceeded 24 C.

RESULTS

Fifteen female, five male, and nine walleye of undetermined sex were used in this study (Table 1). These fish ranged in size from 1.08-4.82 kg. A total of 649 fixes was obtained over a 22-month period. Five walleye were still active at the end of this study. Five walleye died during the study, three presumably from implantation and two from unknown causes. Four walleye were considered missing before the transmitter batteries were expected to expire, but one of these fish (walleye 613) was caught later by an angler. Four other transmitters were returned by anglers, including walleye 513 that was caught from the tailwater in the spring of 1997.

Home ranges for 14 walleye varied in size from 6 -133 ha (Table 1). Walleye 583 was the only fish that did not establish a home range; this fish traveled in a nomadic fashion throughout the year, covering nearly the entire lake. Four walleye established dual home ranges which included a summer home range that was established only during critical water conditions. Based on a t-test, there was no significant difference ($t=0.8099$, $p=0.4337$) between the mean home range of males (75.2 ha) and females (57.4 ha). There was no significant correlation between home range and total length of fish tagged ($r=0.09$, $p=0.738$).

Peak spawning movement occurred during the last week of March and the first week of April during both 1993 and 1994. Surface water temperatures during this period ranged from 11-13 C. The length of the spawning period varied among individual walleye. Walleye 513 left the dam area and spent nearly 12 weeks in 1993 and 10 weeks in 1994 to travel to the headwater spawning area, spawn, and return. In contrast, walleye 543 traveled from mid lake to the headwater and back in less than 2 weeks.

Female and male walleye were located in different areas of the lake during the spawning period. Four female walleye moved to the same area of the lake's headwater in the Paint Creek arm to spawn. Three of these fish were all located within 100 m of each other; the remaining fish was found approximately 1.5 km downstream of this location. Four additional females moved outside of their home range during the spawning period, but remained near mid lake. Three females were not located outside of their home range, near mid lake, during the spawning period. All five tagged males used an identified spawning area in the spring. One male walleye moved to the headwater during the spawning period, then returned to the lower end of the lake. Three males remained in the lower end and frequented the riprap near the dam during the spawning period. One male moved from the headwater to the riprap near the dam during this period, then returned to the upper end of the lake.

Only 14 % of the lake's total surface area contains flooded timber; however, walleye were located 67% of the time in flooded timber (Table 2). Open water was used 16% of the time. Five other types of shoreline structure comprised 15% of habitat selected. Standing timber preference may have been somewhat inflated since 78% of the tracked walleye were collected and tagged in flooded timber. These fish were fixed 76% (range = 45-100%) of the time in timber, while fish collected along other shoreline structures averaged 46% (range = 21-67%) of their fixes in timber. Weather conditions did not appear to affect habitat selection.

March was the only month when flooded timber was not the most frequented type of structure. Habitat selected in March was nearly equal for all three major types: standing timber, various shoreline structure, and open water (Figure 2). Many walleye were en route to spawning areas, staging, or moving randomly in March. On 11 March 1994, lake levels were approximately 3 m above normal pool. Six of the 16 walleye tracked that day were located in flooded shoreline. Flooded timber use was 82% during April and May and 65% in July-August (Figure 3). The migration and utilization of restricted, cool-oxygenated water in the lower end accounts for the reduction in flooded timber use during July and September. During the months of October through December, walleye inhabited similar habitat.

Walleye had a strong preference for occupying littoral areas while remaining in close proximity to the bottom (Table 3). Forty-seven percent of the fixes in April were within 10 m of the shoreline (Figure 4). As water temperatures increased in June, most walleye sought deeper, cooler water farther from shore, but returned when water temperatures began to cool in the fall.

Walleye typically chose water depths averaging 2.5-6.5 m and water temperatures of 18-20 C when DO was not limited (Figures 5-6). Depth selection was dependent on water temperature, DO content, water clarity, time of year, and presence of heavy cover. Temperature selection was most dependent on the availability of >4.0 mg/l DO during the summer months. Walleye were most often found at depths of <4.5 m during March-May. Walleye that were located in heavy cover or turbid water during these months were often <1.5 m in depth. Walleye responded to rising water temperatures in June by moving deeper to remain in cooler water (Figure 5). As the lake temperatures began to cool in September, walleye returned to shallower water until the lake destratified and became isothermal in late November. Depth selection varied more in December than any other month, averaging 6.2 m.

The upper end of the lake experienced anoxic conditions in the hypolimnion beginning in July. Walleye in this area remained near the thermocline or moved down lake to cooler water. This downstream movement during the summer created a shift in the general areas of the lake where walleye were concentrated (Figure 6). The epilimnion decreased in depth during July-September, forcing walleye into shallow water (Figure 7). The epilimnion began to expand in October, allowing walleye to move deeper and redistribute throughout the lake more evenly.

Diel movement was greatest during periods from dusk to shortly after dawn (Figure 8). The first 1.5-2.5 hour period after dusk was the most active period on 5-31-93 and 8-11-94 and the second most active period on 5-25-94 and 6-28-93. Nocturnal movement among individual fish varied from being continuous throughout the night to periods of heavy movement combined with resting or inactive stages. Movement was also random, with frequent directional and speed changes throughout the night. None of the walleye tracked during the two diurnal periods moved greater than 4 km from their daytime resting site, nor did any of them remain in the same location during the entire nocturnal period.

Little schooling behavior was observed during this study with the exception of February and March 1994. On March 19, 10 of the 16 walleye tracked were all within 3.2 km of each other near mid lake. Only 1 of the 10 fish were found in a school but this was a very unusual occurrence and it was the only time many of the tracked walleye were near mid lake. Walleye were again dispersed one week later. Tagged walleye were found to be in close proximity to each other on a number of occasions in flooded timber, but this was not considered to be schooling activity. Several timbered coves at Paintsville Lake were frequented heavily by numerous tagged walleye, while others never contained tagged walleye. Many of the timbered coves had specific sites that attracted walleye while the remaining cove was often never found to contain a tagged walleye. There was no observed characteristics that drew fish to a particular coves or specific locations within the coves.

