BELEWS LAKE LARGEMOUTH BASS SURVEY, 2007–2009

FINAL REPORT

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Abstract.—Boat–mounted electrofishing gear was used to sample largemouth bass *Micropterus salmoides* in Belews Lake during April of 2007, 2008, and 2009. Belews Lake, a cooling water reservoir located primarily in Stokes County, N.C., is comprised of two distinct thermal areas. The uplake area of the reservoir maintains ambient water temperatures, while the downlake area is significantly affected by heated effluent. Catch rates of largemouth bass ranged from 38 to 43 fish per hour during the survey period. Size distributions each year were dominated by fish < 400 mm in total length, with very few fish > 500 mm being collected. Stock indices declined steadily during the survey period, with PSD decreasing from 73 to 59 and RSD-P decreasing from 33 to 23. Relative weights were generally low, ranging from 83–89 during the survey period, with condition being slightly higher in uplake areas with ambient water temperatures (Wr=89) than in downlake areas with elevated water temperatures (Wr=85). Largemouth bass ranged in age from 1–10, although few older fish were present. Overall, 67% of fish collected were ≤ 2 years old, with proportions of younger fish being higher in downlake areas than in uplake areas. Total annual mortality (A) was estimated to be 43%. Growth rates were faster in downlake areas than in uplake areas, with fish in downlake areas being among the fastest growing in the state for ages 1–5. Despite the high growth rates exhibited by bass in the downlake areas of Belews Lake, the overall size structure is below average in comparison to most N.C. reservoirs due to poor survival.

Belews Lake is a 1,631 ha-impoundment of Belews, East Belews, and West Belews Creeks, northwest of Winston-Salem, N.C. The Belews Creek drainage empties into the Dan River in Stokes County, where most of Belews Lake is located, although the reservoir also stretches into Rockingham, Forsyth, and Guilford Counties. Impounded by Duke Energy in 1973 to provide cooling water for the Belews Creek Steam Station, the lake has an average depth of 15 m with a maximum depth of 44 m (NCDENR 2010). The reservoir is classified as being oligotrophic, with secchi depths of 3–5 m within the main body of the reservoir (NCDENR 2010). Owing to the small volume of water contributed by the Belews Creek drainage in relation to the total volume of the reservoir, retention time is 4.1 years (NCDENR 2010). The upper end of the reservoir adjacent to and south of N.C. Highway 65 maintains ambient water temperatures, higher productivity levels, and lower water clarities than the lower end of the lake north of N.C. Highway 65, which displays elevated water temperatures year-round due to the heated effluent it receives from the steam station (Figure 1). Severe declines in the Belews Lake fish community were documented between 1976 and 1985 due to the release of selenium into the lake via ash basin effluent (Cumbie and VanHorn 1978; Olmsted et al. 1986). Subsequent to operational changes that eliminated the discharge of ash basin effluent into the lake, the fish community has recovered and there are no longer any fish health advisories in effect for the reservoir (Duke Power 2006), aside from state-wide advisories covering fish species with high mercury levels (NCDHHS 2011).

Although regular monitoring of the overall fish community is conducted by Duke Energy fisheries biologists, few targeted sportfish surveys by N.C. Wildlife Resources Commission (WRC) staff have been conducted on Belews Lake. The most popular sportfisheries in Belews Lake include largemouth bass (*Micropterus salmoides*), crappie (*Pomoxis* spp.), and sunfish (*Lepomis* spp.), along with an emerging fishery for the newly-introduced flathead catfish (*Pylodictis olivaris*). WRC staff assisted Duke Power staff with fish community assessments in 1999 to gather cursory data on the largemouth bass population, and an additional low-intensity bass sample was conducted by WRC staff in 2002, both of which were summarized in 2004 (Hodges 2004). Due to concerns about gear avoidance due to the extreme water clarities in the main body of Belews Lake, WRC staff conducted a comparison of daytime and nighttime electrofishing in 2004 to determine which period would produce optimal results (Hining 2004). 1

This report summarizes the findings of a three-year survey conducted between 2007 and 2009 to provide updated data on the relative abundance, size structure, condition, age structure, and growth rates of the Belews Lake largemouth bass population.

Methods

Boat-mounted electrofishing gear was used to collect largemouth bass from fixed transects throughout Belews Lake during daylight hours in late April 2007, 2008, and 2009. All transects were 300 m in length and were evenly distributed throughout the lake, with sites being selected in both uplake (adjacent to or south of N.C. Highway 65) and downlake (north of N.C. Highway 65) regions to account for the potential effects of the differences in water clarity, productivity, and temperature on the largemouth bass population (Figure 1). Individual sites were subjectively selected on the basis of containing habitat favored by bass. Although using subjectively-selected sites has the potential to overestimate true population density estimates and stock index values (Hubbard and Miranda 1986) this sampling scheme was chosen to minimize the effort needed to collect usable numbers of fish, given that Belews Lake is known to be relatively unproductive with low bass densities. Twelve sites were sampled in 2007, with 14 sites being sampled in 2008 and 2009 after insufficient numbers of bass were collected during the 2007 survey. Electrofishing settings of 1000 V, 4 A, and 120 pulses per second (pps) were used throughout the study. All bass collected were measured for total length (mm) and weight (g). Catch per unit effort (CPUE) was indexed as the number of bass collected per hour of electrofishing time. Length distribution histograms were constructed and stock indices were calculated. The lengths for stock (200 mm), quality (300 mm), preferred (380 mm), and memorable (510 mm) sized largemouth bass used in determining stock index values were those proposed by Gabelhouse (1984). Relative weights were computed using the equation of Wege and Anderson (1978).

Sagittal otoliths were removed from all largemouth bass kept for age determination. In 2007 and 2008, all bass were kept for age determination. In 2009, sampling time was limited due to personnel scheduling issues and otoliths could only be removed from a sub-sample of bass. Otoliths from fish ≤ 3 years old were submerged in a shallow dish of water and read in whole view using a dissecting microscope. For fish > 3 years old, otoliths were prepared for reading by breaking them in half perpendicular to their longest axis and polishing the broken end using 320–400 grit sandpaper. The otolith section was then submerged in a shallow dish of water, with the unbroken end embedded in a layer of clay lining the bottom of the dish. The otolith section was illuminated from the side with a fiber optic light and read under a dissecting microscope. Otoliths were read independently by two readers, and discrepancies in annuli counts between readers were rectified at a joint reading. No age was assigned in situations where discrepancies could not be rectified after a joint reading.

The reported age of the fish in this survey is not always equal to the number of annuli that were present on the otoliths. Previous work in Illinois has shown that annulus formation in largemouth bass occurs between April and June (Taubert and Tranquilli 1982). For most fish collected in this survey, the annulus for the year in which they were collected had not yet begun to form and there was significant growth between the last annulus and the otolith radius. In these cases, fish were assigned an age equal to the number of annuli plus one since annulus formation was imminent. For all fish aged in this survey, it was assumed that length at age at time of capture was approximately equal to true length at age since the survey coincided with the period of annulus formation.

