Chapter 8. Ichthyoplankton (Primary Responsibility - John Ackerson)

Introduction:

Ichthyoplankton is defined as small, planktonic stages of fish (Snyder 1983). Fish larval stages are often represented in ichthyoplankton sampling. The beginning of the larval period is categorized by the ability to first capture food organisms and significant absorption of the yolk sac. Completion of the larval period consists of the formation of adult fin rays (Moyle and Cech 1988). Fish larvae studies can be utilized to assess and monitor fish populations and to predict and monitor environmental impacts on these populations. When evaluating an environmental impact of a fishery, early life stages of fish are more sensitive to biological changes than adult fish and are good indicators of pollution factors (Snyder 1983). Larval fish samples are frequently used to identify nursery areas and approximate spawning grounds and seasons. Distribution and abundance data can assess the current status, document yearly fluctuations, and detect long-term trends of a particular fishery (Snyder 1983). The purpose of this study was to evaluate the relative abundance and temporal and spatial distribution of larval fishes using two sampling methods in Newton Lake as compared to Coffeen Lake, and Lake of Egypt.

Methods and Materials:

Ichthyoplankton sampling began in August of 1997 on Newton Lake, Lake of Egypt, and Coffeen Lake. In 1998-99, sampling frequency was twice per month from mid-March through July and once a month from August until larval fish capture had ceased. Sampling design divided Newton Lake into four segments Coffeen Lake and Lake of Egypt into two segments. Segment 1 was the discharge (warmer water) area in all three lakes while the intake (cooler water) was in segment 4 for Newton and segment 2 for Coffeen and Lake of Egypt.

Conical plankton nets

Two conical plankton nets were towed in tandem from the bow of the boat during daylight hours. Net construction included 500μ mesh size, 0.5m diameter opening, minimum 5:1 (length to diameter) ratio, and a catch basin. Tranter and Smith (1968) recommended combination conical nets with a minimum 5:1 ratio. A calibrated General Oceanic Model 2030 flow meter was mounted at the net opening to measure total water volume sampled. Brass depressors and boat velocities were used to keep the tow depth just below the water surface. The duration of each tow was ten minutes (± 1 min). Six towing stations were sampled per segment, three paired tows in the littoral (shoreline) and three in the pelagic (open-water or limnetic) areas. Sampling stations for Newton, Coffeen, and Lake of Egypt are in Figures 8.1, 8.2, and 8.3, respectfully. Net tow densities were calculated as the number of fish per cubic meter of water sampled.

Light Traps

At dusk, four floating lights traps were set in each segment (two littoral, two pelagic) in conjunction with the ichthyoplankton tow sampling periods. Each set required a minimum of two hours. Light trap construction included an 18.9-L translucent, white, plastic chamber illuminated by a 1.5-V light bulb and charged by a 6-V lantern battery. Styrofoam was the floatation device and anchoring was provided by cement weights tied onto the catch basin. This particular design has been used by Southern Illinois University successfully as well as the Illinois Department of Natural Resources at LaSalle Hatchery to assess stocking success in rearing ponds. Catch per unit of effort (CPUE) of fish collected by the light traps was calculated as the number of fish sampled per hour.

Identification

Larval fish were transported to SIUC in labeled plastic bags stored on ice. Larval fish were identified and measured to the nearest mm before preserving in order to obtain accurate total lengths. Taxonomic identification of target fish were to species for largemouth bass (*Micropterus salmoides*) and genus for shad (*Dorosoma*), temperate basses (*Morone*), crappie (*Pomoxis*), and sunfishes (*Lepomis*) species. All other non-target larval fish captured were counted and identified to family. Auer (1982) and Hogue et al. (1976) were the primary keys used for identification. A common criteria used for larval fishes identification are myomere (muscle tissue) counts, both pre and post anal. A common problem in larvae identification is the geographical and temporal variation in myomere counts (Bosley and Conner 1984). Variations from these keys were found in myomere counts when differentiating between *Pomoxis* and *Lepomis* in early spring. For example, according to the keys, *Lepomis* spp. postanal myomeres are usually 14-18 and our *Lepomis* spp. were 16-19. *Pomoxis* spp. postanal myomeres are usually listed as 19-21 and our *Pomoxis* spp. were always 21. A sample was used to identify problem fish genetically with starch-gel electrophoresis. This data allowed us to easily identify these fish with the aid of myomere counts. In each sample, up to 20 of each target taxon were measured randomly for total length to the nearest millimeter. All measurements were taken with a microscope equipped with a digitizing camera, frame grabber, monitor, and a computer using BioScan's OPTIMAS digital image software.

Aging

Larval fish to be aged were frozen until sagittal otoliths were removed for counting daily rings (Pannella 1973). When available in 1998, 20 fish per taxon were aged from each segment for each sampling date. Using the method described by Miller and Storck (1982), otoliths were mounted on glass microscope slides and aged by counting daily rings. Two experienced readers aged the otoliths and the counts were averaged if they were within 10% of each other. More than 10% differences were reconciled by recounting. Hatch dates were determined by subtracting the number of rings from the collection date. A length-age prediction equation for each taxa was developed from larvae that were aged in 1998. In both 1998 and 1999 all other larvae measured for total length were then aged using the appropriate prediction equation.

The results were analyzed for differences in abundance and time of hatching among segments and between spatial locations. This includes the temporal (by segment) and the spatial (littoral vs. pelagic) differences. A general linear model was used to test for significant differences, followed by Tukey's post hoc test when there was a significant difference (SAS Institute 1995). All significant differences were determined at alpha ≤ 0.05. The majority of larval fish collected were ≤13 mm in total length. Only light traps collected larvae larger than 13mm in total length. Mean densities and CPUE used larvae ≤13mm because it helps eliminate fish that have developed beyond the larval stage and helps prevent counting larvae twice from a spawning cohort. For example, when including larger fish, they may be from a previous spawning cohort and counting these fish again would artificially increase the CPUE or density for that capture date. Some fish captured and analyzed exceeded the larvae stage and developed into the juvenile stage (aging portion of this study). These fish are an important early life stage and are termed "larvae" in this report to maintain consistency. Mean densities and CPUE were calculated using samples from the capture duration of each taxa. For example, if *Dorosoma* in Newton Lake were captured from April 10 to June 09, then only samples between those dates were included in the mean abundance estimates.

Results:

1997 Net Tows

Sampling began in August and was completed in September on Lake of Egypt and October on Newton Lake and Coffeen Lake in 1997. Sampling was stopped after no ichthyoplankton were captured. Only *Lepomis* were captured in 1997. Mean densities ($\#/m^3$) of *Lepomis* in Newton Lake were higher (P = 0.0257) in segment 2 ($0.0433/m^3$) than segment 4 ($0.0031/m^3$). There were no other significant differences among segments.

In Coffeen Lake there were no significant differences in density of larvae between segments. Mean densities of *Lepomis* were $0.0230/m^3$ for segment 1 and $0.0042/m^3$ for segment 2. In September, no fish larvae were collected in segment 2 and a low density of *Lepomis* ($0.0046/m^3$) were collected in segment 1.

In August, *Lepomis* in Lake of Egypt had a low density ($0.0090/m^3$) in segment 1 and no fish were collected in segment 2.

1998 Net Tows

When densities were broken down by taxa and segment in Newton Lake (Table 8.1), mean densities ranged from $0.000/m^3$ for Percidae in segment 1 to $1.4203/m^3$ for *Dorosoma* in segment 4. *Dorosoma* mean densities were significantly higher (P=0.0001) than all other larval fish in Newton Lake. Also, *Dorosoma* mean density (Table 8.1) in segment 4 was higher than segments 1 and 2 (P=0.0014). Those mean densities were due to the peak density difference in early-May (Figure 8.4). *Morone* mean densities (Table 8.1) were higher in segment 4 than segment 2 (P=0.0239). *Lepomis* mean densities were not different (Table 8.1) but two summer peaks occurred in the cooler water areas of segments 3 and 4. This biological pattern may suggest gradual movement to cooler water as temperature increases in the late summer months (Figure 8.5). Other larvae represented no additional differences in the 1998 Newton net tow densities (Table 8.1).

