Over-winter Movements of Adult Largemouth Bass in a North Carolina Reservoir

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Abstract: Radio-telemetry was used to evaluate the movements of 11 adult largemouth bass (*Micropterus salmoides*) from November 1995 through May 1996. A significant offshore migration occurred during the day throughout much of the winter. Seasonally, fish shifted offshore during cold water temperatures; a significant inverse correlation existed between distance offshore and water temperature. During high water levels some fish moved inshore to use inundated terrestrial habitat, even at water temperatures as low as 6 C. Although fish tended to move less during colder weather, most fish remained active throughout the study; average movement between weekly tracking sessions was 298 m during the winter (17 Dec–20 Mar). Ten of 11 fish exhibited distinct home ranges, while 1 fish exhibited inter-embayment mobility and no home range. Four fish redistributed themselves to new home ranges in late fall, but returned to their prior home ranges by early spring. Permanent redistribution during the over-winter period was limited; dispersal occurred in only 1 fish.

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Movements of largemouth bass have been studied over a variety of seasonal conditions, aquatic environments, and life stages. Most studies have followed adult fish from the prespawn period through the fall of the year. Mark-recapture studies conducted during the over-winter period (Hasler and Wisby 1958, Moody 1960, Lewis and Flickinger 1967) were limited in the amount and type of movement information they could provide. Early bio-telemetry studies of largemouth bass were unable to monitor movements over the full annual cycle due to short transmitter life (Chappell 1974, Peterson 1975, Warden and Lorio 1975, Winter 1977) and most were conducted in small impoundments where movements were limited. As telemetry technology improved, studies tended to focus on high activity periods critical to biological success of the species, such as prespawn, spawn, and growth periods.

The over-winter period of reduced activity and slower metabolism has been studied. While several telemetry studies covering the fall through spring period have been conducted on the species in Florida (Mesing and Wicker 1986, Colle et al. 1989), little is known about the movements of largemouth bass during this period at more northern climates where seasonal changes are more dramatic and seasonal movements should be accentuated. It is the goal of this research to supplement the understanding of largemouth bass over the annual cycle. This study examines a relatively unstudied portion of the largemouth bass life cycle—mid-fall through the spring spawn.

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Methods

B. E. Jordan Lake is a 5,790-ha impoundment in the Piedmont area of North Carolina. Water temperatures typically range from the low 30s (C) to the single digits annually; ice cover during winter is rare. Water temperatures recorded during this study ranged from 20.4 C in late October to 5.5 C in late December, before warming to 21.5 C by late April. Normal pool level for Jordan Lake is 65.8 m above sea level; water levels over the study period ranged from 65.8 to 67.4 m above sea level.

The principal study area was the Little Beaver creek embayment of Jordan Lake. Maximum depth of Little Beaver Creek is 7 m. Cover is sparse in the embayment at normal pool consisting of infrequent occurrences of grass hummocks, vegetation, standing timber, small woody debris, tree roots, and undercut banks (Irwin 1994). Little Beaver Creek was the site of previous movement studies on fingerling largemouth bass (Copeland and Noble 1994) and the principal study area of a North Carolina State University comprehensive multi-year study on largemouth bass (Jackson et al. 1995).

All fish were collected from and, after being tagged, released in the Little Beaver Creek embayment. From 27 October through 20 November 1995, 11 fish ranging from 442 to 858 g and 329 to 400 mm TL (Table 1) were collected by electrofishing and surgically implanted with radio tags as described by Woodward (1996). Fish were implanted with tags and released on the day they were collected. All tagged fish were below the minimum length limit of 406 mm in order to reduce the likelihood of angler harvest. Tags varied in weight from 8.0 to 8.5 g in air (Model FSM-5, Lotek Eng., Ontario, Can.). These transmitted 150.345–150.877 MHz at 43–46 pulses/minute. Implanted fish were allowed 1 week to recover before tracking began.

Fish were located with a 4-element, mast-mounted yagi antenna used for scanning and a 3-element, hand-held yagi antenna for specific location. After a fish was detected, its location was established by triangulation. A blind study using 5 tags hidden in Jordan Lake verified that tags could be consistently located to within 1 m.

Table 1. Size distribution and tracking information for adult largemouth bass in Jordan Lake, North Carolina.