Age distribution histograms were constructed and mean length at age was determined for all year classes represented by at least 2 fish. Since the subsample of fish kept for age determination in 2009 was randomly selected, it was not necessary to use an age-length key to determine overall age structure or mean length at age. Annual mortality rate (A) was calculated for largemouth bass via weighted catch curve regression which reduces the influence of rare and older fish on the slope of the catch curve (Steel and Torrie 1980). Age structures for each year of the survey were pooled to estimate the annual mortality rate.

Results and Discussion

Abundance

Densities of largemouth bass remained fairly constant throughout the study period. We collected 88, 121, and 118 largemouth bass in 2007, 2008, and 2009, respectively. Greater numbers were collected in 2008 and 2009 after 2 additional sample sites were added beginning in 2008. For 2007, 2008, and 2009, CPUE values were 38 (SE = 4.6), 38 (SE = 4.1), and 43 (SE = 6.8) fish/hr, in that order. Catch rates were slightly higher in uplake sites (43 fish/hr; SE = 3.8) than in downlake sites (39 fish/hr; SE = 4.6).

The catch rates obtained between 2007 and 2009 were slightly higher than those from previous Belews Lake largemouth bass surveys. During electrofishing surveys conducted by WRC staff in 2002, only 29 fish/hr were collected (Hodges 2004). Additionally, WRC staff assisted Duke Energy biologists during their general fish community assessments on Belews Lake in 1999. Although electrofishing time was not recorded in these surveys, it is possible to compute CPUE based on the length of shoreline sampled. In 1999, the mean number of largemouth bass captured per 300 m of shoreline was 8.0, with uplake sites producing higher catch rates (9.1 fish/300 m) than downlake sites (6.9 fish/300 m; Hodges 2004). When catch rates during the current study period were converted to fish per 300 m to facilitate comparisons with the 1999 survey, mean catch rates for 2007–2009 were 8.7 fish/300 m (SE = 1.3), with uplake catch rates (9.0 fish/300 m; SE = 1.2) being only marginally higher than downlake catch rates (8.0 fish/300 m; SE = 0.8). Overall, Belews Lake catch rates are lower than those observed in Mayo Lake (46 fish/hr; Harris 2007) and Hyco Lake (84 fish/hr; Oakley 2005), two nearby cooling water reservoirs located within the Roanoke River basin.

Size Structure

Overall, the size structure of Belews Lake largemouth bass is below average in comparison to other N.C. reservoirs. Largemouth bass captured during this survey ranged in length from 69 to 600 mm. Few fish > 500 mm in length were collected in all years, while in 2007, relatively few fish < 200 mm in length were collected (Figure 2). Given that the proportion of fish between 200–400 mm in length did not decline significantly in 2008 and 2009, it appears as if more fish < 200 mm were present in 2007 than our survey suggested. Length distributions from the current survey were comparable to those obtained during previous surveys in 1999 and 2002, although the proportion of fish ≥ 400 mm was lower in 1999 (6%) than during all subsequent surveys when the proportion of fish ≥ 400 mm ranged from 11–16%.

Despite the differences in water clarity and productivity between uplake and downlake areas, overall size distributions of fish collected from both areas during this survey were fairly similar, although the few fish ≥ 500 mm in length were all collected from uplake sites (Figure 3). This disparity was much more pronounced in the 1999 survey when the percentage of fish ≥ 400 mm in length collected uplake (13%) was noticeably greater than at downlake sites (<1%). Differences in water clarity, productivity levels, and temperatures in uplake and downlake areas of Hyco Lake mimic those seen in Belews Lake, although differences in the size structure of bass between uplake and downlake areas are much more pronounced in Hyco Lake than in Belews Lake (Oakley 2005).

Stock indices declined during each subsequent year of the survey period, with PSD declining from 73–59 and RSD-P declining from 33–23 between 2007 and 2009 (Table 1). During 2009, when the proportion of larger fish was at its lowest, we noted that many of the fish appeared to be spawned out and we also observed several clouds of bass fry. These observations suggest that we may have collected our sample too late in the season after the larger fish had moved off the beds and back into deeper water, which could possibly explain the lack of larger fish in the sample.

Although PSD values declined throughout the survey period, they were generally comparable to those observed in 1999 and 2002 (Table 1). Although PSD and RSD-P were highest in 2007, the proportion of memorable-sized fish was higher in 1999 and 2002 than in all subsequent surveys (Table 1). PSD and RSD-P values during the survey period were within the range observed in recent surveys of Lake Hyco (Oakley 2005) and Lake Mayo (Harris 2007).

Condition

Relative weights for Belews Lake largemouth bass averaged 87, 89, and 83 in 2007, 2008, and 2009, respectively. Anecdotal evidence suggests that many fish had already spawned at the time of our survey in 2009, which could explain the lower relative weights observed at that time. In 2007 and 2008, relative weight decreased as fish total length increased, while relative weights did not vary in relation to fish size in 2009 (Figure 4). Condition of fish from uplake sites was marginally higher than from downlake sites, with mean relative weight values of uplake and downlake sites being 89 and 85, respectively. Likewise, relative weights of largemouth bass collected from uplake areas of Hyco Lake were greater than those collected from downlake areas (Oakley 2005). The lower relative weights of fish inhabiting downlake areas may be related to the higher metabolic rates that fish would be expected to maintain in response to the elevated water temperatures present in the lower lake. Additionally, given the expected differences in productivity between uplake and downlake areas, bass in uplake areas could also be expected to have higher relative weights as a result of greater food availability.

Mean relative weight values between 2007 and 2009 are considerably greater than mean relative weights from the 1999 survey (mean = 80) and considerably lower than mean relative weights from the 2002 survey (mean = 94). To determine if relative weights were affected by fish densities, catch rates in 1999, 2007, 2008, and 2009 were standardized to fish per 300 m sample site, which allowed data from 1999 to be included, and compared against relative weight values for each year. It was not possible to include data from 2002 since the length of shoreline sampled in that survey was not measured. No clear relationship existed between fish densities and relative weights (Figure 5), suggesting that density-dependent mechanisms are not driving body condition.

Overall, relative weights of largemouth bass from Belews Lake are lower than most other lakes in the region. Relative weights of W. Kerr Scott largemouth bass averaged 92 in 2000 and

93 in 2001 (Hodges 2002), 90–95 in Lake Hickory between 2004–2006, and 92–96 in Mayo Lake in 2006 (Harris 2007). Furthermore, condition of Belews Lake largemouth bass is poor in spite of their relatively low densities. The only comparable reservoir with similarly low body condition is Hyco Lake, where relative weights averaged 80–83 for all size classes of fish except those over 500 mm in length; however, bass densities in Hyco Lake (84 fish/hour) were nearly twice as high as in Belews Lake.

Age Structure

Largemouth bass collected during this survey ranged in age from 1–10, with the population being dominated by a high proportion of younger (≤ age 5) fish and relatively few older (> age 5) fish (Figure 6). Age structure of Belews Lake largemouth bass was similar between 2007 and 2009, with the exception of 2007 when there were fewer age-1 fish than in subsequent years. However, the abundance of age-2 fish in 2008 was still high, suggesting that more age-1 fish were present in 2007 than our data suggested. Likewise, age structures in 1999 and 2002 were similar to those observed in the current survey, with high proportions of younger fish and low proportions of older fish (Hodges 2004).