In 1998, *Dorosoma* densities in Coffeen Lake were higher (P=0.0001) than all other larval fish. In Coffeen, larval fish mean densities ranged from Cyprinidae 0.0000/m^3 in segment 2 to *Dorosoma* 0.1916/m^3 for segment 2 (Table 8.2). Larval fish mean densities were higher in segment 2 than in segment 1 for three larval fish taxa, *Lepomis*, *Dorosoma*, and *Pomoxis* (Table 8.2). Throughout most of the year, *Dorosoma* capture duration was very similar but an early April peak in segment 2 (Figure 8.6) of *Dorosoma* caused a higher density (P=0.0001) than in segment 1. A higher segment 2 mean density (P=0.0001) of *Pomoxis* followed a trend similar to *Dorosoma* with one large peak in April. In segment 2, *Lepomis* mean density was also higher (P=0.0005) than segment 1 but didn't have a similar distribution. By the time *Lepomis* densities in segment 2 reached a peak in late July, segment 1 densities had greatly declined (Figure 8.7). *Morone* and Cyprinidae taxa were captured but at low densities and there were no differences between segments (Table 8.2).

Mean density of *Dorosoma* was higher (P=0.0001) than any other taxa in Lake of Egypt. Mean densities of larval fish in Lake of Egypt ranged from Cyprinidae (0.0000/m^3) in segment 1 to *Dorosoma* (0.6134/m^3) in segment 2. The cooler water (segment 2) of Lake of Egypt contained significantly higher (P=0.0103) *Dorosoma* densities than the warmer water of segment 1 (Table 8.2). A high early-May density in segment 2 (cooler water) was the main difference between the segments (Figure 8.8). Atherinidae showed opposite trends than other taxa (Table 8.2) because the density of *Dorosoma* in segment 1 (0.0116/m^3) was significantly higher (P=0.0001) than in segment 2 (0.0011/m^3). Although not significantly different between segments, *Lepomis* mean densities (Table 8.2) by date showed two distinct peaks, early summer in segment 1 and late summer in segment 2 (Figure 8.9). Other larval fish collected in Lake of Egypt were Cyprinidae and Percidae but in low densities (Table 8.2).

1999 Net Tows

Dorosoma densities were significantly higher (P=0.0001) than other taxa in Newton Lake. When densities were broken down by taxa and segment for Newton Lake (Table 8.3), mean densities ranged from Cyprinidae 0.0000/m^3 (segments 2 and 3) to *Dorosoma* 1.0510/m^3 (segment 3). Only *Morone* density was significantly different (Table 8.3), with segment 4 (cooler water) higher (P=0.0371) than segments 2 and 3. *Dorosoma* densities by date peaked earlier in the warmer water (segment 1) with a second peak in the cooler water (segments 3 and 4) (Figure 8.4). *Lepomis* densities by segment were not different, but warmer water segment 1 peaked earlier than cooler water segments 3 and 4 (Figure 8.10).

When densities were broken down by taxa and segment for Coffeen Lake (Table 8.4), mean densities ranged from *Lepomis* 0.0007/m^3 (segment 1) to *Dorosoma* 0.1809/m^3 (segment 2). *Dorosoma* mean density was higher in segment 2 (cooler water) (P=0.0001) than segment 1 (Figure 8.6). *Lepomis* initially were captured in late May and June in both segments but were captured again in the cooler water (segment 2) in August (Figure 8.11).

When densities were broken down by taxa and segment for Lake of Egypt (Table 8.4), mean densities ranged from *Morone* 0.0000/m^3 (segment 1) to *Dorosoma* 0.4557/m^3 (segment 1). Cyprinidae and Atherinidae families had significantly higher mean densities in segment 1 than segment 2 (Table 8.4). *Lepomis* mean densities by date were similar between segments (Figure 8.12).

1997 Light Traps

No larval fish were collected in light traps that were first set in September on Newton Lake. Light traps were not set on Coffeen or Lake of Egypt in 1997.

1998 Light Traps

When analyzing Newton Lake data for differences among taxa and segments (Table 8.5), *Lepomis* mean CPUE increased from the discharge to intake segments with the intake (segment 4) (8.48/hour) being significantly higher (P=0.0218) than the discharge (segment 1) (1.21/hour). Mean CPUE by date explained the overall differences among segments (Figure 8.13). *Dorosoma* mean CPUE also increased from discharge to intake, but was not significantly different (Table 8.5). Only the cooler water portion (segments 3 and 4) of the lake in early-May had significant *Dorosoma* CPUE peaks (Figure 8.14). All other larval fish mean CPUE were not different among segments. Largemouth bass were present in low densities in Newton Lake light traps (Table 8.5).

Lepomis CPUE was significantly higher (P=0.0137) than any other larval fish in Coffeen Lake, however, between the two segments no single taxon was collected at significantly different mean densities (Table 8.6). *Lepomis* CPUE had similar seasonal distribution when comparing segments. *Lepomis* CPUE in segment 2 had a high peak in July but there were no significant differences between the segments (Figure 8.15).

Dorosoma had higher mean CPUE than all other taxa (P=0.0001) in Lake of Egypt (Table 8.6). *Dorosoma* CPUE had a significantly higher peak in segment 2 than segment 1 on 5/19/98 (P=0.0001) but did not produce significant overall segment differences (Figure 8.16). *Lepomis* had a higher CPUE (P=0.0170) in segment 2 than in segment 1 (Table 8.6). *Lepomis* CPUE in both segments peaked in late May but in segment 2 (cooler water) there was a second peak in July (Figure 8.17).

1999 Light Traps

Lepomis had higher mean CPUE than all other taxa (P=0.0001) in Newton Lake. *Lepomis* in segment 4 had a higher CPUE (P=0.0358) than segment 1 (Table 8.7). A strong peak in early-July was the primary reason for these differences (Figure 8.18). Other taxa had a trend of higher mean CPUE in the cooler water segments but no significant differences were found.

Lepomis had higher mean CPUE than all other taxa (P=0.0018) in Coffeen Lake. An early-July peak of *Lepomis* (Figure 8.19) was responsible for the higher segment 1 mean CPUE (Table 8.8). *Dorosoma* segment 1 CPUE was higher than segment 2 due to a mid-May CPUE peak (Figure 8.20).

There were no taxa with differences in CPUE by segment in Lake of Egypt (Table 8.8). Mean CPUE in segment 2 was higher for *Dorosoma* (Figure 8.16) and *Lepomis* (Figure 8.21) and each taxon displayed two distinct peaks of fish density.

Net Tow Spatial Locations (pelagic vs. littoral)

In 1998, mean densities of larvae in Newton Lake by spatial location ranged from Percidae $0.0002/m^3$ (pelagic) to *Dorosoma* $0.9233/m^3$ (littoral). Mean densities were higher in the littoral locations for *Lepomis* (P=0.0001), *Pomoxis* (P=0.0207), and Percidae (P=0.0002) taxa than the pelagic locations (Table 8.9). In 1999, mean densities of larval fish in Newton Lake by spatial location ranged from Percidae $0.0001/m^3$ (pelagic) to *Dorosoma* $1.2287/m^3$ (littoral). Mean densities were higher in the littoral locations for *Lepomis* (P=0.0001), *Dorosoma* (P=0.0327), and Percidae (P=0.0045) taxa than the pelagic locations (Table 8.10).

In 1998, mean densities of larval fish in Coffeen Lake by spatial location ranged from Cyprinidae 0.0000/m^3 (pelagic) to *Dorosoma* 0.1444/m^3 (littoral). Mean densities were higher in the littoral locations for *Lepomis* (P=0.0001) and *Dorosoma* (P=0.0207) taxa than the pelagic locations (Table 8.11). In 1999, spatial location mean densities in Coffeen Lake were not different for any taxa (Table 8.12).