DISCUSSION

Walleye home ranges at Paintsville Lake were all related to areas containing flooded timber. Ager (1976), Hall (1982), and Prophet (1989) found walleye establishing home ranges or activity areas. In addition, Einhouse (1981) found walleye occupying well defined home ranges most frequently within weedlines. Conversely, Fossum (1975) and Holt et al. (1977) did not find walleye establishing home ranges in systems lacking heavy cover. All home ranges in this study contained 1-4 specific activity areas that were visited at a much higher frequency. One activity area was near the lake's only weedbed, another was at the marina, and all others were in coves containing flooded timber. The lake's marina and boat docks were located over deep water which provided cover for some walleye. Home ranges were smaller than most observed by the previous authors, but this was likely due to the lack of continuity between timbered coves where home ranges were focused.

Four walleye abandoned their home range during the summer. Three of these fish moved down lake to areas containing cooler water. Interestingly, walleye 523 moved from the headwater region of the lake to the lower end in 1993 and 1994 when oxygenated water rose to 24 C, but returned as soon as water temperatures cooled to 24 C. This may reflect a preferred temperature of 24 C for some walleye at Paintsville Lake. Walleye 543 frequented the lower end periodically during summer. Walleye 663 moved from the headwater to mid lake only during the most critical summer period. Walleye 623 moved to the headwater during the summer. The only explanation proposed for this walleye moving to the warmer area of the lake during the summer is increased forage. A more abundant shad forage in the headwater is likely due to increased fertility. No other walleye were observed outside of their home range during the summer.

Walleye movement varied throughout the year, but was greatest during March and the fall months. Leeds (1990) suggested that increased activity in the fall and spring may be a result of lowered food availability. Increased foraging in the fall and March may also be a result of preparation for the winter and spawning. Many walleye made long excursions in March that were not related to chosen spawning sites, but may have been a result of a search for spawning sites. Most fall movement began immediately after destratification and decreased slightly in late November and December. As water temperatures rose in the summer, there was reduced movement, similar to Lake Bemidji (Holt et al. 1977), and a tendency to remain closer to activity areas.

Spawning activity for many walleye in this study was consistent with the observations of Parks and Kraii (1991). They reported walleye activity during the spawning season consisted of three stages: pre-staging, staging, and spawning. All five males exhibited this behavior with varying degrees; however, only four females were observed displaying these stages. Staging in close proximity to activity areas or staging between weekly tracking intervals may account for the discrepancies.

Site selection during the spawning period varied greatly. Paintsville Lake contains three small headwater streams, none of which contain adequate flows for spawning migrations. The only headwater stocking of walleye occurred in Open Fork (Figure 1). Spawning walleye were only tracked in the Paint Creek arm, which precludes imprinting from stocking locations as an influence for headwater spawning. Although large, relatively smooth bedrock can be found throughout Paintsville Lake, concentrations of shallow course substrate is virtually non-existent except for two areas of rip rap. The only other concentration of tagged walleye found during the spawning period was in the lower lake area along a rip-rapped bank of the boat landing/marina facility. The lake's heaviest wave action also occurs along this bank. The nearby rip-rapped dam, which does not experience much wave action, was not identified as a spawning site. Schultz (1992) hypothesized that walleye in Dale Hollow Lake were composed of discrete river-run and reservoir stocks based on differentiation in spawning areas. Walleye stocked at Paintsville lake originated from a variety of sources, which may have included both river and lake spawning populations.

Walleye were usually located in shallow water near the shoreline and typically within 1 m of the bottom during the day, when preferred water temperatures and adequate DO were available. Pitlo (1978) also found walleye preferred to be within 1 m of the bottom when not suspended in vegetation. Holt et al. (1977) said walleye preferred depths of <5 m in Lake Bemidji, Minnesota. Since walleye are photosensitive, Ryder (1977) noted that walleye reduced light intensities in shallow water by utilizing shelter. Walleye at Paintsville lake were located frequently in <5 m of water and many times at depths of <2 m during daytime periods in flooded timber. Summers (1981) reported walleye are often found on steeply sloping shoreline or structure, especially when vegetation is present. Ager (1976) found walleye in Center Hill Reservoir, Tennessee inhabited several different types of habitats. Walleye in this study most frequently utilized various shoreline structures along both steep slopes and dense cover. The utilization of heavy woody debris reduced light intensity and allowed for walleye to inhabit shallow water in Paintsville Lake. Walleye moved away from the shoreline and suspended most often in flooded timber during late summer when DO was better over deeper water. Many of these fish were located within 10 m of the timbers edge at the mouth of coves.

Although most monitoring was conducted during diurnal hours, the four 24-hour tracks agreed with other literature reports (Pitlo 1978; Prophet 1989; Einhouse 1981; Schultz 1992) showing increased movement at night. Nocturnal excursions were consistent with movement expected during feeding forays. All walleye tracked during these periods were found resting in timbered coves prior to dusk. There was an established pattern of activity consisting of three phases: departure of daytime resting area at or after dusk, aggressive movement sometimes interspersed with rest periods at night, and the return to a timbered cove during the night or shortly after dawn. Walleye tracked at night during June primarily stayed along the shoreline, while walleye tracked in August spent most of their time moving around in open water. This could be due to increased foraging on small shad in the summer.

Data from this study were used to improve walleye fishing success at Paintsville Lake. Various outlets were utilized to provide the angling public with information as the study was conducted. A summary report of the results was also made available following completion of the study. According to creel surveys, walleye harvest and catch rates dramatically increased from 1988 to 1994. Total harvest was 1,091 walleye (1.61 kg/ha) in 1994 compared to only 125 walleye (0.17 kg/ha) in 1988. Additional knowledge of walleye habits and locations along with increased fishing pressure were likely responsible for the increased walleye harvest rates. The identification of spawning areas also allowed for more efficient broodstock collection for the states hatchery.