Comparison of aggregate age distributions of bass collected from uplake and downlake sites between 2007 and 2009 suggests that uplake sites contained a greater proportion of fish older than age two, while more age-1 fish were collected from downlake sites (Figure 7). A similar trend was observed in the 1999 survey (Figure 7). All samples in 2002 were collected from downlake areas, precluding any comparisons between age structure in uplake and downlake sites. The higher proportion of age-1 fish collected downlake is likely related to age-1 fish being significantly larger in downlake areas affected by heated effluent than in uplake areas at ambient temperatures (see subsequent section on *Growth*), making them more susceptible to being captured by electrofishing gear. However, meaningful comparisons between uplake and downlake areas in this study are limited by the small number of fish collected from uplake sites. Given that the majority of Belews Lake is north of N.C. Highway 65, most sample sites were located in the main body of the lake with only 4 sites being located uplake. Future surveys should incorporate more sites in uplake areas to increase sample sizes and allow more robust comparisons with downlake areas.

The high proportion of young fish and corresponding low proportion of older fish in the overall population indicates that survival of fish to older ages is poor, a finding which is supported by the estimated mortality rate for the Belews Lake largemouth bass population. Using ages 2–10 in the catch curve regression, total annual mortality (A) was estimated to be 43%, which is higher than the nationwide average of 35% reported by Beamesderfer and North (1995). Insufficient numbers of older age classes were collected to conduct separate analyses of mortality for uplake and downlake areas.

The causes of this apparent poor survival are unknown. Given how popular catch-and-release angling has become among largemouth bass anglers (Quinn 1996; Noble 2002; Myers et al. 2008), it seems unlikely that excessive harvest rates would be decreasing survival. In lieu of mortality directly associated with harvest, it is possible that bass caught and released by anglers in the main body of the lake suffer higher rates of post-release mortality due to the elevated water temperatures. Die-offs of largemouth bass near bass tournament release sites are occasionally observed on Belews Lake, but the extent to which they affect the overall population is unknown.

Another possible factor in the reduced survival of largemouth bass in Belews Lake is largemouth bass virus (LMBV), which was first detected in Belews Lake in 2002 (USFWS 2011). LMBV caused numerous summertime die-offs of largemouth bass in the southeastern U.S. in the mid-to-late 1990's, with anecdotal evidence suggesting that abundance of larger fish is decreased immediately after kills (Grizzle and Brunner 2003). However, no large-scale kills of largemouth bass have been reported at Belews Lake. Additionally, electrofishing surveys show that population densities and age structure have remained fairly constant since 1999. If widespread LMBV-related mortality events were occurring, fluctuations in densities and age structure would be expected.

An additional explanation for the lack of larger, older largemouth bass collected in Belews Lake could involve gear avoidance by larger fish due to the increased water clarities in the main body of the lake. Previous studies have shown that bass electrofishing surveys are sometimes more effective in clear-water reservoirs when conducted at night, presumably because fish are more likely to avoid capture during daylight hours (Dumont and Dennis 1997; McInerny and Cross 2000). However, during a 2004 comparison of day and night electrofishing conducted on Belews Lake and two other reservoirs, catch rates were similar and PSD values were significantly higher for largemouth bass collected during daytime sampling versus nighttime sampling, suggesting that large fish were no more susceptible to capture at night than during the day (Hining 2004). Furthermore, size distributions of bass collected from uplake areas of Belews Lake, where water clarities are significantly lower than in downlake areas, are very similar to those collected from downlake areas with higher water clarities. As such, avoidance of the gear by larger fish does not seem to fully explain the lack of larger fish collected from Belews Lake.

A final possibility involves a reduction in life expectancy as a result of the elevated water temperatures from the heated cooling water discharged into Belews Lake. Water temperatures in the main body of Belews Lake are significantly affected by the heated effluent it receives, with a significant percentage of summertime surface temperature readings exceeding the state water quality standard of 32^{o}C (NCDENR 2010). Previous studies have demonstrated reduced longevity of bass inhabiting systems with elevated temperatures. Studies of tropical reservoirs have demonstrated reduced longevity of largemouth bass (Churchill et al. 1995), with one telemetry study documenting that survival of largemouth bass to age 3 was <1% (Lilyestrom et al. 1994). Comparisons of largemouth bass age structure between heated and ambient portions of Hyco Lake also suggest that longevity is reduced in areas of the lake receiving heated effluent (Oakley 2005). No bass older than age 5 were collected from Lake Julian, a western North Carolina cooling reservoir, in an October 1998 survey (CP&L 1999). Although subsequent surveys conducted at Lake Julian during the spring have yielded higher proportions of larger fish, no age and growth work has been undertaken since 1998, so it is unclear as to whether the larger fish collected in the spring were actually older than age 5 or not. Although the proportion of older fish in Belews Lake appears to be lower than normal, reductions in overall longevity of largemouth bass do not appear to be as extreme as in some other systems with elevated temperatures. Increasing sample sizes of fish collected from uplake areas of Belews Lake with ambient water temperatures in future surveys should allow for more robust comparisons of age structures between uplake and downlake areas.

Growth

Largemouth bass in Belews Lake generally reached harvestable size (354 mm) by age 3 (Table 2). Growth rates for Belews Lake bass were among the fastest for ages 1–5 when compared against a sub-sample of well-known N.C. bass fisheries (Figure 8) and were considerably higher than the national average for ages 1–5 nationwide (Beamesderfer and North 1995). Figuring growth rates separately for bass inhabiting uplake and downlake areas of Belews Lake demonstrated a marked difference in growth (Table 3), with bass from downlake areas receiving heated effluent growing even faster in comparison to other lakes across the state and bass from uplake areas with ambient temperatures growing considerably slower (Figure 8). Differences in growth increments between uplake and downlake areas were greatest for 1 and 2-year old bass, with length at age becoming nearly identical by age 5.

However, in contrast to most of the other bass populations represented in this comparison, length at age for age-6 fish was less than length at age for age-5 fish during all three years of the study in both uplake and downlake areas of Belews Lake. Although back-calculated lengths at age were not determined during this study, the reduction in length at age for age-6 fish suggests the presence of Rosa Lee's phenomenon, in which growth rates are reduced for older cohorts within a population (Ricker 1975). Although Rosa Lee's phenomenon is generally associated with fishing pressure, it can also occur due to natural causes given that faster-growing fish tend to die earlier than slower-growing fish (Gerking 1957). Given the aforementioned lack of older fish in the Belews Lake bass population and their fast growth rates up until age 5, especially in the portion of the lake affected by heated effluent, it is possible that growth rates of older bass could be reduced because the faster-growing individuals have already died, with only the slowest-growing members of these older cohorts remaining in the population. Given that bass in uplake areas experience ambient temperatures and do not exhibit abnormally high growth rates, the dropoff in length at age at age 6 is more difficult to explain. However, growth rates rebounded after age 6 in uplake areas and age-5 length at age was again exceeded by bass aged 8–10, while in downlake areas, insufficient numbers of bass older than age 6 were collected to allow determination of length at age. It should be noted, however, that only 19 bass ≥ age 6 and 9 bass ≥ age 7 were collected throughout the entire lake during the three years of this survey, so any inferences that can be drawn from the growth rates of these advanced age classes are limited. Increasing samples sizes in future surveys will facilitate a more vigorous analysis of growth rates.