In 1998, mean densities in Lake of Egypt by spatial location ranged from Percidae 0.0010/m^3 (pelagic) to *Dorosoma* 0.3940/m^3 (pelagic). Mean densities were higher in the littoral locations for Percidae (P=0.0008) and Atherinidae (P=0.0200) taxa than the pelagic locations (Table 8.11). In 1999, mean densities in Lake of Egypt by spatial location ranged from *Morone* 0.0000/m^3 (pelagic) to *Dorosoma* 0.4619/m^3 (pelagic). Mean densities were higher in the littoral locations for *Lepomis* (P=0.0003), Percidae (P=0.0013), and Atherinidae (P=0.0208) taxa than the pelagic locations (Table 8.12).

Light Trap Spatial Locations (pelagic vs. littoral)

In 1998, mean CPUE in Newton Lake by spatial location ranged from *Pomoxis* 0.00/hour (pelagic) to *Lepomis* 9.45/hour (littoral). Mean CPUE was higher in the littoral locations for *Lepomis* (P=0.0001), *Dorosoma* (P=0.0211), and *Micropterus* (P=0.0315) taxa than the pelagic locations (Table 8.13). In 1999, mean CPUE in Newton Lake by spatial location ranged from Percidae 0.00/hour (pelagic) to *Lepomis* 49.89/hour (littoral). Mean CPUE was higher in the littoral locations for *Lepomis* (P=0.0050), Cyprinidae (P=0.0361), and Percidae (P=0.0044) taxa than the pelagic locations (Table 8.14).

In 1998, mean CPUE in Coffeen Lake by spatial location ranged from Cyprinidae 0.00/hour (pelagic) to *Lepomis* 4.26/hour (littoral). Mean CPUE was higher in the littoral location for *Lepomis* (P=0.0032) than the pelagic location (Table 8.15). In 1999, mean CPUE in

Coffeen Lake by spatial location was not different for any taxa (Table 8.16).

In 1998, mean CPUE in Lake of Egypt by spatial location ranged from *Pomoxis* 0.00/hour (pelagic) to *Dorosoma* 10.40/hour (littoral). Mean CPUE was higher in the littoral location for *Lepomis* (P=0.0129) than the pelagic location (Table 8.15). In 1999, mean CPUE in Lake of Egypt by spatial location ranged from Percidae 0.00/hour (pelagic) to *Lepomis* 10.02/hour (littoral). Mean CPUE was higher in the littoral location for *Lepomis* (P=0.0330), than the pelagic location (Table 8.16).

Hatching Dates

Hatching dates were calculated by subtracting the age of the larvae(days) from the collection date. Hatching data used larvae from both net tows and light traps. The majority of the larvae aged and the following discussion will be based on *Lepomis* and *Dorosoma* data; however, *Pomoxis* spp. in Coffeen Lake and Lake of Egypt, as well as *Micropterus* in Newton Lake also had a sufficient sample size to create prediction equations. Length-age prediction equations using aged 1998 larvae from the previously mentioned taxa for all three lakes (Figures 8.22-8.30) had significant positive relationships (P=0.0001) and high correlation coefficients. As one would expect, as total length increased, age prediction variance surrounding the regression line increased. This trend is expected, as growth rates can be drastically different as the larvae develop. Hatching date ranges by lake, year, and taxa are listed in Table 8.17.

In Newton Lake, hatching date ranges were slightly extended for *Lepomis* (3/31-10/01) and *Dorosoma* (3/11-7/01) in 1999 when compared to *Lepomis* (4/04-9/17) and *Dorosoma* (3/31-6/29) in 1998 (Table 8.17). In 1998, *Dorosoma* in Newton Lake had three distinct hatching pulses in all four segments (Figures 8.31-8.34). The three pulses were in early-April, late-April, and early-May in all four segments. A smaller pulse of *Dorosoma* hatched in mid-May in all four segments. In 1999, *Dorosoma* in Newton Lake had four distinct hatching pulses in all four segments (Figures 8.35-8.38). These pulses were in early-April, mid-April, late-April, and mid-May in all four segments. An additional hatching pulse in early-May of 1999 coincides with the last distinct hatching pulse in 1998. In 1998, *Lepomis* in Newton Lake hatched sporadically throughout the hatching date range (Figures 8.39-8.42). There was a greater overall number of *Lepomis* hatched in the cooler water segments 3 and 4 but in all four segments, *Lepomis* had a hatch in mid-September as mean daily temperatures declined. In 1999, *Lepomis* in Newton Lake hatched sporadically throughout the hatching date range (Figures 8.43-8.46). In segments 2-4, a hatching pulse in early August coincides with the peak mean daily temperatures of 1999. When those temperatures declined, another hatch of *Lepomis* occurred in mid-August.

In Coffeen Lake, hatching date ranges for *Lepomis* and *Dorosoma* were similar between years (Table 8.17). In 1998 and 1999, *Dorosoma* in Coffeen Lake had three distinct hatching pulses in both segments but segment 2 (cooler water) had a higher number of fish than segment 1 (Figures 8.47-8.50). The hatching pulses were similar to the pulses in Newton Lake in 1998, early-April, late-April, and early-May. In 1998, *Lepomis* in Coffeen Lake had continuous hatching from early-May to early August with sparse hatching numbers in late August and September (Figures 8.51-8.54). In 1999, hatching in both segments virtually stopped in late June as the water temperature increased. After the rapid decrease in water temperature in early August, *Lepomis* hatching proceeded again in both segments (Figures 8.53-8.54).

In Lake of Egypt, hatching date ranges for all taxa were similar between years (Table 8.17). In 1998, *Dorosoma* hatching in segment 1 began earlier than segment 2 but both segments had four distinct hatching pulses (Figures 8.55-8.56). In 1999, *Dorosoma* had four hatching pulses that were similar between segments (Figures 8.57-8.58). In segment 1, the majority of *Lepomis* hatched was during May and early June, while hatching continued through July and August in segment 2. This trend continued for both 1998 and 1999 (Figures 8.59-8.62).

When comparing between years, Newton Lake density and CPUE were higher in 1999 when compared to 1998 but there were no significant differences (Tables 8.18-8.19). Lake of Egypt had higher densities of *Lepomis* in net tows in 1998 (Table 8.18) when compared to 1999 but no other abundance differences in Lake of Egypt or Coffeen Lake were detected.

Discussion:

Gizzard shad (*Dorosoma cepedianum*) are consider to be spring spawners with one dominant density peak (Bodola 1966). Threadfin shad (*D. petenense*) spawn throughout the summer and fall (Heidinger 1977). The *Dorosoma* species sampled with both methods in all lakes were collected no later than late July with peaks in April or May. Adult threadfin shad were not collected in Newton or Coffeen so we are assuming all *Dorosoma* species captured are gizzard shad. Lake of Egypt has a threadfin shad population but no *Dorosoma* larvae were collected past mid-July.

Net Tows-Temporal and Spatial Distribution

Dorosoma was the dominant taxon in all three lakes over both years. In 1998, *Dorosoma* and *Lepomis* mean densities were higher in the cooler water than the warmer water segments. This coincides with Newman's (1981) findings that densities of larvae in Coffeen Lake increased with increased distance from the thermal discharge. Bergmann (1981), on the other hand found that densities of *Lepomis* larvae were highest in the discharge (warmer water) arm in Lake Sangchris, IL. Bergmann (1981) also found no temporal distribution differences in densities of

Dorosoma. In 1999, only *Dorosoma* in Coffeen Lake was significantly higher in the cooler water segment. Density trends in temporal distributions in Newton Lake and Coffeen Lake were similar to Lake of Egypt.

Lepomis mean densities were higher in the littoral versus pelagic locations for all three lakes and both years. Newman (1981) reported that *Lepomis* densities in Coffeen Lake were higher in shoreline areas than mid-lake areas. Storck et al. (1978) also reported higher littoral densities of *Lepomis* in Lake Shelbyville, IL. *Dorosoma* mean densities were higher in the littoral locations in 1998 Coffeen Lake and 1999 Newton Lake samples. In our study overall *Dorosoma* densities were evenly distributed throughout the spatial locations. Storck et al. (1978) reported similar results with large numbers of *Dorosoma* larvae in the pelagic locations.