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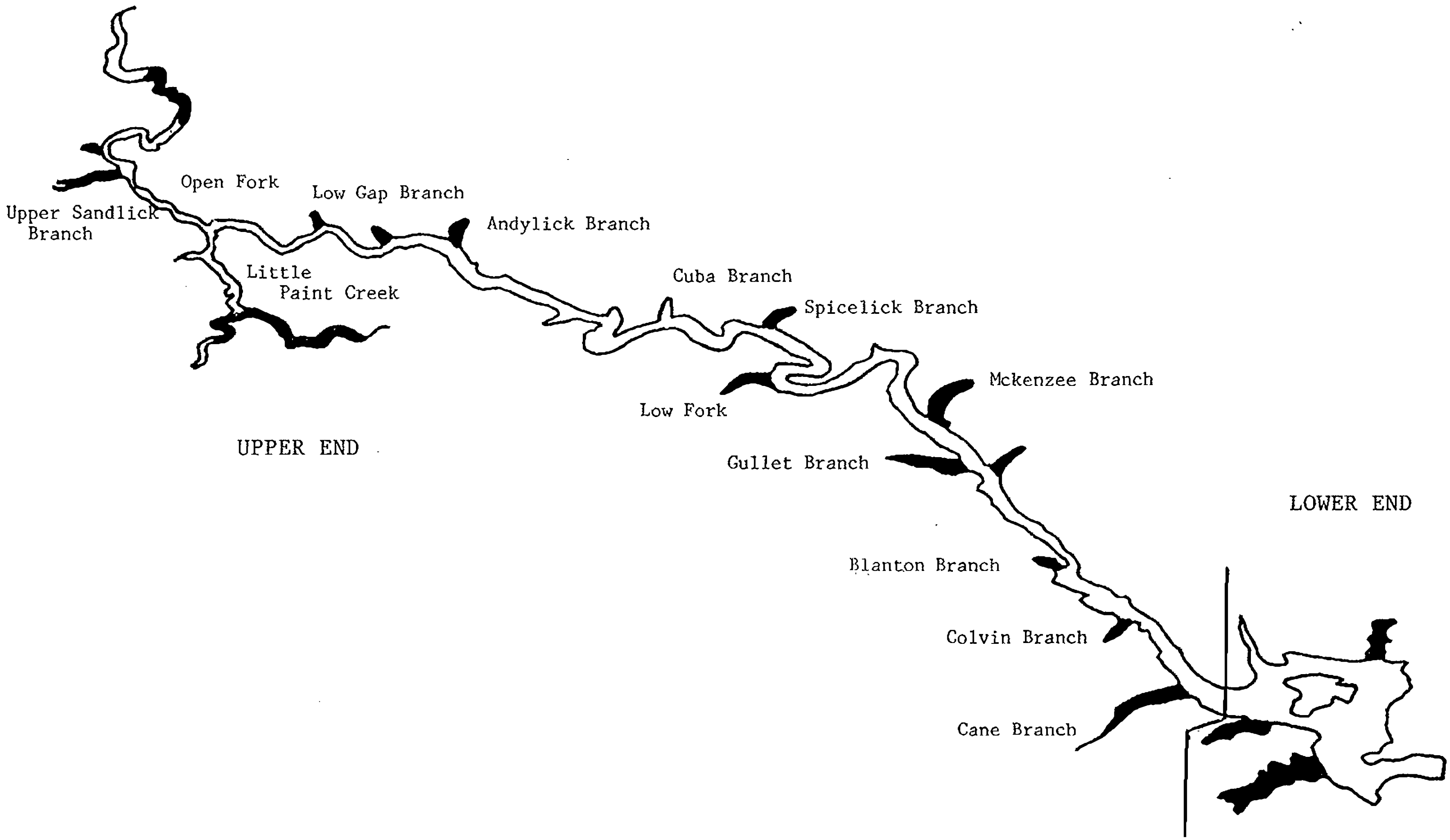

Figure 1. Shaded areas are coves in Paintsville Lake that contain standing timber.