Fish no.	Weight (g)	TL (mm)	Observations/ attempts	Tagging date	Last observation
1	782	386	29/29	30 Oct 95	8 May 96
2	555	358	28/30	27 Oct 95	8 May 96
3	590	380	30/30	27 Oct 95	8 May 96
4	555	356	30/30	27 Oct 95	8 May 96
5	790	395	26/30	27 Oct 95	8 May 96
6	794	400	29/29	6 Nov 95	8 May 96
7	817	389	29/29	30 Oct 95	8 May 96
8	858	395	27/30	27 Oct 95	22 Apr 96
9	442	329	28/29	30 Oct 95	8 May 96
10	571	352	29/29	6 Nov 95	8 May 96
11	581	373	27/27	20 Nov 95	8 May 96

The 11 adult largemouth bass were radio-tracked from November 1995 through early May 1996. Three tracking periods were established—0600 to 1200 hours, 1201 to 1800 hours, and 1801 to 2400 hours, and time periods were chosen at random. With consideration of the danger of winter night-time conditions, tracking was not conducted from 0000 to 0600 hours. Attempts to find all fish were conducted on a weekly basis, except during April 1996 when fish were tracked twice/week to determine spawning activity. Locations of fish were recorded in the field on a fish-specific map. The convex polygon method was used to calculate home range size (Winter 1977). Weekly data were supplemented with 2 diel studies. Diel patterns were evaluated by tracking 4–5 fish, locating each fish once every 4–5 hours over a 24-hour period. The same fish were tracked during both diel studies; however, the second diel study included 1 additional fish.

All statistical tests were conducted using non-parametric techniques. Diel shift inshore-offshore was examined by fitting a quadratic equation to all data points of fish locations, organized by time of day and distance offshore. Relationships between variables were examined by linear correlation tests and included the following: home range size to fish body weight; average distance moved to body weight, water temperature, amount of water release at the dam and lake level; and average distance offshore to water temperature, body weight, water release at dam and lake level. A significance level of $P < 0.05$ was established for all tests.

Surface water temperature was obtained once during each tracking period at a standard location inside the Little Beaver Creek embayment. Water level data were obtained from the U.S. Army Corps of Engineers.

Results

Data collection was highly successful, as fish were located 97% of the time (Table 1). Ten of the 11 fish were tracked through completion of the study. Only the signal of 1 fish was lost in late April, near the end of the study. The fate of this fish was undetermined, as this disappearance coincided with time of potential spawning migrations, return of migratory avian predators, increased angling pressure, and the expected expiration of the tag's battery.

Despite a minimum length limit of 406 mm, fish no. 5 was discovered in an angler's creel on 12 December. The fish, which had been detained for approximately 30 minutes, was released unharmed upon request. The fish appeared healthy when released and was tracked through the completion of the study.

No direct observation of fish spawning occurred. Gonadal analysis of fish collected during the spawning season in April 1995 indicated that both sexes of the sizes implanted were mature. During tracking from late March to early May, 5 fish exhibited a lack of movement characteristic of male spawning behavior. Largemouth bass spawn during April and May in Little Beaver Creek, with peak spawning occurring from 15 April to 15 May (Phillips 1994).

Diel Movements

A diel study of 4 fish conducted on 21 November 1995 indicated that largemouth bass exhibit a shift offshore during the middle of the day (Fig. 1). A diel study of 5 fish on 5 March 1996 indicated that fish were no longer making such a shift and remained near shore throughout the day (Fig. 1). Weekly tracking data (recorded between 1000 and 2400 hours) from 21 November 1995 through 18 February 1996 confirmed that fish tended to be further from shore at midday (Fig. 1). A quadratic equation fit to these weekly data points of distances offshore relative to time, indicated a significant diel shift ($R^2 = 0.42$, 127 *df*). Based on data collected weekly, fish were an average of 25 m offshore during the morning, 40 m during the afternoon, and 10 m during the evening.

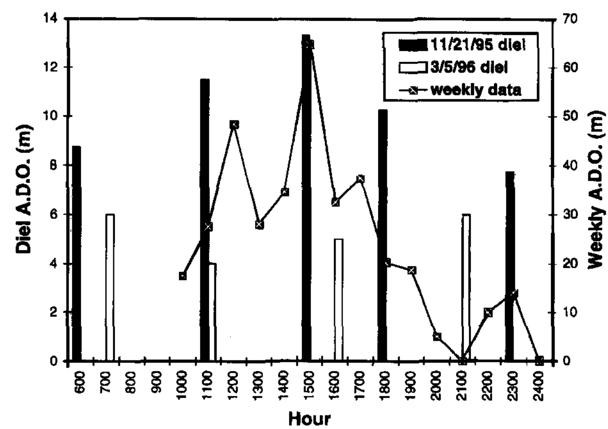

Figure 1. Average distance offshore (ADO) in meters, relative to time of day, for Jordan Lake largemouth bass; includes data from diel studies on 21 November 1995 and 5 March 1996 as well as data collected by weekly tracking during the period from 21 November 1995 through 18 February 1996.