In our study, in all lakes, all larvae captured were less than 13 mm in total length, suggesting gear avoidance by the larger, more mobile larvae. Largemouth bass were not captured with net tows. Largemouth bass males guard the schools of larvae after absorption of the yolk sac and their common habitat is shallow *water* close to or in dense vegetation (Holland and Huston 1983). After the schools break up, the bass move into heavily vegetated, shallow water. Net tows are not effective in this type of habitat.

Light Traps-Temporal and Spatial Distribution

Lepomis CPUE were significantly higher than any other taxa in Newton Lake and Coffeen Lake but not in Lake of Egypt. Perry (1981) also found light traps to be effective in attracting *Lepomis* larvae in Coffeen Lake. In Newton Lake, the cooler water intake segment had higher CPUE than the warmer water discharge segment in both years, similar to the supporting net tow data. The littoral location in Lake of Egypt also had higher CPUE of *Lepomis* than the pelagic location in 1998. *Lepomis* CPUE were higher in the littoral versus the pelagic locations for all three lakes and both years, similar to the net tow data. Fewer numbers of largemouth bass were captured in light traps from late April to early June in Newton Lake and Lake or Egypt. These largemouth bass were larger (8-32 mm total length) than the majority of larvae captured in the study. Largemouth bass seemed to be attracted to the light and were observed feeding on other larval fish.

Hatching Dates

Since the cooler water segments had higher mean densities and CPUE, we wanted to determine if hatching times were different among segments in each lake. In Newton Lake, the first hatching pulse of *Dorosoma* occurred in early April in all four segments in both years. This was somewhat surprising since mean daily surface temperatures ranged from 52-74°F. The first *Dorosoma* hatching pulse was also in early April in Coffeen Lake and Lake of Egypt with mean daily surface temperatures ranging from 63-78°F and 63-67°F, respectively. The *Dorosoma* hatching temperatures are similar to the range of spawning temperatures (62-73°F) reported by Bodola (1966) in Lake Erie. The number of *Dorosoma* hatching was higher in the cooler portion of all three lakes but the hatching date range was not altered among segments. This suggests that photoperiod had a greater influence on the hatching of *Dorosoma* than did the temperature.

Lepomis hatching began at the same time as *Dorosoma* so beginning hatching temperature ranges were similar to that of *Dorosoma*. *Lepomis* hatching began earlier in Newton Lake (early-April) when compared to Coffeen Lake (late-April) and Lake of Egypt (early-May). The end of the hatching date range of *Lepomis* extended into September in all three lakes. In all three lakes there were higher numbers of *Lepomis* in the cooler water segments than the warmer water segments. In Newton Lake, *Lepomis* hatching peaks in the non-discharge segments (2-4) coincided with the highest temperatures of the summer. After the surface temperatures in each segment declined, hatching continued in late August and early September in both 1998 and 1999. The same trend occurred in Coffeen Lake in 1998, but in 1999 *Lepomis* hatching virtually stopped in July as temperatures increased from 95-112°F. After the surface temperatures declined in the August, hatching continued. In Lake of Egypt, *Lepomis* hatching in the warmer segment virtually stopped in late-May in both years, while in the cooler segment, *Lepomis* hatching continued well into August. This suggests that *Lepomis* hatching were dictated by photoperiod and increasing and decreasing temperatures in all three lakes, especially in Newton Lake and Coffeen Lake.

The beginning of *Dorosoma* and *Lepomis* hatching date ranges in Newton Lake were similar and both larvae consume zooplankton when exogenous feeding begins. Garvey and Stein (1998) reported that *Dorosoma* deplete zooplankton and reduce *Lepomis* growth when *Dorosoma* spawn earlier than *Lepomis*. Even though the beginning hatching ranges were similar, the majority of *Lepomis* hatch in June and July, while by that time the hatching of *Dorosoma* had virtually stopped. In Newton Lake, total zooplankton (#/L) had decreased before many *Lepomis* had hatched and after many *Dorosoma* hatched (Figures 8.63-8.66). Due to reduced mobility in early development, larvae need food items in close proximity after their yolk sac in absorbed (Jobling 1995). *Lepomis* that hatched later in the summer may have lower recruitment through the winter and increased predation than larvae hatched earlier because of smaller size. This may be related to stored energy and increased vulnerability to predation.

In conclusion, larval fish mean densities and CPUE were higher in the cooler water segments of all three lakes. Net tows primarily captured *Dorosoma* while light traps primarily captured *Lepomis*. It is important to note that largemouth bass were only captured in light traps.

In Newton Lake, *Dorosoma* and *Lepomis* densities and CPUE increased from 1998 to 1999 but were not significantly different. The only significant difference in any of the three lakes was higher 1998 *Dorosoma* densities in net tows in Lake of Egypt. In all three lakes, *Lepomis* were concentrated in littoral locations while *Dorosoma* were more evenly distributed between littoral and pelagic locations. Contrary to Newman's (1981) findings, spawning duration was not restricted in the warmer water segments but overall numbers were lower when compared to the cooler water segments for all three lakes. The hatching date ranges were not restricted in Newton Lake or Coffeen Lake and were actually extended when compared to Lake of Egypt. Declining July and August total zooplankton abundance in Newton Lake could result in reduced fitness of late hatching *Lepomis*. Extreme summer temperatures in 1999 in Coffeen Lake reduced *Lepomis* hatching but after temperatures declined, hatching continued. Extreme temperatures in 1999 in Newton Lake did not reduce the hatching of *Lepomis* in non-discharge segments. Further research would be needed to determine if these trends are indicative of the long-term effects of the variance on Newton Lake.

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Table 8.1. Larval fish mean densities ($\#/m^3$) in Newton Lake sampled with net tows in 1998. Superscripts with different letters are significantly different among segments, by taxa, at alpha 0.05. Mean densities were calculated using samples within the time period of capture of each taxa.

Taxa	Segment	Density	Range	Std. dev.
Lepomis	1	0.0068^{a}	0 - 0.0832	0.0148
Lepomis	2	0.0129^{a}	0 - 0.1981	0.0255
Lepomis	3	0.0146^{a}	0 - 0.2089	0.0343
Lepomis	4	0.0174^{a}	0 - 0.3742	0.0498
Dorosoma	1	0.2998^{a}	0 - 1.9898	0.4702
Dorosoma	2	0.5334^{a}	0 - 3.3347	0.7858
Dorosoma	3	0.9434^{ab}	0 - 10.7906	1.9364
Dorosoma	4	1.4203^{b}	0 - 12.9895	2.5033
Morone	1	0.0013^{ab}	0 - 0.0242	0.0047
Morone	2	0.0000^{a}	0 - 0.0000	0.0000
Morone	3	0.0006^{ab}	0 - 0.0147	0.0029
Morone	4	0.0062^{b}	0 - 0.1309	0.0213
Cyprinidae	1	0.0011^{a}	0 - 0.0147	0.0036
Cyprinidae	2	0.0007^{a}	0 - 0.0129	0.0029
Cyprinidae	3	0.0000^{a}	0 - 0.0000	0.0000
Cyprinidae	4	0.0072^{a}	0 - 0.1163	0.0240
Pomoxis	1	0.0059^{a}	0 - 0.0253	0.0075
Pomoxis	2	0.0006^{b}	0 - 0.0132	0.0027
Pomoxis	3	0.0011^{b}	0 - 0.0137	0.0038
Pomoxis	4	0.0011^{b}	0 - 0.0137	0.0038
Percidae	1	0.0000^{a}	0 - 0.0000	0.0000
Percidae	2	0.0004^{a}	0 - 0.0145	0.0024
Percidae	3	0.0065^{ab}	0 - 0.0822	0.0171
Percidae	4	0.0080^{b}	0 - 0.0555	0.0155

Table 8.2. Larval fish mean densities (#/m^3) sampled with net tows in 1998. Superscripts with different letters are significantly different between segments, by taxa, at alpha 0.05. Mean densities were calculated using samples within the time period of capture of each taxa.