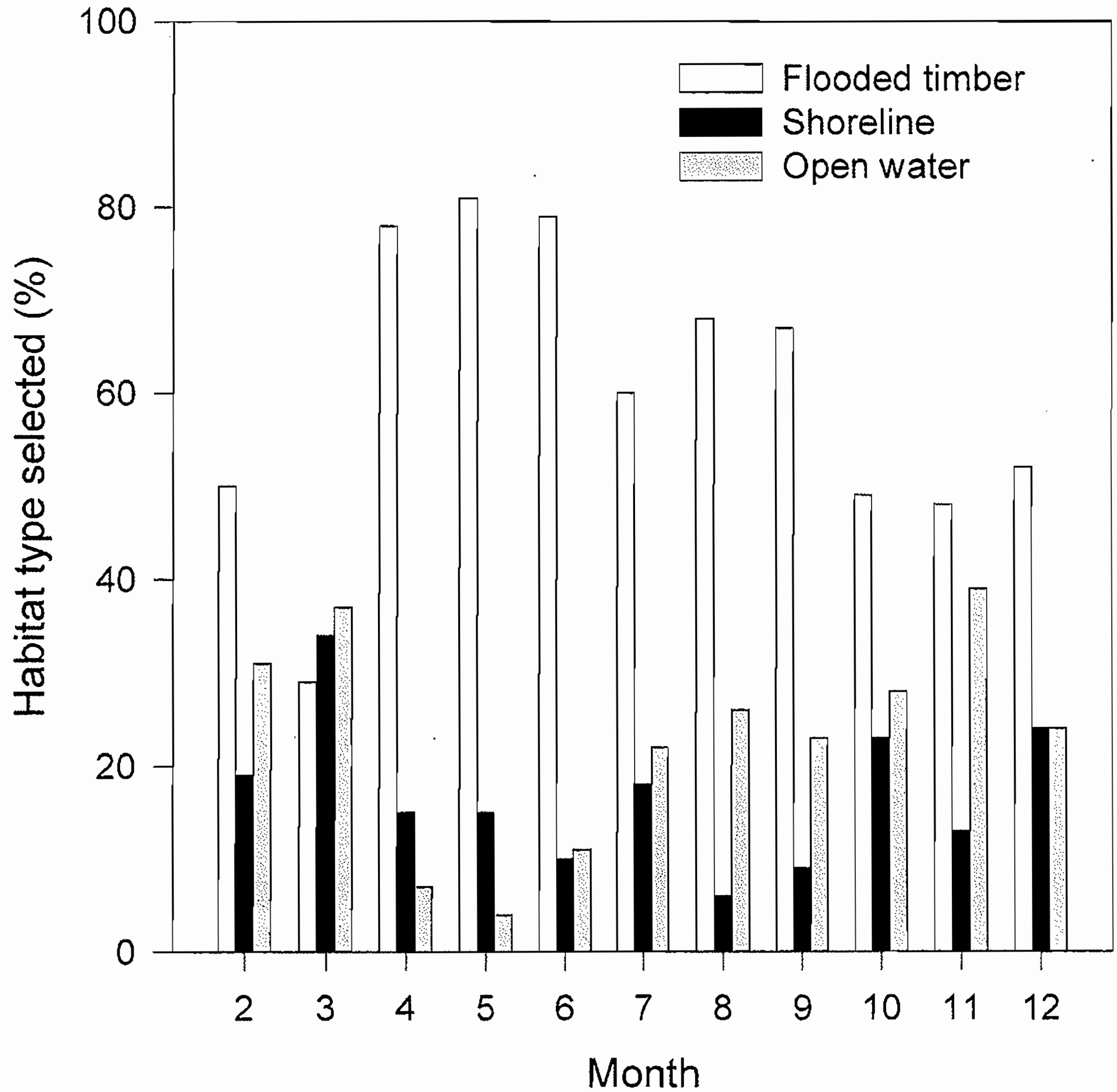

Figure 2. Walleye habitat selection during 1993 and 1994 diurnal tracking in Paintsville Lake for the months of February-December.

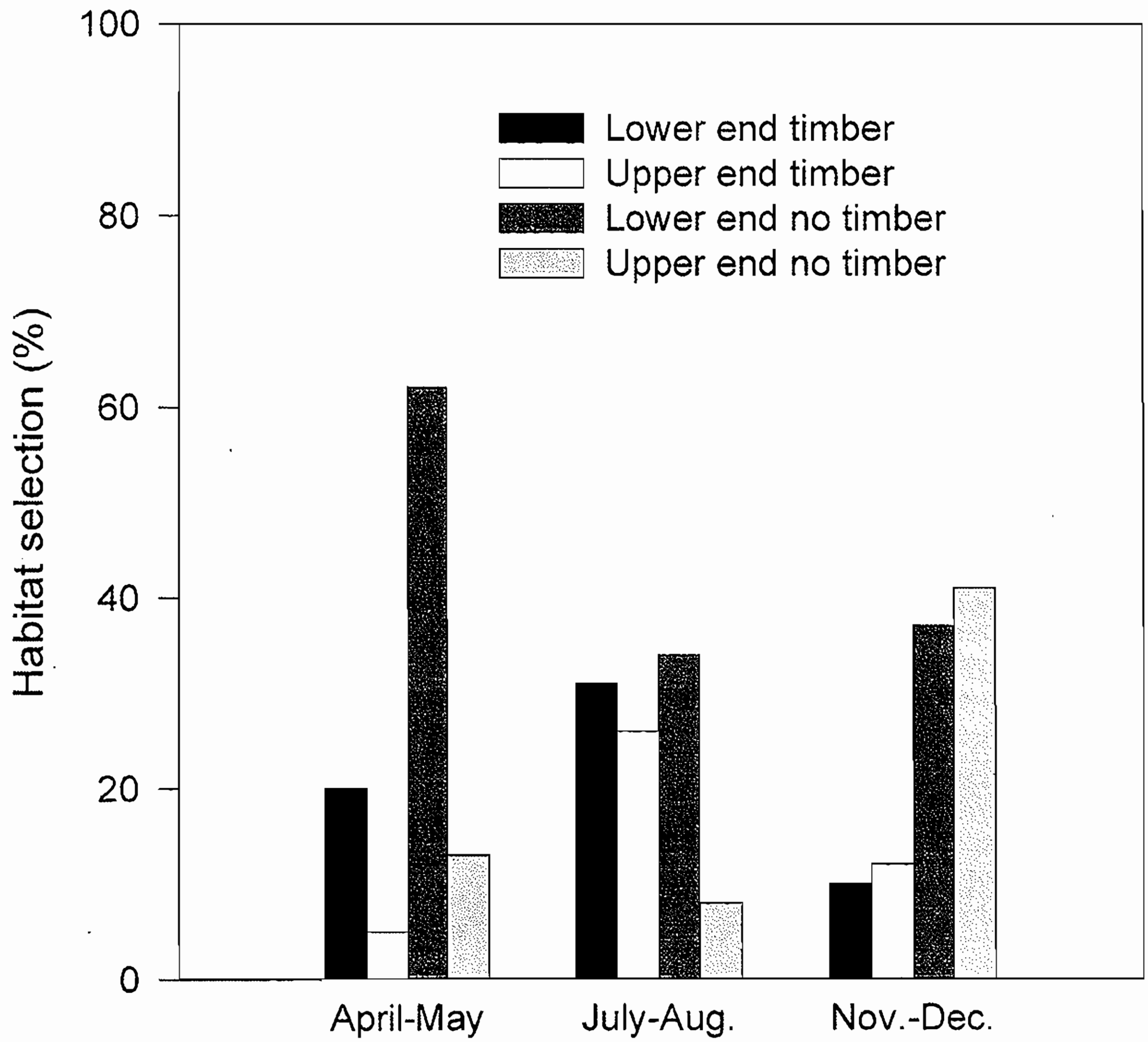

Figure 3. Walleye habitat selection during 1993 and 1994 diurnal tracking in Paintsville Lake by season.