Long-term Movements

Three distinct long-term patterns were exhibited by fish in this study—1) singular home range; 2) multiple home ranges; and 3) mobile pattern with no identifiable home range. Ten of 11 fish exhibited ≥1 defined home range (Table 2).

Multiple home ranges occurred in 4 fish (Table 2). This pattern consisted of a shift from an initial home range to a winter home range, and a subsequent return to the initial home range. Initial home range was the home range utilized by fish during late fall and, in the case of fish with multiple home ranges, was reoccupied in late winter through spring. Winter home range shifts were toward larger portions of the impoundment and deeper water. These shifts were over substantial distance, ranging from 400 to 1,500 m.

Two fish (no. 1 and no. 5) appeared to have multiple shifts in home areas. These fish exhibited an initial home range, a winter home range, and an apparent spawning home area. Both fish returned from winter home ranges to their initial home ranges when water temperature rose in late winter and then moved into spawning areas, where they spent >1 month. These apparent spawning migrations were approximately 1.1 km and 5.5 km for fish no. 1 and no. 5, respectively. Fish no. 1 returned to its initial home range after spawning activity. Fish no. 5 had not returned, but was moving in the direction of its initial home range in mid-May when its tag battery expired.

Of the remaining fish, only no. 2 was observed making an apparent spawning migration. This fish had migrated 1.7 km, from its home range near the mouth of Little Beaver Creek to the back of Little Beaver Creek on 27 February. The fish had returned to its earlier home range by 29 March, where it remained at the end of the study.

Table 2. Movement patterns and home range (h.r.) sizes of adult largemouth bass in B. E. Jordan Lake, North Carolina, 15 November 1995–8 May 1996.

Fish no.	Type of movement pattern	Initial home range (ha)	Initial home range (m)[a]	Winter home range (ha)	Winter home range (m)[a]
1	Multiple h.r.	0.55			340
2	Singe h.r.	7.83			
3	Single h.r.	0.88			
4	Multiple h.r.	0.26		2.35	
5	Multiple h.r.		750		1,210
6	Multiple h.r.	3.71		na[b]	
7	Single h.r.		827		
8	Single h.r.	2.43			
9	Mobile				
10	Single h.r.	0.78			
11	Single h.r.[c]	0.46		<0.01[c]	

a. These home ranges were linear and best measured in length, not area.

b. Insufficient number of data points to calculate home range.

c. Fish remained in initial home range, but reduced movement.

Initial home ranges ranged from 0.26 to 7.83 ha and averaged 2.11 ha. Winter home ranges varied from < 0.01 to 2.35 ha. Two initial and 2 winter home ranges were along shorelines and best measured in terms of length rather than area (Table 2). Winter data points were included in initial home range calculations when fish did not exhibit a separate winter home range and where the initial home range was the only home range exhibited. Home range size was not significantly correlated with body weight.

The home range estimate of < 0.01 ha was for fish no. 11, which exhibited no detectable movement from mid-December through early March, even though tag locations were detectable to within 1 m. This winter home range consisted of a single position within its initial home range and not a shift to a new area as was the case in other fish with winter home ranges. This fish remained within its initial home range at all times; however, the fish again exhibited movement from early March through the end of the study.

Although fish generally moved less during the winter, absence of movement was the exception (Fig. 2). Fish moved an average of 298 m weekly during the period of 17 December 1995 to 20 March 1996; movement was 253 m when calculated only for fish exhibiting home ranges (i.e., without fish no. 9). Fish no. 9, the only fish to be classified as mobile, did not establish a home range; it moved an average of 740 m weekly during the same period, and an average of 849 m weekly over the duration of the study. Average distances moved by all fish were not significantly correlated with fish body weight, water temperature, water release at dam, or lake level.