Previous studies have demonstrated faster growth rates of largemouth bass collected from heated versus ambient sections of cooling reservoirs, with growth differences generally being most pronounced for younger age classes (Busacker 1971; Smith 1971; Bennett and Gibbons 1974; Sule 1981; Perry and Tranquilli 1984). Reasons cited for faster growth of younger bass in general include younger bass possessing relatively greater capacity for growth in length, earlier hatching dates for young-of-year bass in thermally affected areas, earlier onset of growth in the spring relative to older fish (Stroud 1948; Gerking 1966), and continuation of growth later in the fall due to their ability to grow at lower water temperatures (Markus 1932). As a result, younger fish may benefit more from elevated temperature regimes. In an Illinois cooling reservoir, smaller bass grew faster in heated areas than in areas subject to ambient temperatures, although differential growth was not evident between thermal environments for fish > 425 mm in length (Perry and Tranquilli 1984). Interestingly, this is the approximate length at which length at age estimates converge for bass collected in heated and ambient areas of Belews Lake. The degree to which growth rates of bass in heated and ambient areas of cooling reservoirs converge over time is likely affected by overall reservoir productivity and the extent to which growth and longevity are affected by differences in water temperature regimes.

The differences observed in growth rates between uplake and downlake areas of Belews Lake, combined with the aforementioned differences in longevity, likely explain the similarity between largemouth bass size distributions in uplake and downlake areas. While size distributions of fish from downlake areas would be expected to contain more quality-sized fish than uplake areas given how much faster fish grow downlake, fewer fish survive long enough to attain larger sizes in downlake areas. Conversely, while there is a greater proportion of older fish uplake, their slower growth rates relative to fish inhabiting downlake areas limits the abundance of larger fish. As a result, differences in growth and longevity tend to cancel each other out, resulting in similar size distributions lake-wide.

Recommendations

1. Add more sample sites in the upper end of Belews Lake to increase sample sizes.

2. Incorporate open-water gillnet sets into future surveys to investigate the possibility that larger, older bass may be holding in water that is too deep for them to be collected with electrofishing gear.

3. Investigate potential for Florida strain largemouth bass to exhibit increased longevity in cooling water reservoirs.

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TABLE 1.— Stock index values for Belews Lake largemouth bass, 1999–2009.

Year	PSD	RSD-P	RSD-M
1999	67	29	2
2002	54	25	4
2007	73	33	0
2008	66	26	1
2009	59	23	0

TABLE 2.— Mean length at age, with range, standard error (SE), and sample size (n), for Belews Lake largemouth bass, 2007–2009.

	2007				2008				2009			
Age	Mean	Range	SE	n	Mean	Range	SE	n	Mean	Range	SE	n
1	214	131–297	12	16	167	69–265	7.7	45	205	91–293	7.7	44
2	311	222–391	6.6	31	299	145–372	8.6	40	331	243–395	7.4	27
3	375	282–426	9.7	16	363	305–424	10.8	13	368	325–430	10	9
4	376	323–429	7.5	17	404	323–453	13.5	9	366	355–377	11	2
5	446	442–451	2.6	3	414	378–451	12.7	6	436	411–475	9.8	6
6	400	395–404	4.5	2	396	363–429	33	2	419	388–466	13.5	6
7					421	407–435	14	2				
8					500	495–504	4.5	2				
9												
10					537	474–600	63	2				

TABLE 3.— Mean length at age, with range, standard error (SE), and sample size (n), for largemouth bass collected from upper and lower reaches of Belews Lake, 2007–2009.

	Upper				Lower			
Age	Mean	Range	SE	n	Mean	Range	SE	n
1	142	69–224	8.9	20	201	89–297	5.5	86
2	265	145–360	8.4	30	332	254–395	3.6	68
3	346	282–430	9.2	16	386	331–426	5.5	22
4	378	323–453	8.7	16	393	336–452	10.4	12
5	424	382–451	15.3	4	431	378–475	8.2	11
6	420	388–466	16.4	5	401	363–429	11.4	5
7								
8	473	441–504	31.5	2				
9								
10	537	474–600	63	2				