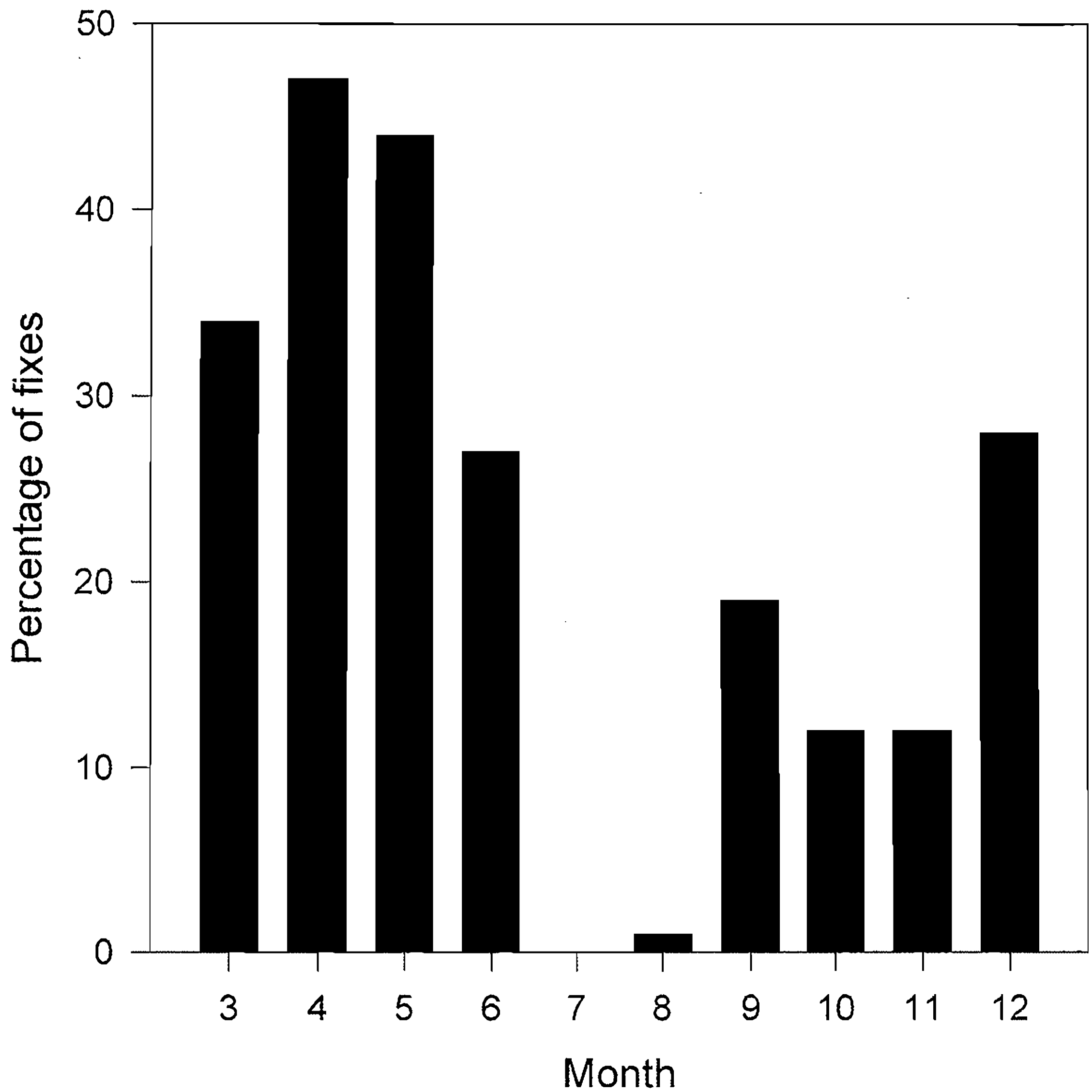

Figure 4. Percentage of walleye located within 10 m of the shoreline during diurnal tracking at Paintsville Lake in 1993 and 1994.