Lake	Taxa	Segment	Density	Range	Std. dev.
Coffeen	*Lepomis*	1	0.0030^a	0 - 0.0614	0.009
	Lepomis	2	0.0103^b	0 - 0.1341	0.022
	Dorosoma	1	0.0340^a	0 - 0.6437	0.086
	Dorosoma	2	0.1916^b	0 - 1.5038	0.321
	Morone	1	0.0022^a	0 - 0.0395	0.008
	Morone	2	0.0032^a	0 - 0.0236	0.007
	Cyprinidae	1	0.0000^a	0 - 0.0000	0.000
	Cyprinidae	2	0.0029^a	0 - 0.0303	0.007
	Pomoxis	1	0.0045^a	0 - 0.0383	0.008
	Pomoxis	2	0.0511^b	0 - 0.1816	0.053
Lake of Egypt	*Lepomis*	1	0.0678^a	0 - 1.1457	0.2050
	Lepomis	2	0.1215^a	0 - 4.8619	0.5383
	Dorosoma	1	0.0681^a	0 - 0.8888	0.1530
	Dorosoma	2	0.6134^b	0 - 12.9930	2.1139
	Cyprinidae	1	0.0028^a	0 - 0.0602	0.0106
	Cyprinidae	2	0.0000^a	0 - 0.0000	0.0000
	Pomoxis	1	0.0315^a	0 - 0.1278	0.0418
	Pomoxis	2	0.0496^a	0 - 0.2346	0.0541
	Percidae	1	0.0096^a	0 - 0.4359	0.0442
	Percidae	2	0.0084^a	0 - 0.4570	0.0445
	Atherinidae	1	0.0232^a	0 - 0.2390	0.0515
	Atherinidae	2	0.0021^b	0 - 0.0372	0.0062

Table 8.3. Larval fish mean densities ($\#/m^3$) in Newton Lake sampled with net tows in 1999. Superscripts with different letters are significantly different among segments, by taxa, at alpha 0.05. Mean densities were calculated using samples within the time period of capture of each taxa.

Taxa	Segment	Density	Range	Std. dev.
Lepomis	1	0.0112^{a}	0 - 0.2727	0.0340
Lepomis	2	0.0120^{a}	0 - 0.2533	0.0323
Lepomis	3	0.0186^{a}	0 - 0.2666	0.0476
Lepomis	4	0.0169^{a}	0 - 0.4291	0.0558
Dorosoma	1	0.7009^{a}	0 - 13.3963	2.0462
Dorosoma	2	1.0190^{a}	0 - 9.8992	2.0290
Dorosoma	3	1.0510^{a}	0 - 38.7903	4.2898
Dorosoma	4	0.9595^{a}	0 - 8.3818	1.7038
Morone	1	0.0004^{ab}	0 - 0.0126	0.0021
Morone	2	0.0000^{a}	0 - 0.0000	0.0000
Morone	3	0.0000^{a}	0 - 0.0000	0.0000
Morone	4	0.0023^{b}	0 - 0.0292	0.0068
Cyprinidae	1	0.0004^{a}	0 - 0.0138	0.0023
Cyprinidae	2	0.0000^{a}	0 - 0.0000	0.0000
Cyprinidae	3	0.0000^{a}	0 - 0.0000	0.0000
Cyprinidae	4	0.0007^{a}	0 - 0.0123	0.0028
Percidae	1	0.0013^{a}	0 - 0.0155	0.0042
Percidae	2	0.0006^{a}	0 - 0.0285	0.0041
Percidae	3	0.0040^{a}	0 - 0.1108	0.0166
Percidae	4	0.0028^{a}	0 - 0.0414	0.0091

Table 8.4. Larval fish mean densities (#/m^3) sampled with net tows in 1999. Superscripts with different letters are significantly different between segments, by taxa, at alpha 0.05. Mean densities were calculated using samples within the time period of capture of each taxa.

Lake	Taxa	Segment	Density	Range	Std. dev.
Coffeen	*Lepomis*	1	0.0007[a]	0 - 0.0468	0.0055
	Lepomis	2	0.0024[a]	0 - 0.0406	0.0078
	Dorosoma	1	0.0212[a]	0 - 0.1889	0.0400
	Dorosoma	2	0.1809[b]	0 - 2.1079	0.3754
Lake of Egypt	*Lepomis*	1	0.0255[a]	0 - 0.4620	0.0661
	Lepomis	2	0.0235[a]	0 - 0.3763	0.0513
	Dorosoma	1	0.4557[a]	0 - 20.6104	2.1793
	Dorosoma	2	0.2823[a]	0 - 5.5845	0.7496
	Morone	1	0.0000[a]	0 - 0.0000	0.0000
	Morone	2	0.0013[a]	0 - 0.0152	0.0044
	Cyprinidae	1	0.0067[a]	0 - 0.0299	0.0105
	Cyprinidae	2	0.0006[b]	0 - 0.0148	0.0030
	Pomoxis	1	0.3685[a]	0 - 12.3662	2.0572
	Pomoxis	2	0.0130[a]	0 - 0.0631	0.0168
	Percidae	1	0.0049[a]	0 - 0.0440	0.0096
	Percidae	2	0.0071[a]	0 - 0.0601	0.0153
	Atherinidae	1	0.0077[a]	0 - 0.2310	0.0294
	Atherinidae	2	0.0010[b]	0 - 0.0156	0.0037

Table 8.5. Larval fish mean CPUE (#/hour) in Newton Lake sampled with light traps in 1998. Superscripts with different letters are significantly different among segments, by taxa, at alpha 0.05. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Taxa	Segment	CPUE	Range	Std. dev.
Lepomis	1	1.21[a]	0 - 13.35	2.89
Lepomis	2	4.16[ab]	0 - 55.28	9.94
Lepomis	3	6.87[ab]	0 - 63.56	14.26
Lepomis	4	8.48[b]	0 - 78.33	17.39
Dorosoma	1	0.58[a]	0 - 5.75	1.36
Dorosoma	2	0.89[a]	0 - 9.16	2.10
Dorosoma	3	3.11[a]	0 - 66.36	12.47
Dorosoma	4	5.19[a]	0 - 62.81	15.42
Pomoxis	1	0.73[a]	0 - 5.45	1.91
Pomoxis	2	0.00[a]	0 - 0.00	0.00
Pomoxis	3	0.00[a]	0 - 0.00	0.00
Pomoxis	4	0.23[a]	0 - 1.40	0.50
Morone	1	0.08[a]	0 - 0.34	0.17
Morone	2	0.10[a]	0 - 0.40	0.20
Morone	3	0.09[a]	0 - 0.39	0.19
Morone	4	0.10[a]	0 - 0.41	0.20
Cyprinidae	1	0.88[a]	0 - 8.92	2.54
Cyprinidae	2	0.00[a]	0 - 0.00	0.00
Cyprinidae	3	0.00[a]	0 - 0.00	0.00
Cyprinidae	4	0.03[a]	0 - 0.46	0.13
Micropterus	1	1.22[a]	0 - 8.90	2.54
Micropterus	2	2.57[a]	0 - 12.08	4.40
Micropterus	3	1.31[a]	0 - 13.95	3.99
Micropterus	4	0.00[a]	0 - 0.00	0.00
Percidae	1	0.00[a]	0 - 0.00	0.00
Percidae	2	0.03[a]	0 - 0.44	0.12
Percidae	3	1.13[a]	0 - 9.79	2.82
Percidae	4	0.00[a]	0 - 0.00	0.00