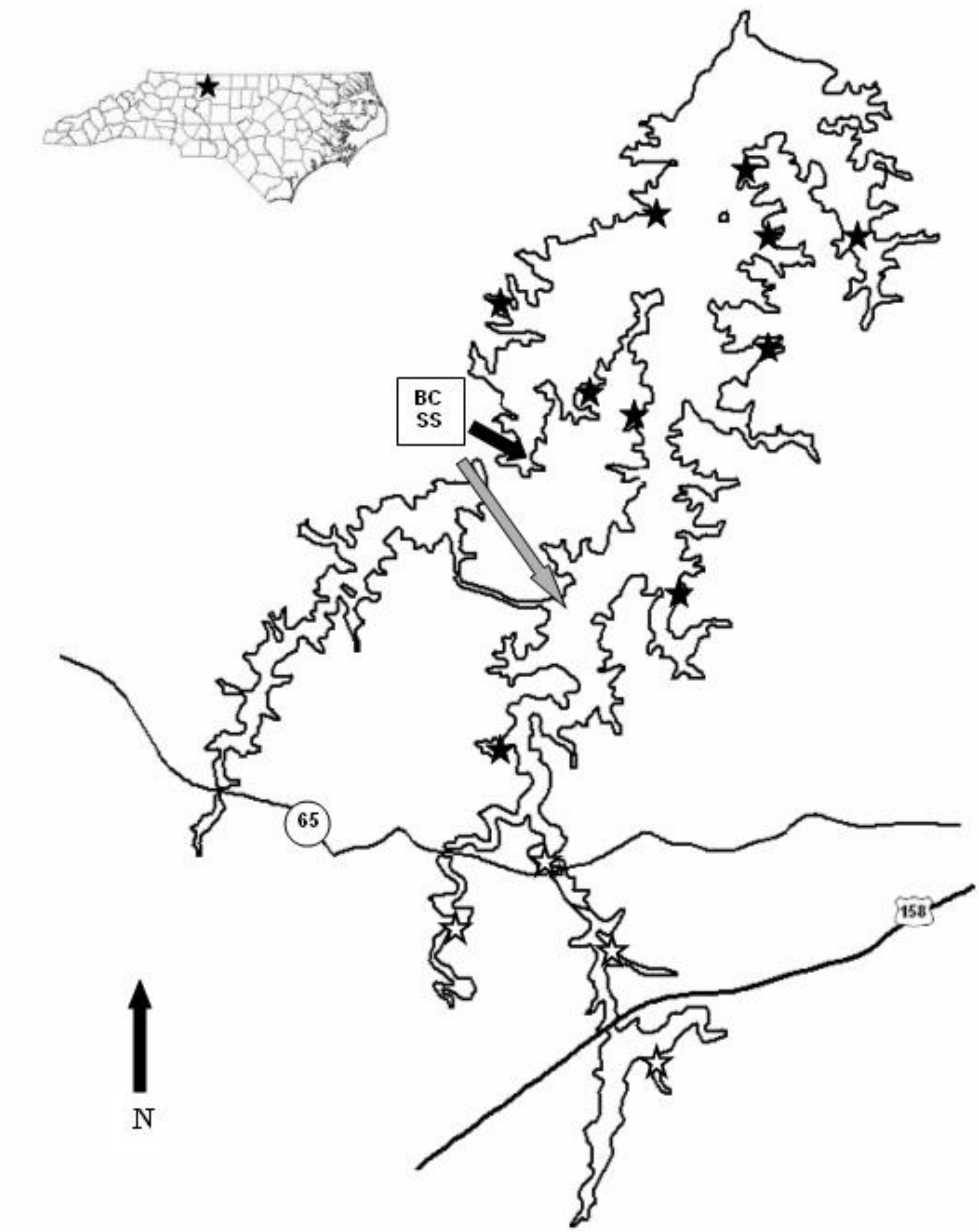

FIGURE 1.— Map showing largemouth bass sample sites on Belews Lake, 2007–2009. Black stars indicate lower-lake sites while white stars indicate upper-lake sites. The Belews Creek Steam Station (BCSS) is shown, along with the cooling water intake (dark arrow) and heated cooling water discharge canal (light arrow).

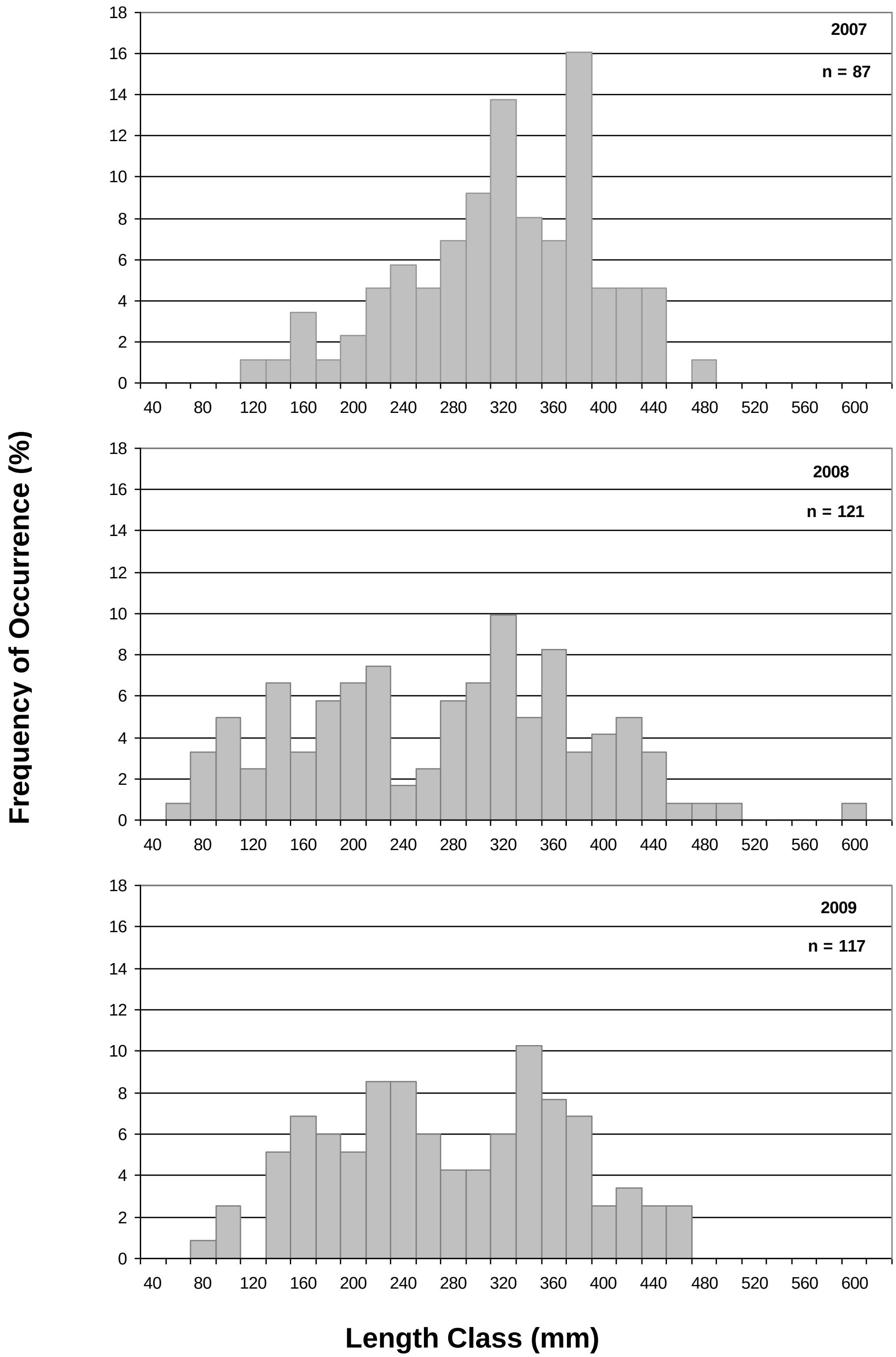

FIGURE 2.— Length-frequency distributions for Belews Lake largemouth bass, 2007–2009.