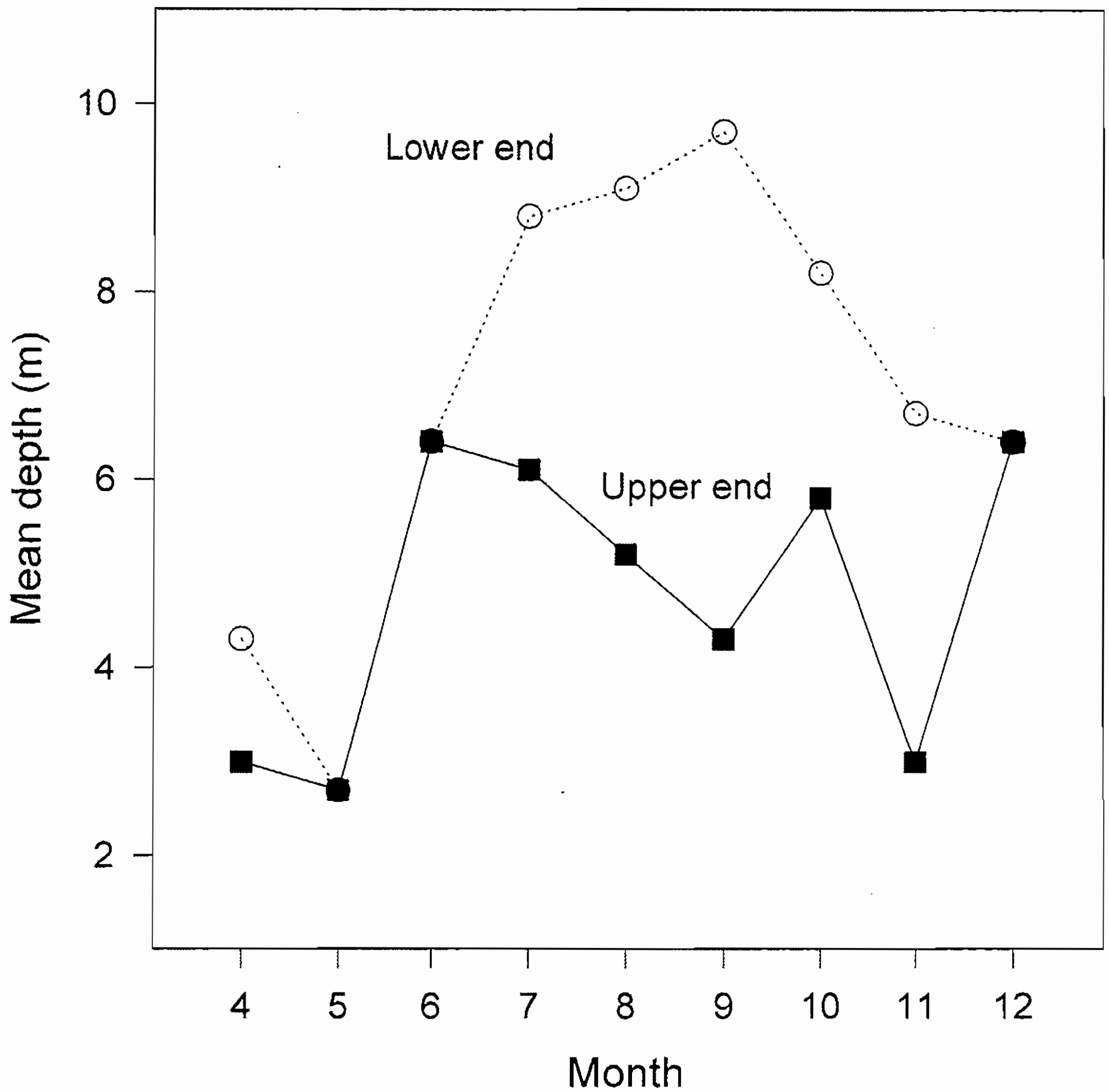

Figure 5. Mean depth selected by walleye during diurnal tracking in the lower and upper ends of Paintsville Lake from April-December 1993 and 1994.

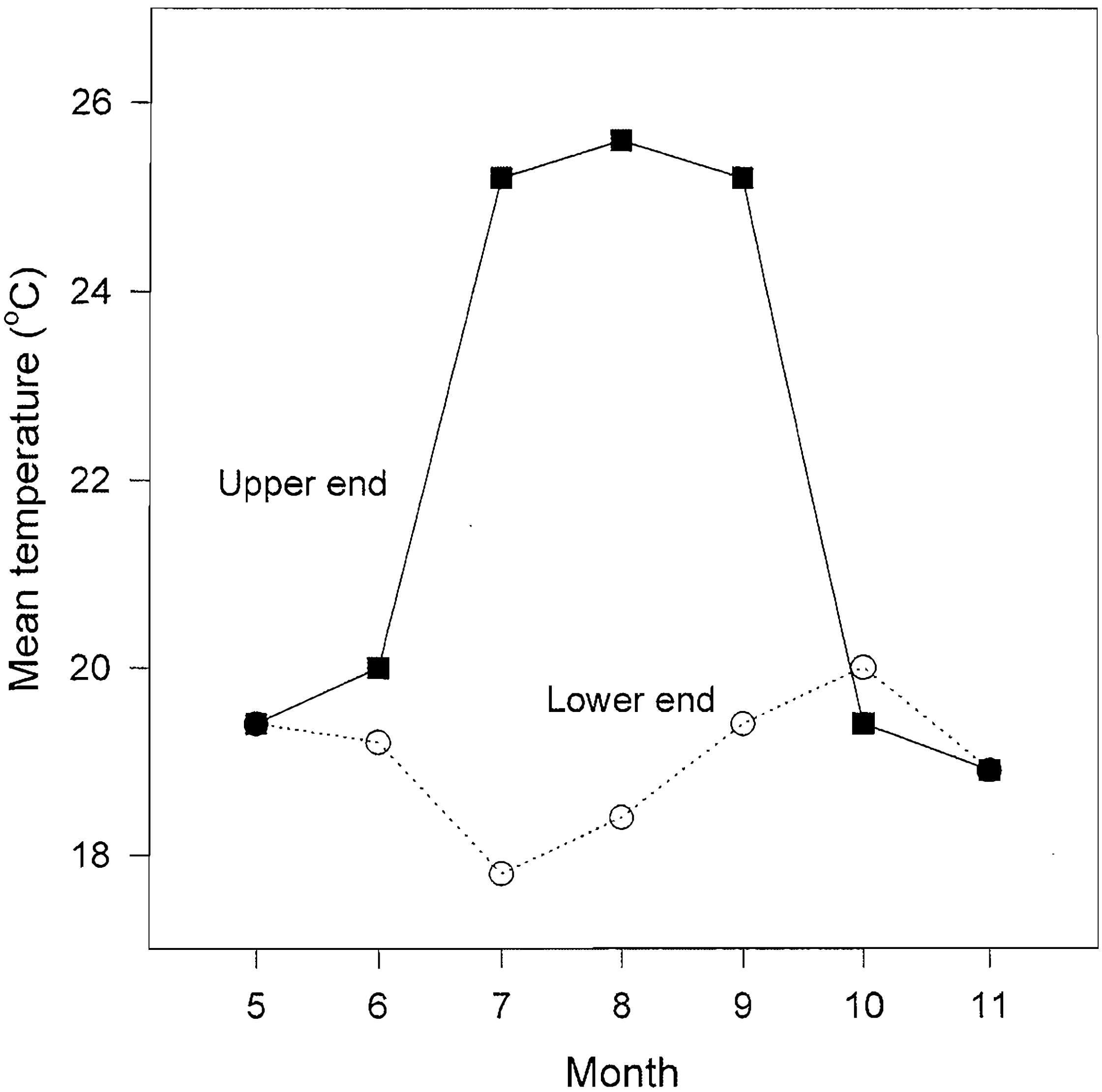

Figure 6. Mean temperature selected by walleye during diurnal tracking in the lower and upper ends of Paintsville Lake from May-November 1993 and 1994.