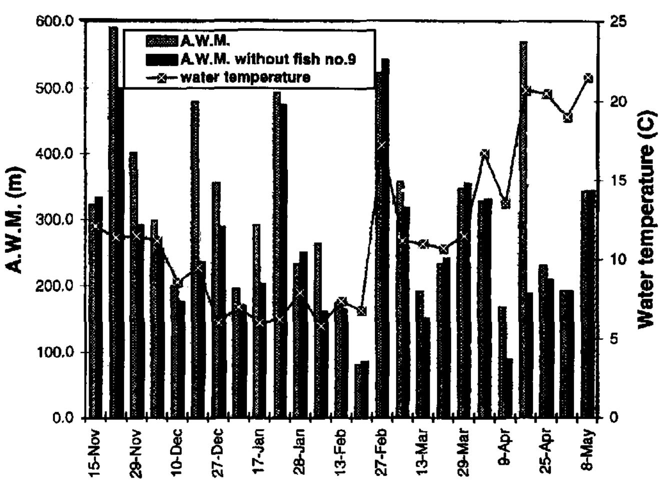

Figure 2. Average weekly movement (AWM) of Jordan Lake largemouth bass and water temperatures from 15 November 1995 through 8 May 1996 (with and without mobile fish no. 9).

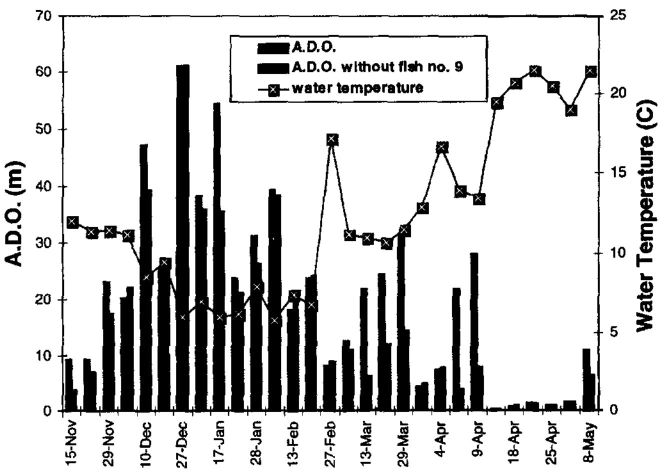

Figure 3. Average distance offshore (ADO) of Jordan Lake largemouth bass and water temperatures from 15 November 1995 through 8 May 1996 (with and without mobile fish no. 9).

Fish exhibited a winter shift offshore followed by a dramatic shift towards shore as water warmed in late winter (Fig. 3). A significant negative correlation existed between water temperature and average distance offshore (ADO). Mobile fish no. 9 tended to remain further offshore than fish with established home ranges. However, fish no. 9 moved near shore for approximately 3 weeks during spawning season in April, resulting in similar ADO calculated with and without fish no. 9 (Fig. 3). ADO was not significantly correlated with body weight, water release at dam, or lake level.

Fish moved into newly-flooded areas during periods of high water. High water periods were considered to be times at which the lake was > 0.15 m above normal pool, resulting in inundation of shoreline bushes and trees. Utilization of inundated areas occurred both day and night. Generally, at higher water levels, more fish moved into newly flooded areas. These movements occurred at temperatures as low as 6.2 C. However, only 4.5% of fish locations were in newly inundated areas during periods of high water from 1 December through 20 January, suggesting seasonality. In contrast, during high water periods before 1 December and after 20 January, 19.6% of fish locations were in inundated areas.

Although movements took 7 of 11 fish outside of Little Beaver Creek at some time during the study, little permanent dispersal occurred. Fish no. 5 left Little Beaver Creek immediately after tagging and established a home range in another area of the reservoir, which suggests that this fish was on an excursion from its existing home range when captured and tagged in Little Beaver Creek. Of the other 10 adults, 9 remained in Little Beaver Creek at the end of the study. No significant correlation existed between fish weight and the distance fish ultimately moved from their initial location.

Discussion

This research is one of the few studies which has monitored adult largemouth bass winter movements and the only known study to do so with wild adults at a latitude so far north. This study, in conjunction with previous research, strongly indicates that adult largemouth bass tend to exhibit long-term site fidelity and little dispersal.

Early mark-recapture studies suggested that largemouth bass exhibit fidelity to specific areas (Hasler and Wisby 1958, Lewis and Flickinger 1967). Numerous biotelemetry studies have since measured home ranges, finding a large degree of variability among individuals. Adult largemouth bass in Jordan Lake also exhibited site-fidelity, with 10 of 11 fish exhibiting ≥ 1 specific home range, which varied from < 0.01 to 7.83 ha. By comparison, Florida largemouth bass (*M. s. floridanus*) exhibited home ranges of 0.6 to 39.5 ha. in Lake Baldwin, Florida, through the same segment of the year (Colle et al. 1989). The smaller home ranges of Jordan Lake fish may be due in part to colder weather encountered in North Carolina.