Table 8.6. Larval fish mean CPUE (#/hour) sampled with light traps in 1998. Superscripts with different letters are significantly different between segments, by taxa, at alpha 0.05. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Lake	Taxa	Segment	CPUE	Range	Std. dev.
Coffeen	*Lepomis*	1	1.64[a]	0 - 11.80	3.29
	Lepomis	2	3.16[a]	0 - 40.80	7.34
	Dorosoma	1	0.70[a]	0 - 8.64	2.17
	Dorosoma	2	0.57[a]	0 - 8.36	1.75
	Pomoxis	1	4.43[a]	0 - 30.00	10.44
	Pomoxis	2	0.61[a]	0 - 2.00	0.78
	Cyprinidae	1	0.12[a]	0 - 0.48	0.24
	Cyprinidae	2	0.12[a]	0 - 0.49	0.24
	Micropterus	1	0.04[a]	0 - 0.48	0.14
	Micropterus	2	0.04[a]	0 - 0.49	0.14
Lake of Egypt	*Lepomis*	1	1.21[a]	0 - 13.50	2.93
	Lepomis	2	4.46[b]	0 - 36.00	8.23
	Dorosoma	1	2.90[a]	0 - 39.16	7.96
	Dorosoma	2	11.01[a]	0 - 153.97	32.01
	Pomoxis	1	0.00[a]	0 - 0.00	0.00
	Pomoxis	2	3.07[a]	0 - 19.30	6.19
	Cyprinidae	1	0.00[a]	0 - 0.00	0.00
	Cyprinidae	2	0.12[a]	0 - 0.48	0.24
	Micropterus	1	1.06[a]	0 - 8.03	2.82
	Micropterus	2	0.54[a]	0 - 2.34	0.85
	Percidae	1	0.03[a]	0 - 0.44	0.12
	Percidae	2	0.83[a]	0 - 6.56	1.93
	Atherinidae	1	8.16[a]	0 - 100.62	18.25
	Atherinidae	2	0.65[b]	0 - 7.93	1.48

Table 8.7. Larval fish mean CPUE (#/hour) in Newton Lake sampled with light traps in 1999. Superscripts with different letters are significantly different among segments, by taxa, at alpha 0.05. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Taxa	Segment	CPUE	Range	Std. dev.
Lepomis	1	1.66[a]	0 - 17.35	4.34
Lepomis	2	18.90[ab]	0 - 250.26	44.15
Lepomis	3	18.73[ab]	0 - 314.42	54.27
Lepomis	4	71.04[b]	0 - 1010.42	200.96
Dorosoma	1	3.44[a]	0 - 63.45	12.29
Dorosoma	2	5.25[a]	0 - 80.54	16.24
Dorosoma	3	8.21[a]	0 - 110.23	22.60
Dorosoma	4	8.49[a]	0 - 184.83	34.70
Morone	1	0.22[a]	0 - 0.88	0.44
Morone	2	0.00[a]	0 - 0.00	0.00
Morone	3	0.12[a]	0 - 0.48	0.24
Morone	4	0.11[a]	0 - 0.44	0.22
Cyprinidae	1	0.18[a]	0 - 1.45	0.43
Cyprinidae	2	0.00[a]	0 - 0.00	0.00
Cyprinidae	3	0.03[a]	0 - 0.48	0.12
Cyprinidae	4	0.07[a]	0 - 0.92	0.26
Micropterus	1	0.28[a]	0 - 2.41	0.62
Micropterus	2	0.14[a]	0 - 1.00	0.28
Micropterus	3	8.19[a]	0 - 158.57	35.40
Micropterus	4	2.86[a]	0 - 24.00	7.32
Percidae	1	0.04[a]	0 - 0.48	0.13
Percidae	2	0.04[a]	0 - 0.50	0.14
Percidae	3	0.32[a]	0 - 1.41	0.52
Percidae	4	0.10[a]	0 - 0.93	0.31

Table 8.8. Larval fish mean CPUE (#/hour) sampled with light traps in 1999. Superscripts with different letters are significantly different between segments, by taxa, at alpha 0.05. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Lake	Taxa	Segment	CPUE	Range	Std. dev.
Coffeen	*Lepomis*	1	25.03[a]	0 - 579.66	102.25
	Lepomis	2	8.98[a]	0 - 85.00	19.82
	Dorosoma	1	2.35[a]	0 - 36.80	7.38
	Dorosoma	2	0.61[a]	0 - 10.67	2.17
	Micropterus	1	0.50[a]	0 - 3.50	1.22
	Micropterus	2	0.12[a]	0 - 1.01	0.35
	Percidae	1	0.12[a]	0 - 0.50	0.25
	Percidae	2	0.00[a]	0 - 0.00	0.00
	Atherinidae	1	0.05[a]	0 - 1.00	0.19
	Atherinidae	2	0.09[a]	0 - 1.50	0.31
Lake of Egypt	*Lepomis*	1	1.26[a]	0 - 21.50	4.04
	Lepomis	2	9.62[a]	0 - 99.50	23.86
	Dorosoma	1	0.34[a]	0 - 5.50	1.03
	Dorosoma	2	7.14[a]	0 - 109.00	21.73
	Pomoxis	1	0.02[a]	0 - 1.04	0.15
	Pomoxis	2	0.62[a]	0 - 16.63	2.89
	Cyprinidae	1	1.97[a]	0 - 18.00	5.15
	Cyprinidae	2	1.70[a]	0 - 23.69	5.90
	Micropterus	1	2.58[a]	0 - 30.50	8.79
	Micropterus	2	0.12[a]	0 - 1.00	0.31
	Percidae	1	0.00[a]	0 - 0.00	0.00
	Percidae	2	0.25[a]	0 - 1.50	0.50
	Atherinidae	1	19.54[a]	0 - 308.50	70.68
	Atherinidae	2	0.16[a]	0 - 2.50	0.46

Table 8.9. Larval fish mean densities (#/m^3) in Newton Lake sampled with net tows in 1998. Superscripts with different letter are significantly different between locations, by taxa, at alpha 0.05. Mean densities were calculated using samples within the time period of capture of each taxa.

Taxa	Location	Density	Range	Std. dev.
Lepomis	Littoral	0.0206[a]	0 - 0.3742	0.0449
Lepomis	Pelagic	0.0053[b]	0 - 0.0961	0.0120
Dorosoma	Littoral	0.9233[a]	0 - 10.7906	1.6217
Dorosoma	Pelagic	0.6751[a]	0 - 12.9895	1.7570
Morone	Littoral	0.0032[a]	0 - 0.1309	0.0154
Morone	Pelagic	0.0008[a]	0 - 0.0145	0.0033
Cyprinidae	Littoral	0.0039[a]	0 - 0.1163	0.0172
Cyprinidae	Pelagic	0.0005[a]	0 - 0.0264	0.0034
Pomoxis	Littoral	0.0033[a]	0 - 0.0253	0.0063
Pomoxis	Pelagic	0.0010[b]	0 - 0.0134	0.0035
Percidae	Littoral	0.0072[a]	0 - 0.0822	0.0163
Percidae	Pelagic	0.0002[b]	0 - 0.0145	0.0017

Table 8.10. Larval fish mean densities (#/m^3) in Newton Lake sampled with net tows in 1999. Superscripts with different letters are significantly different between locations, by taxa, at alpha 0.05. Mean densities were calculated using samples within the time period of capture of each taxa.

Taxa	Location	Density	Range	Std. dev.
Lepomis	Littoral	0.0249[a]	0 - 0.4291	0.0583
Lepomis	Pelagic	0.0044[b]	0 - 0.1124	0.0136
Dorosoma	Littoral	1.2287[a]	0 - 38.7903	3.5439
Dorosoma	Pelagic	0.6204[b]	0 - 7.9568	1.2721
Morone	Littoral	0.0004[a]	0 - 0.0134	0.0023
Morone	Pelagic	0.0007[a]	0 - 0.0292	0.0041
Cyprinidae	Littoral	0.0003[a]	0 - 0.0123	0.0020
Cyprinidae	Pelagic	0.0002[a]	0 - 0.0138	0.0016
Percidae	Littoral	0.0042[a]	0 - 0.1108	0.0137
Percidae	Pelagic	0.0001[b]	0 - 0.0137	0.0014

Table 8.11. Larval fish mean densities (#/m^3) sampled with net tows in 1998. Superscripts with different letters are significantly different between locations, by taxa, at alpha 0.05. Mean densities were calculated using samples within the time period of capture of each taxa.