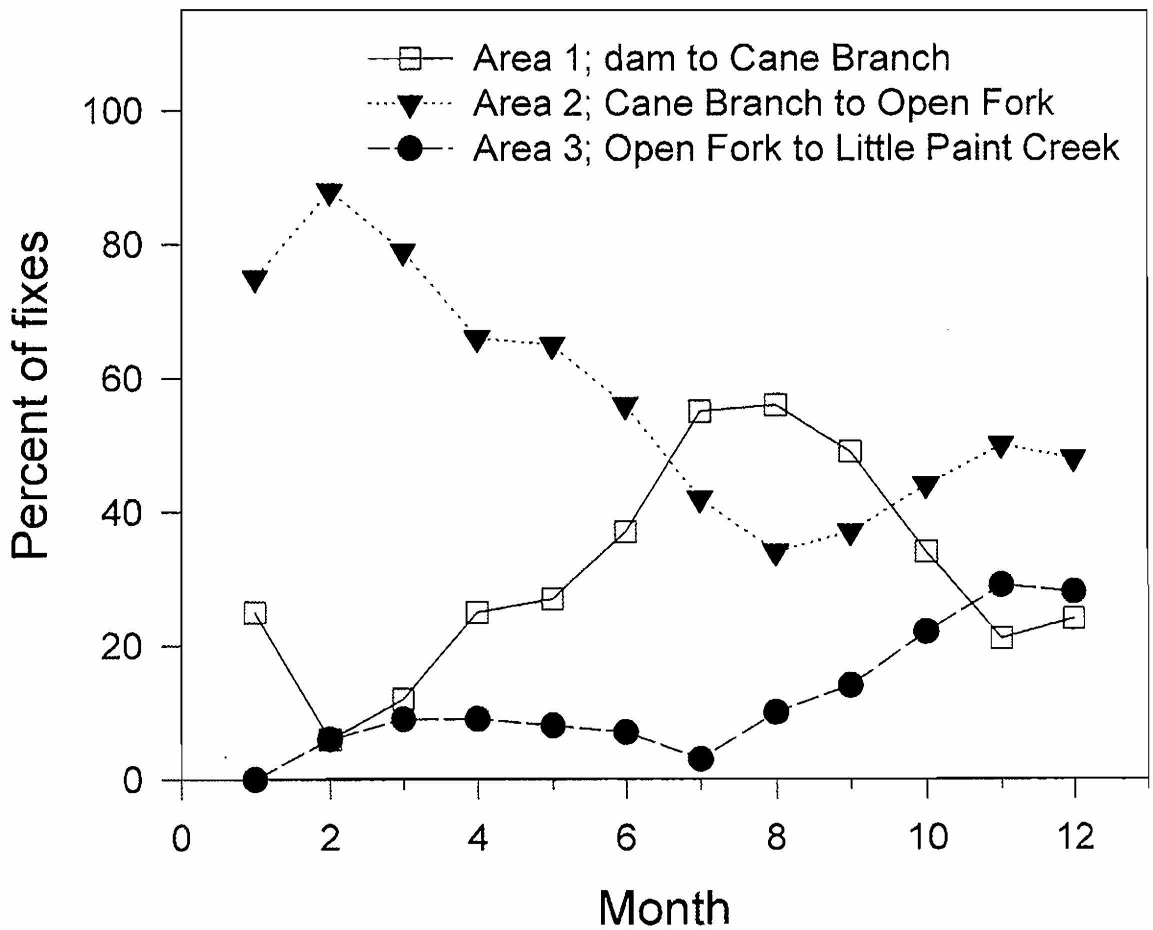

Figure 7. Percentage of walleye fixes in three lake areas during diurnal tracking at Paintsville Lake from April-December 1993 and 1994.