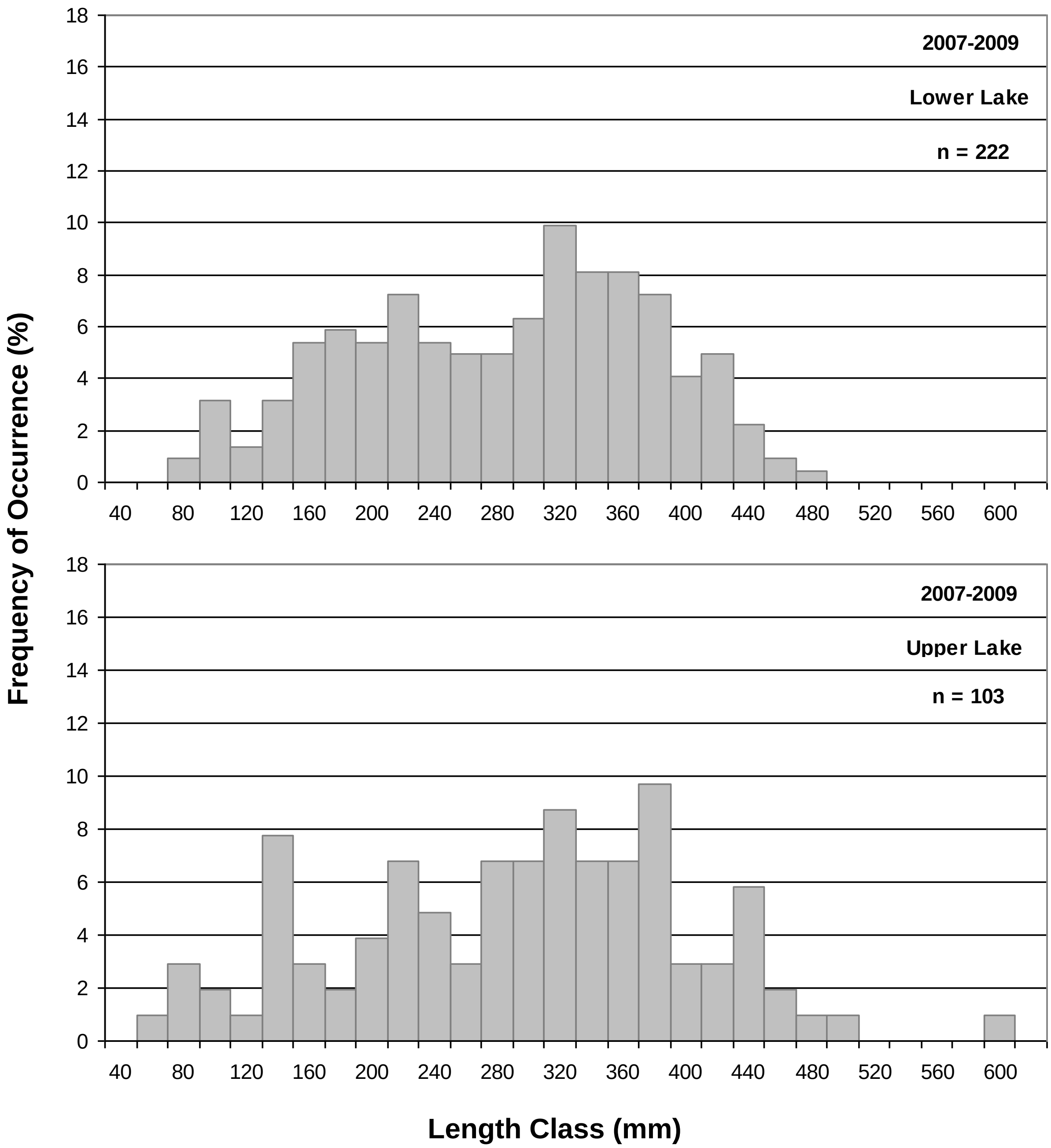

FIGURE 3.— Length-frequency distributions for largemouth bass collected from lower and upper reaches of Belews Lake, 2007–2009.

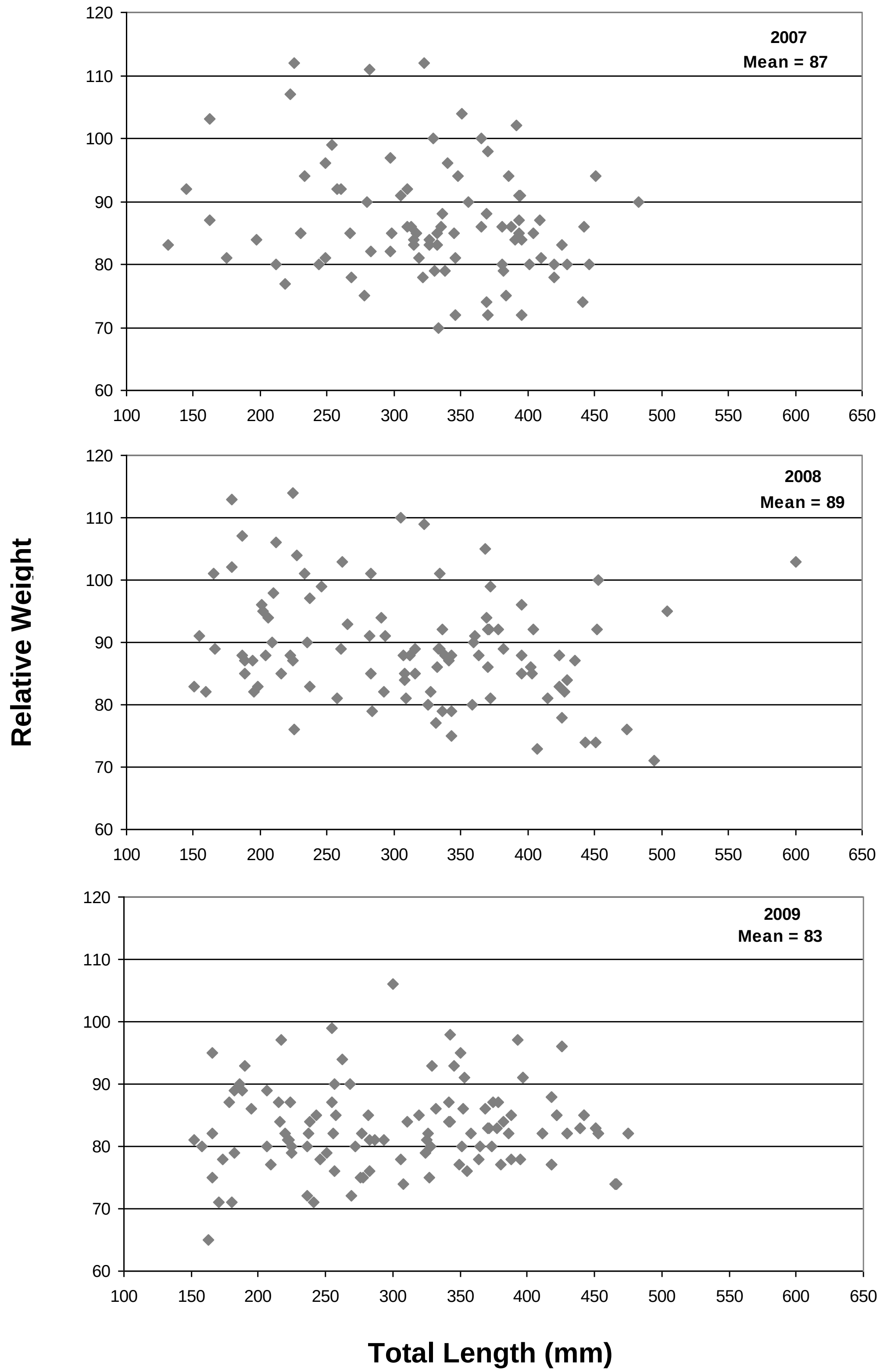

FIGURE 4.— Relative weights of Belews Lake largemouth bass, 2007–2009.