One Jordan Lake largemouth bass exhibited no detectable movement (home range < 0.01 ha) from early January through the end of March. Fish no. 11 spent this period under tree roots on the edge of an undercut bank. Warden and Lorie (1975) observed that 2 largemouth bass lacked movement during the period from late-November and mid-January in Mississippi. However, due to tag life in their study, their fish were monitored for < 3 weeks each. Woodwood (1996) observed a healthy sub-adult largemouth bass to cease movement for 4 months from November through April. Although movement of fish over a winter home range seems to typify largemouth bass behavior during winter, individual choices are likely made on the basis of energetics, cover, or other factors.

Earlier studies have reported that largemouth bass exhibit winter migrations characterized by fish shifting offshore during the winter and returning when water temperature warms (Hasler and Wisby 1958, Lewis and Flickinger 1967, Betsill et al. 1986). While Jordan Lake fish shifted offshore during the winter and returned in the spring (Fig. 3), 4 of 11 also redistributed themselves within the reservoir during the cold weather period. Unlike fish in previous studies, these 4 fish did not simply shift offshore, but established entirely new home ranges in late fall and returned to previous home ranges by early spring. This behavior has only been observed previously in sub-adult largemouth bass (Woodward 1996).

Inter-embayment mobility exhibited by 1 of 11 Jordan Lake fish supports earlier research that suggests mobile segments exist within some largemouth bass populations (Hasler and Wisby 1958, Moody 1960, Wanjala et al. 1986, Woodward 1996). Early mark-recapture studies (Hasler and Wisby 1958, Moody 1960) suggested that mobility may be related to fish size, with small to intermediate fish being most mobile. Echo-sound location also indicated intermediate-sized fish (250–380 mm) are most mobile (Wanjala et al. 1986). Aside from 1 recent study on intermediate-sized, sub-adult largemouth bass (Woodward 1996), such mobility has not been observed in telemetered largemouth bass. The Jordan Lake adult which displayed such mobility was only 329 mm, the smallest fish in the study (Table 1). The reason that inter-embayment mobility has not been observed in most telemetry studies may be that tags have been too large for intermediate-sized fish until recently.

Movement into newly inundated areas by Jordan Lake largemouth bass, coupled with the fact that 1 fish used shoreline cover as a sedentary winter home, suggests an importance of cover, even during the over-winter period. The embayment is characterized by sparse amounts of cover at normal pool (Irwin 1994) and an abundance of terrestrial vegetation (primarily trees and shrubs) which grows just above normal pool elevation, resulting in a drastic relative increase in cover at high water levels. In contrast, Warden and Lorio (1975) did not observe largemouth bass utilization of newly inundated areas when water levels were above normal pool level in Loakfoma Lake, Mississippi, perhaps due to the difference in the relative increase of cover created at water levels above normal pool.

Although the movements of some adult largemouth bass result in a temporary redistribution, it does not appear that much, if any, dispersal occurs during the winter period. Fish in this study which shifted home ranges in the winter, returned to their previous home ranges by early spring. This return to earlier home ranges suggests strong site fidelity.

Spawning migrations by largemouth bass appear to be true migrations and not dispersal. As in Jordan Lake, previous studies have suggested that fish return to prior home ranges, even after spawning migrations up to 3 km (Mesing and Wicker 1986, Nack et al. 1993). The fact that tag batteries expired near the end of the spawning period adds uncertainty to whether all Jordan Lake fish returned to earlier home ranges, but all evidence suggested that they did.

Large-scale mobility, as displayed by fish no. 9, may result in dispersal for an apparently small portion of the population. This mobility appears to occur in some intermediate-sized fish, from sub-adult through early adulthood, and seems to lessen as fish grow larger. Although tag life limited extended study, the possibility does exist that mobile fish may later develop home ranges in areas distant from their hatching sites resulting in dispersal. This dispersal may be important in maintaining genetic heterogeneity for the reservoir population. However, the general lack of dispersal during the over-winter period, coupled with well-defined summer home ranges indicated by other studies, suggests that largemouth bass exhibit site fidelity throughout the year. If site fidelity is long-term, the potential exists for life-long, management of largemouth bass at a smaller spatial scale than lake-wide.

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