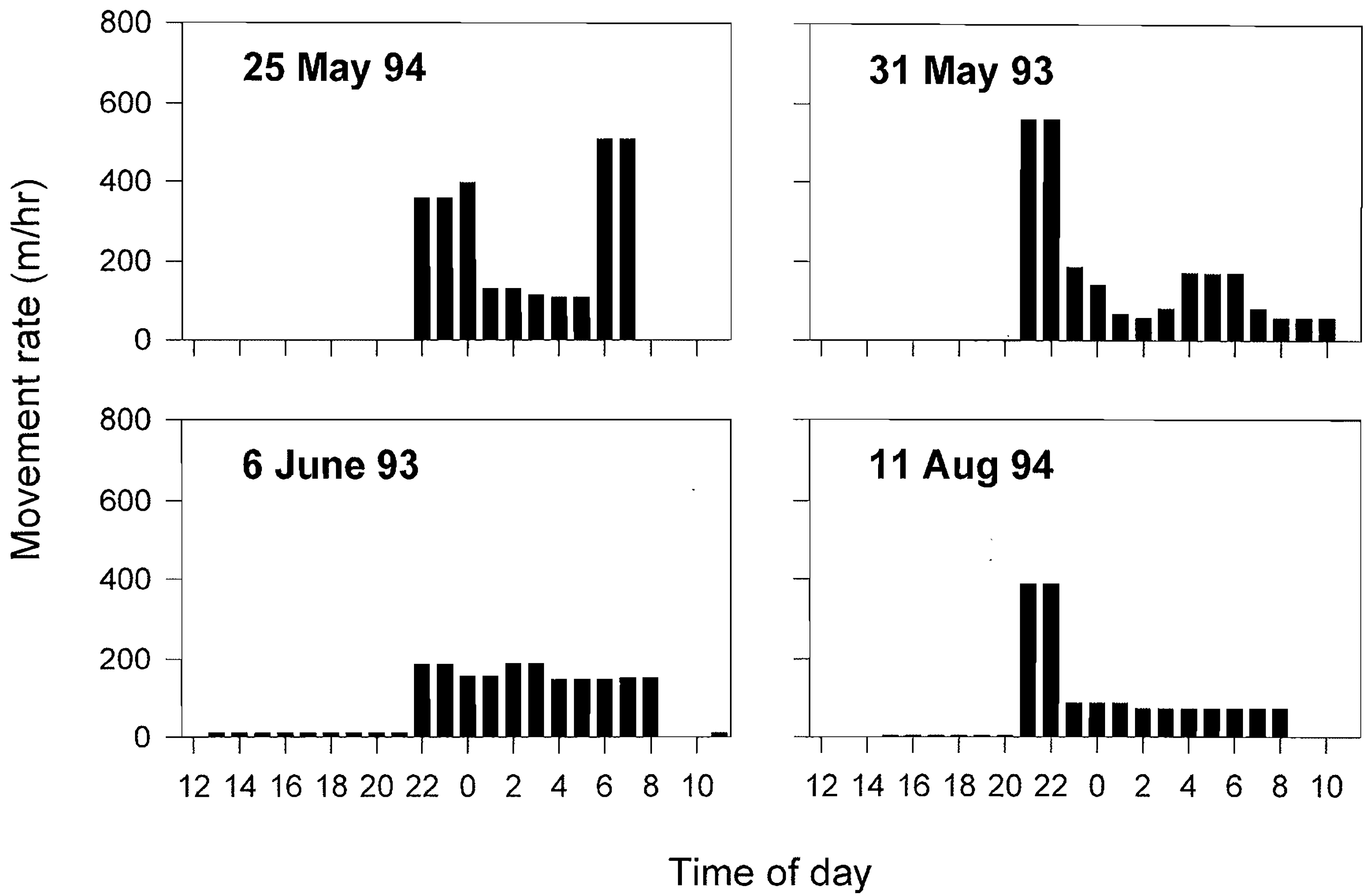

Figure 8. Mean movement rate for walleye tracked at Paintsville Lake.

Table 1. Tagging and tracking statistics for walleye implanted with radio transmitters in Paintsville Lake. Four walleye established winter (w) and summer (s) ranges as marked under Home Range.

Walleye ID #	Length (mm)	Weight (kg)	Sex	Date Tagged	Last Date Tracked	Home Range (ha)	Status
463	670	3.57	F	3-01-93	5-03-93	---	died
473	711	4.59	F	3-26-93	4-27-93	---	died
483	597	1.93	F*	3-26-93	1-20-93	48	
493	588	2.41	F	3-26-93	5-10-93	---	died
503	620	2.65	F	4-01-93	8-16-93	---	died
513	513	2.92	F	3-05-93	1-20-95	62	
523	655	2.52	F*	4-01-93	8-11-94	43w/63s	
533	619	1.98	F*	4-01-93	1-20-95	12	
543	718	4.82	F	4-01-93	8-11-94	44w/70s	
553	607	2.24	F*	4-01-93	1-20-95	49	
563	602	3.37	F*	4-01-93	4-19-93	---	missing
573	651	3.09	F	4-01-93	8-24-93	---	missing
583	613	2.17	F*	4-02-93	8-11-93	none	
593	716	3.60	F*	4-02-93	1-20-95	132	
603	722	4.59	F*	4-06-93	9-24-93	---	
613	572	1.67	F?	3-26-93	4-19-93	---	missing
623	565	1.59	F?	4-01-93	4-13-94	2.5w/20s	
633	574	1.56	F?	4-01-93	5-03-93	---	caught
643	488	1.70	F?	4-02-93	5-19-93	---	caught
653	534	1.50	F?	4-02-93	11-05-95	102	missing
663	573	1.62	M	4-06-93	3-11-94	39w/11s	
673	523	1.08	M	4-06-93	8-11-94	133	
683	501	1.16	M	4-06-93	5-11-94	41	
693	500	1.08	M	4-06-93	8-11-94	108	
703	516	1.39	M	3-01-93	9-24-93	5.5	died
473b	633	2.94	F	12-20-93	5-25-94	---	missing
603b	542	1.66	F	12-20-93	4-13-94	---	caught
613b	524	1.33	F	12-20-93	5-25-94	---	missing
633b	500	1.22	F	12-20-93	4-13-94	---	missing

F* = Females had spawned prior to transmitter implantation
F? = Suspected immature females

Table 2. Daytime habitat selection for walleye at Paintsville Lake from March 1993 through January 1995 (649 fixes).

Habitat Type	**Number of Fixes**	**%**
Flooded timber	438	67.5
Open water	105	16.2
Mud bank	24	3.7
Rock bank	23	3.5
Fallen trees	14	2.2
Marina/boat docks	10	1.5
Underwater ledge	9	1.4
Point	8	1.2
Rip rap	6	0.9
Miscellaneous structure*	12	1.8

*Miscellaneous structure includes: flooded shoreline (6), woody debris (2), brush piles (2), roadbed (1), and shallow flats (1)

note: 3-11-94 was the only tracking date when flooded shoreline was available. Pool levels were 3 m above normal pool; 6 of the 16 fish tracked were found on flooded shoreline.

Table 3. Walleye preference for being in close proximity to the lake bottom. If a walleye was thought to be using habitat that included the bottom the fish would be listed under the heading Bottom, if not it would be listed under Suspended. The numbers presented in the columns represent the total number of times a walleye was found in that habitat on that particular date. Only the locations that fish depths could be determined were used.

	Standing Timber		**No Standing Timber**	
Date	Bottom	Suspended	Bottom	Suspended
4-07-93	5	5	2	1
4-13-93	8	12	4	0
4-19-93	13	7	3	1
4-27-93	14	2	7	0
5-03-93	14	2	5	1
5-10-93	14	1	5	0
5-19-93	8	5	5	0
5-27-93	12	3	3	1
6-01-93	9	4	6	0
6-08-93	9	6	1	3
6-14-93	5	9	1	2
6-28-93	3	12	0	2
7-08-93	4	6	2	1
7-14-93	3	6	5	1
7-20-93	4	7	4	2
7-28-93	2	7	5	2
8-05-93	2	10	5	1
8-10-93	2	8	5	1
8-16-93	3	10	5	0
8-24-93	2	9	4	1
9-01-93	2	12	2	1
9-10-93	3	7	6	0
9-16-93	7	3	1	0
9-24-93	6	2	5	2
10-16-93	5	2	5	1
10-29-93	3	1	7	0
11-05-93	2	1	2	3
11-23-93	0	2	5	1
12-01-93	3	0	5	0
12-09-93	1	1	7	1
2-22-94	3	4	2	6
3-11-94	0	3	5	7
3-19-94	3	2	3	7
4-01-94	1	6	3	6
4-13-94	9	4	1	2
5-11-94	4	8	0	1
5-25-94	2	9	0	0