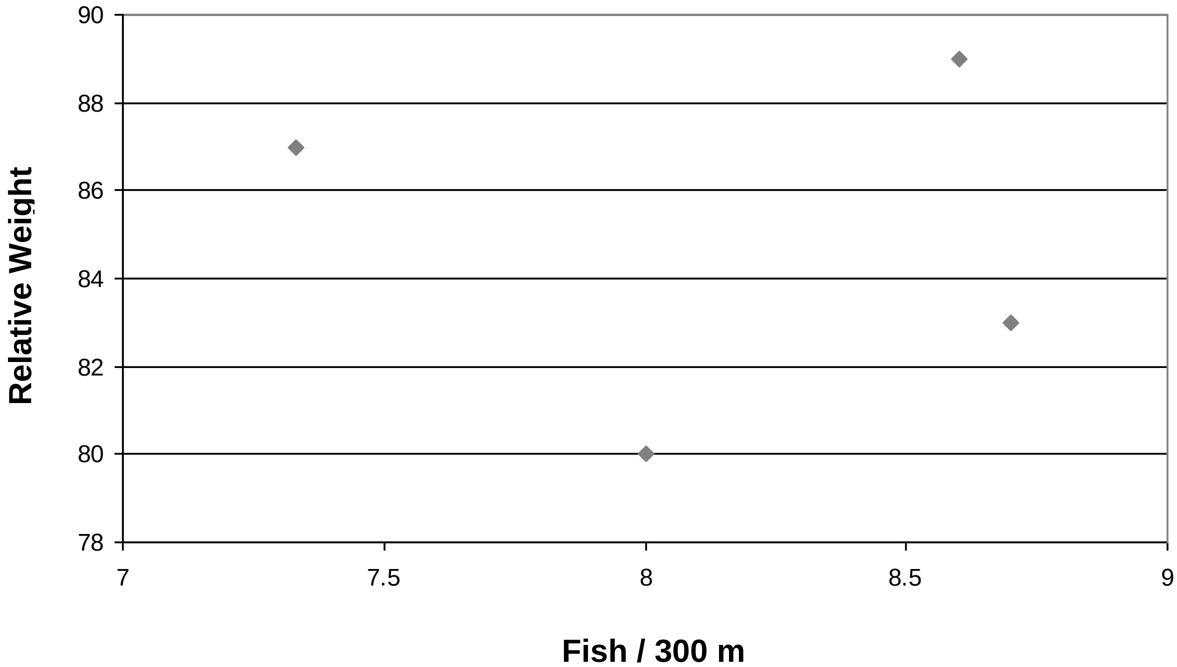

FIGURE 5.— Relative weights of Belews Lake largemouth bass versus electrofishing catch rates, 1999 and 2007–2009.

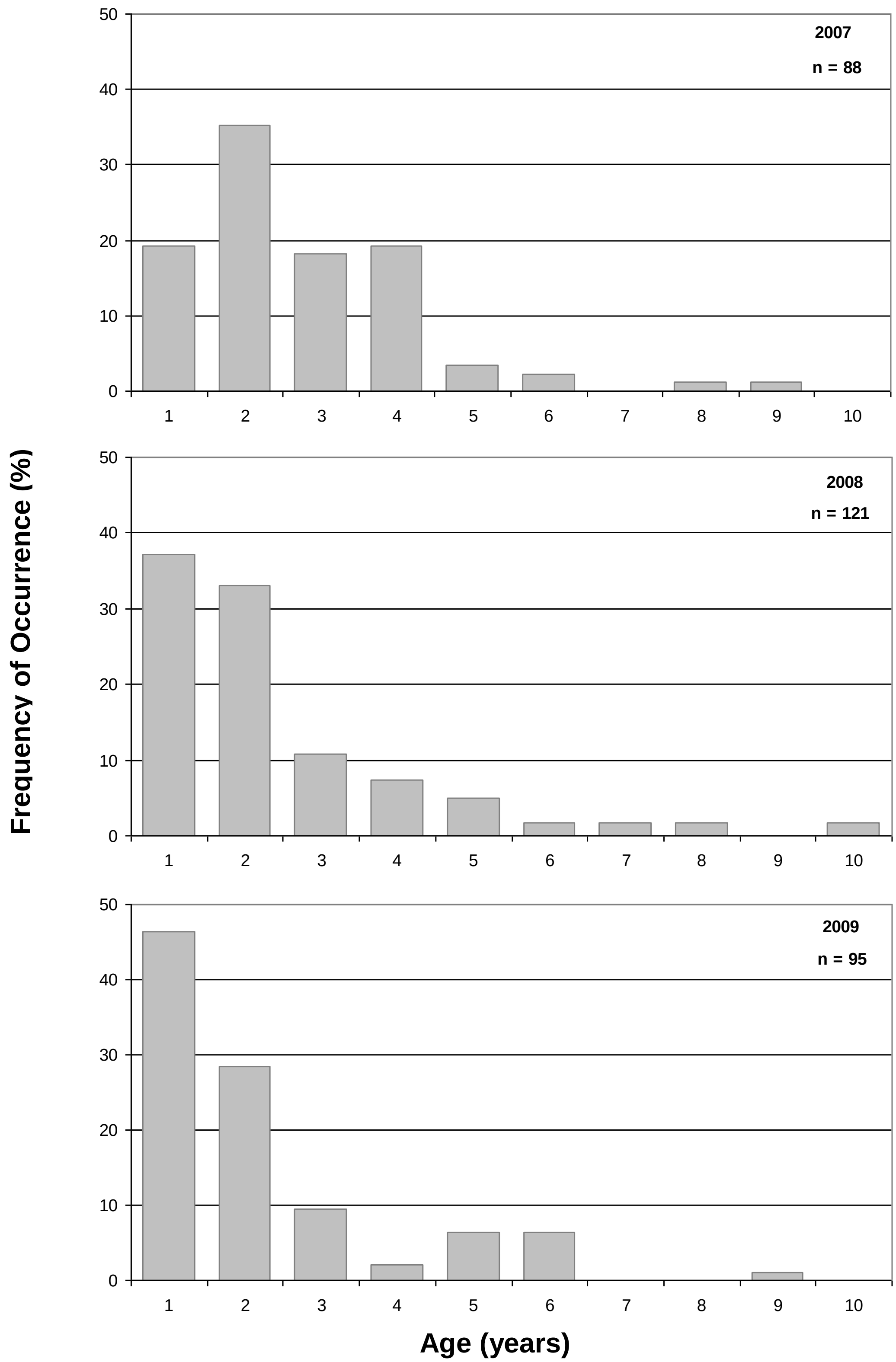

FIGURE 6.— Age structure of Belews Lake largemouth bass, 2007–2009.