Lake	Taxa	Location	Density	Range	Std. dev.
Coffeen	*Lepomis*	Littoral	0.0107[a]	0 - 0.1341	0.0220
	Lepomis	Pelagic	0.0027[b]	0 - 0.0379	0.0076
	Dorosoma	Littoral	0.1444[a]	0 - 1.5038	0.2962
	Dorosoma	Pelagic	0.0803[b]	0 - 1.1966	0.1818
	Morone	Littoral	0.0012[a]	0 - 0.0152	0.0041
	Morone	Pelagic	0.0041[a]	0 - 0.0395	0.0095
	Cyprinidae	Littoral	0.0019[a]	0 - 0.0303	0.0068
	Cyprinidae	Pelagic	0.0000[a]	0 - 0.0000	0.0000
	Pomoxis	Littoral	0.0339[a]	0 - 0.1816	0.0533
	Pomoxis	Pelagic	0.0208[a]	0 - 0.1111	0.0327
Lake of Egypt	*Lepomis*	Littoral	0.1072[a]	0 - 1.1457	0.2258
	Lepomis	Pelagic	0.0821[a]	0 - 4.8619	0.5310
	Dorosoma	Littoral	0.2875[a]	0 - 12.9930	1.4421
	Dorosoma	Pelagic	0.3940[a]	0 - 12.8420	1.5991
	Cyprinidae	Littoral	0.0017[a]	0 - 0.0602	0.0100
	Cyprinidae	Pelagic	0.0012[a]	0 - 0.0145	0.0039
	Pomoxis	Littoral	0.0478[a]	0 - 0.1874	0.0501
	Pomoxis	Pelagic	0.0333[a]	0 - 0.2346	0.0472
	Percidae	Littoral	0.0170[a]	0 - 0.4570	0.0615
	Percidae	Pelagic	0.0010[b]	0 - 0.0295	0.0043
	Atherinidae	Littoral	0.0188[a]	0 - 0.2390	0.0493
	Atherinidae	Pelagic	0.0065[b]	0 - 0.1412	0.0204

Table 8.12. Larval fish mean densities (#/m^3) sampled with net tows in 1999. Superscripts with different letters are significantly different between locations, by taxa, at alpha 0.05. Mean densities were calculated using samples within the time period of capture of each taxa.

Lake	Taxa	Location	Density	Range	Std. dev.
Coffeen	*Lepomis*	Littoral	0.0022[a]	0 - 0.0468	0.0085
	Lepomis	Pelagic	0.0009[a]	0 - 0.0311	0.0045
	Dorosoma	Littoral	0.1195[a]	0 - 2.1079	0.3228
	Dorosoma	Pelagic	0.0792[a]	0 - 1.5296	0.2176
Lake of Egypt	*Lepomis*	Littoral	0.0396[a]	0 - 0.4620	0.0782
	Lepomis	Pelagic	0.0094[b]	0 - 0.1087	0.0206
	Dorosoma	Littoral	0.2761[a]	0 - 5.5845	0.7908
	Dorosoma	Pelagic	0.4619[a]	0 - 20.6104	2.1641
	Morone	Littoral	0.0013[a]	0 - 0.0152	0.0044
	Morone	Pelagic	0.0000[a]	0 - 0.0000	0.0000
	Cyprinidae	Littoral	0.0031[a]	0 - 0.0289	0.0075
	Cyprinidae	Pelagic	0.0042[a]	0 - 0.0299	0.0091
	Pomoxis	Littoral	0.0163[a]	0 - 0.1573	0.0310
	Pomoxis	Pelagic	0.3652[a]	0 - 12.3662	2.0577
	Percidae	Littoral	0.0101[a]	0 - 0.0601	0.0158
	Percidae	Pelagic	0.0019[b]	0 - 0.0340	0.0068
	Atherinidae	Littoral	0.0077[a]	0 - 0.2310	0.0292
	Atherinidae	Pelagic	0.0011[b]	0 - 0.0433	0.0052

Table 8.13. Larval fish mean CPUE (#/hour) in Newton Lake sampled with light traps in 1998. Superscripts with different letters are significantly different between locations, by taxa, at alpha 0.05. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Taxa	Location	CPUE	Range	Std. dev.
Lepomis	Littoral	9.45[a]	0 - 78.33	16.62
Lepomis	Pelagic	0.91[b]	0 - 8.76	2.11
Dorosoma	Littoral	4.43[a]	0 - 66.36	13.91
Dorosoma	Pelagic	0.46[b]	0 - 7.96	1.28
Morone	Littoral	0.14[a]	0 - 0.41	0.20
Morone	Pelagic	0.04[a]	0 - 0.39	0.14
Pomoxis	Littoral	0.48[a]	0 - 5.45	1.37
Pomoxis	Pelagic	0.00[a]	0 - 0.00	0.00
Cyprinidae	Littoral	0.44[a]	0 - 8.92	1.81
Cyprinidae	Pelagic	0.01[a]	0 - 0.45	0.09
Micropterus	Littoral	2.20[a]	0 - 13.95	4.39
Micropterus	Pelagic	0.34[b]	0 - 2.95	0.77
Percidae	Littoral	0.57[a]	0 - 9.79	2.04
Percidae	Pelagic	0.01[a]	0 - 0.39	0.08

Table 8.14. Larval fish mean CPUE (#/hour) in Newton Lake sampled with light traps in 1999. Superscripts with different letters are significantly different between locations, by taxa, at alpha 0.05. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Taxa	Location	CPUE	Range	Std. dev.
Lepomis	Littoral	49.89[a]	0 - 1010.42	145.18
Lepomis	Pelagic	3.54[b]	0 - 58.98	8.68
Dorosoma	Littoral	9.24[a]	0 - 184.83	27.56
Dorosoma	Pelagic	3.22[a]	0 - 110.23	15.04
Morone	Littoral	0.22[a]	0 - 0.88	0.34
Morone	Pelagic	0.00[a]	0 - 0.00	0.00
Cyprinidae	Littoral	0.13[a]	0 - 1.45	0.35
Cyprinidae	Pelagic	0.00[b]	0 - 0.00	0.00
Micropterus	Littoral	5.37[a]	0 - 158.57	25.63
Micropterus	Pelagic	0.23[a]	0 - 2.62	0.52
Percidae	Littoral	0.25[a]	0 - 1.41	0.43
Percidae	Pelagic	0.00[b]	0 - 0.00	0.00

Table 8.15. Larval fish mean CPUE (#/hour) sampled with light traps in 1998. Superscripts with different letters are significantly different between locations, by taxa, at alpha 0.05. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Lake	Taxa	Location	CPUE	Range	Std. dev.
Coffeen	*Lepomis*	Littoral	4.26^{a}	0 - 40.80	7.45
	Lepomis	Pelagic	0.53^{b}	0 - 10.41	1.82
	Dorosoma	Littoral	0.80^{a}	0 - 8.64	2.19
	Dorosoma	Pelagic	0.47^{a}	0 - 8.36	1.71
	Pomoxis	Littoral	5.05^{a}	0 - 30.00	10.17
	Pomoxis	Pelagic	0.00^{a}	0 - .00	0.00
	Cyprinidae	Littoral	0.24^{a}	0 - 0.49	0.28
	Cyprinidae	Pelagic	0.00^{a}	0 - 0.00	0.00
	Micropterus	Littoral	0.04^{a}	0 - 0.48	0.14
	Micropterus	Pelagic	0.04^{a}	0 - 0.49	0.14
Lake of Egypt	*Lepomis*	Littoral	4.54^{a}	0 - 36.00	8.40
	Lepomis	Pelagic	1.14^{b}	0 - 9.42	2.26
	Dorosoma	Littoral	10.40^{a}	0 - 153.97	32.20
	Dorosoma	Pelagic	3.51^{a}	0 - 39.16	7.78
	Pomoxis	Littoral	3.07^{a}	0 - 19.33	6.19
	Pomoxis	Pelagic	0.00^{a}	0 - 0.00	0.00
	Cyprinidae	Littoral	0.12^{a}	0 - 0.48	0.24
	Cyprinidae	Pelagic	0.00^{a}	0 - 0.00	0.00
	Micropterus	Littoral	1.54^{a}	0 - 8.03	2.74
	Micropterus	Pelagic	0.05^{a}	0 - 0.46	0.16
	Percidae	Littoral	0.83^{a}	0 - 6.56	1.93
	Percidae	Pelagic	0.03^{a}	0 - 0.44	0.12
	Atherinidae	Littoral	5.07^{a}	0 - 100.62	16.63
	Atherinidae	Pelagic	3.74^{a}	0 - 42.32	9.29