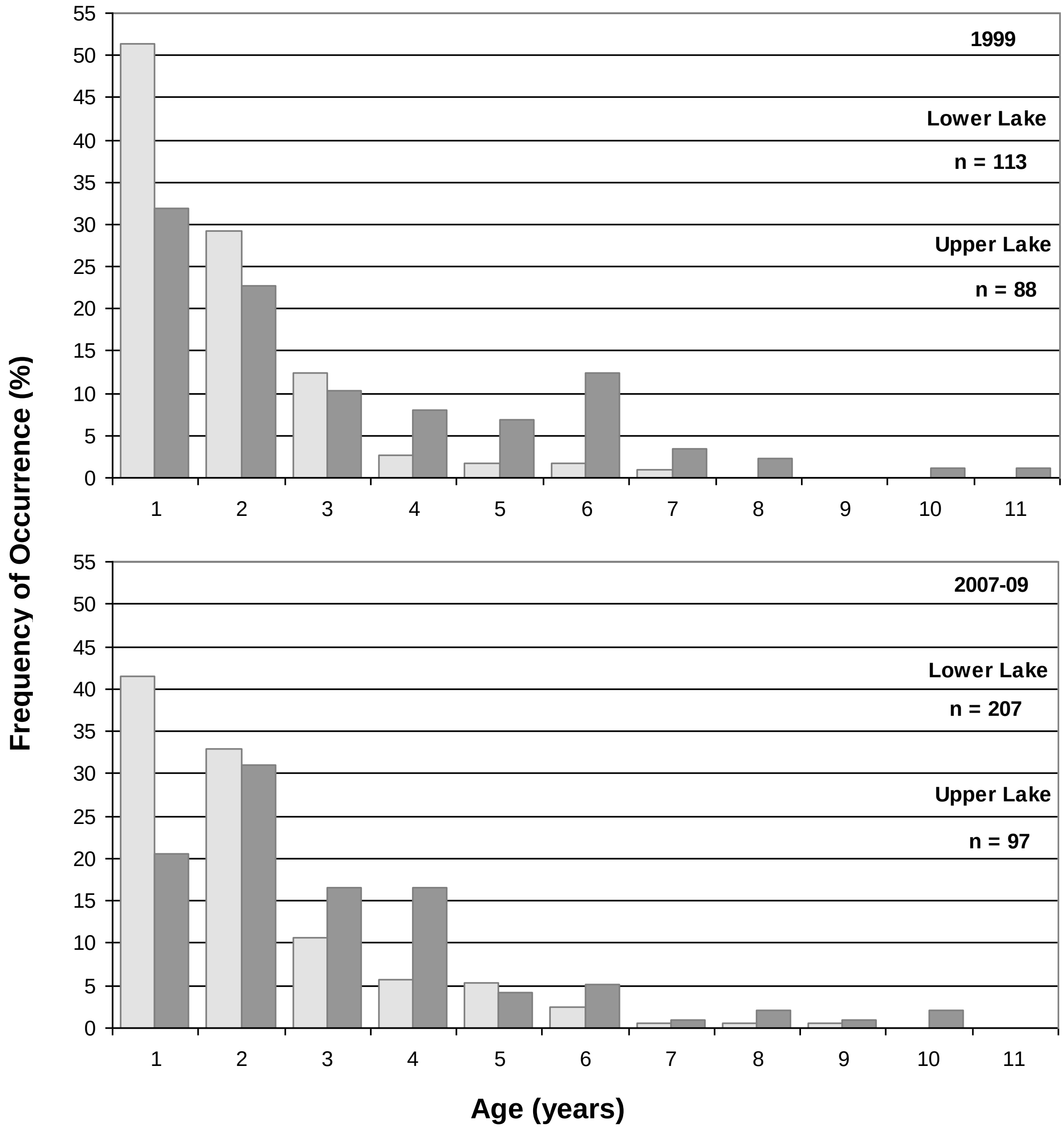

FIGURE 7.— Age structure of largemouth bass collected from lower (light-colored bars) and upper (dark-colored bars) reaches of Belews Lake, 1999 and 2007–2009.

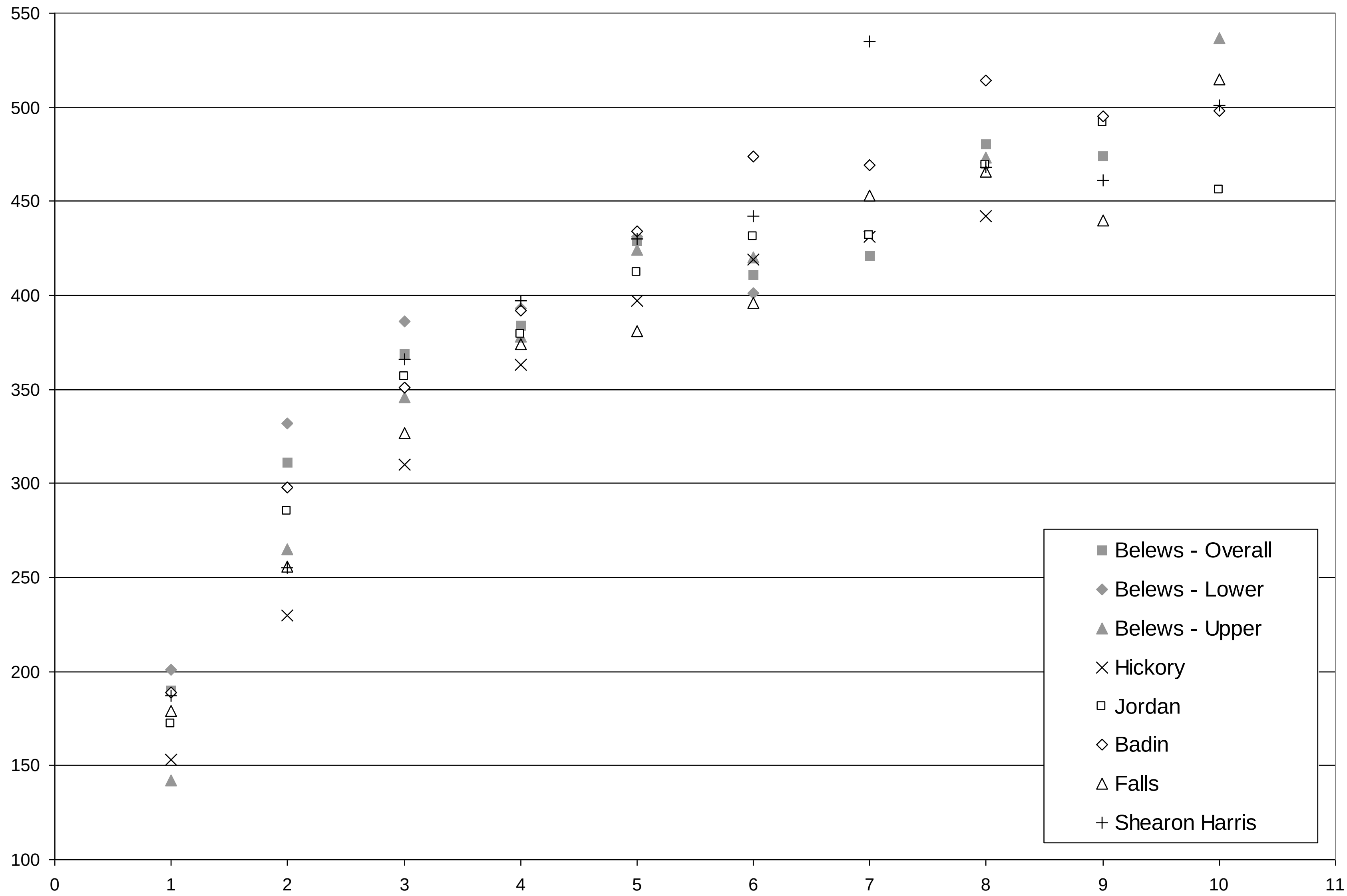

FIGURE 8.— Mean length at age for largemouth bass collected from Belews Lake (2007–2009), Lake Hickory (2004–2006), Lake Jordan (2008), Badin Lake (2008), Falls Lake (2007), and Shearon Harris Lake (2007).