Table 8.16. Larval fish mean CPUE (#/hour) sampled with light traps in 1999. Superscripts with different letters are significantly different between locations, by taxa at alpha 0.05. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Lake	Taxa	Location	CPUE	Range	Std. dev.
Coffeen	*Lepomis*	Littoral	31.36^{a}	0 - 579.66	102.44
	Lepomis	Pelagic	2.65^{a}	0 - 41.37	7.92
	Dorosoma	Littoral	2.49^{a}	0 - 36.80	7.63
	Dorosoma	Pelagic	0.46^{a}	0 - 2.43	0.69
	Micropterus	Littoral	0.56^{a}	0 - 3.50	1.23
	Micropterus	Pelagic	0.06^{a}	0 - 0.50	0.17
	Percidae	Littoral	0.12^{a}	0 - 0.50	0.25
	Percidae	Pelagic	0.00^{a}	0 - 0.00	0.00
	Atherinidae	Littoral	0.09^{a}	0 - 1.00	0.26
	Atherinidae	Pelagic	0.05^{a}	0 - 1.50	0.26
Lake of Egypt	*Lepomis*	Littoral	10.02^{a}	0 - 99.50	23.93
	Lepomis	Pelagic	0.86^{b}	0 - 12.89	2.46
	Dorosoma	Littoral	4.86^{a}	0 - 109.00	19.80
	Dorosoma	Pelagic	2.61^{a}	0 - 56.50	10.11
	Pomoxis	Littoral	0.61^{a}	0 - 16.63	2.86
	Pomoxis	Pelagic	0.02^{a}	0 - 0.99	0.14
	Cyprinidae	Littoral	2.39^{a}	0 - 23.69	6.36
	Cyprinidae	Pelagic	1.28^{a}	0 - 18.00	4.50
	Micropterus	Littoral	2.70^{a}	0 - 30.50	8.75
	Micropterus	Pelagic	0.00^{a}	0 - 0.00	0.00
	Percidae	Littoral	0.25^{a}	0 - 1.50	0.50
	Percidae	Pelagic	0.00^{a}	0 - 0.00	0.00
	Atherinidae	Littoral	9.83^{a}	0 - 308.50	51.44
	Atherinidae	Pelagic	9.87^{a}	0 - 302.47	50.42

Table 8.17. Hatching date ranges for 1998-99 by taxa in three Illinois power cooling reservoirs. In 1998 and 1999, hatching dates were calculated using the 1998 aged larvae and their subsequent length-age linear regression prediction equations. The initial temperature is the lowest temperature at the beginning of the hatching range. The ending temperature is the highest temperature at the end of the hatching range.

					Hatching Range Temp (°F)	
Lake	Year	Taxa	Hatching Date Range	Days	Initial	Ending
Newton Lake	1998	*Lepomis*	4/15-9/19	158	56	94
		Dorosoma	3/27-6/30	96	60	100
		Morone[2]	4/04-5/15[1]	42		
		Micropterus	4/05-5/09[1]	35		
	1999	*Lepomis*	3/31-10/01	185	70	87
		Dorosoma	3/11-7/01	113	52	92
		Morone[2]	3/14-5/03[1]	51		
		Micropterus	3/27-5/11[1]	44		
Coffeen Lake	1998	*Lepomis*	4/23-10/04	165	78	84
		Dorosoma	3/29-6/27	81	62	97
		Morone[2]	4/04-4/28[1]	25		
		Pomoxis	4/08-5/14[1]	37		
	1999	*Lepomis*	5/02-9/10	132	80	103
		Dorosoma	3/21-7/09	111	67	100
Lake of Egypt	1998	*Lepomis*	5/09-9/05	120	67	91
		Dorosoma	4/03-6/29	88	63	92
		Pomoxis	4/01-5/05[1]	35		
		Micropterus[2]	4/26-5/20[1]	25		
	1999	*Lepomis*	5/01-9/08	131	74	87
		Dorosoma	4/08-7/16	100	63	89
		Pomoxis	4/04-5/06[1]	33		
		Micropterus[2]	4/19-5/24[1]	36		

[1]Hatching range temperatures fall within the ranges for those of *Dorosoma* for that year.
[2]Hatching range was calculated from a length-age linear regression equation developed from a small sample size of fish and having relatively low R^2 values.

Table 8.18. Mean densities (#/m^3) of larval fish (all segments combined) in three Illinois power cooling reservoirs. Superscripts with different letters are significantly different between years, within taxa, at alpha = 0.05. Mean densities were calculated using samples within the time period of capture of each taxa.

Lake	Year	Taxa	Density	Range	Std.Dev.
Newton Lake	1998	*Lepomis*	0.0129^a	0-0.0842	0.0174
	1999	*Lepomis*	0.0146^a	0-0.0970	0.0244
	1998	*Dorosoma*	0.7992^a	0-4.6318	1.1534
	1999	*Dorosoma*	0.9326^a	0-5.5988	1.5106
Coffeen Lake	1998	*Lepomis*	0.0067^a	0-0.0441	0.0106
	1999	*Lepomis*	0.0015^a	0-0.0075	0.0024
	1998	*Dorosoma*	0.1123^a	0-0.6234	0.1931
	1999	*Dorosoma*	0.1038^a	0-0.8778	0.2312
Lake of Egypt	1998	*Lepomis*	0.0946^a	0-0.4197	0.1266
	1999	*Lepomis*	0.0245^b	0-0.1107	0.0326
	1998	*Dorosoma*	0.3407^a	0-3.9256	1.0363
	1999	*Dorosoma*	0.3691^a	0-1.833	0.6348

Table 8.19. Mean CPUE (#/hour) of larval fish (all segments combined) collected with light traps in three Illinois power cooling reservoirs. Superscripts with different letters are significantly different between segments, within taxa, at alpha = 0.05. Mean CPUE was calculated using samples within the time period of capture of each taxa.

Lake	Year	Taxa	CPUE	Range	Std.Dev.
Newton Lake	1998	*Lepomis*	5.18[a]	0-30.35	8.01
	1999	*Lepomis*	26.75[a]	0-383.37	68.26
	1998	*Dorosoma*	2.45[a]	0-32.00	6.74
	1999	*Dorosoma*	6.26[a]	0-49.94	12.77
	1998	*Micropterus*	1.27[a]	0-4.53	1.81
	1999	*Micropterus*	2.72[a]	0-40.72	9.29
Coffeen Lake	1998	*Lepomis*	2.4[a]	0-14.94	3.56
	1999	*Lepomis*	17.01[a]	0-152.57	37.38
	1998	*Dorosoma*	0.64[a]	0-2.69	0.98
	1999	*Dorosoma*	1.48[a]	0-9.68	2.76
	1998	*Micropterus*	0.04[a]	0-.12	0.06
	1999	*Micropterus*	0.31[a]	0-1.00	0.47
Lake of Egypt	1998	*Lepomis*	2.84[a]	0-15.47	4.43
	1999	*Lepomis*	5.44[a]	0-46.09	12.35
	1998	*Dorosoma*	6.96[a]	0-56.64	14.96
	1999	*Dorosoma*	3.74[a]	0-36.29	9.36
	1998	*Micropterus*	0.8[a]	0-2.12	0.91
	1999	*Micropterus*	1.35[a]	0-7.75	3.13

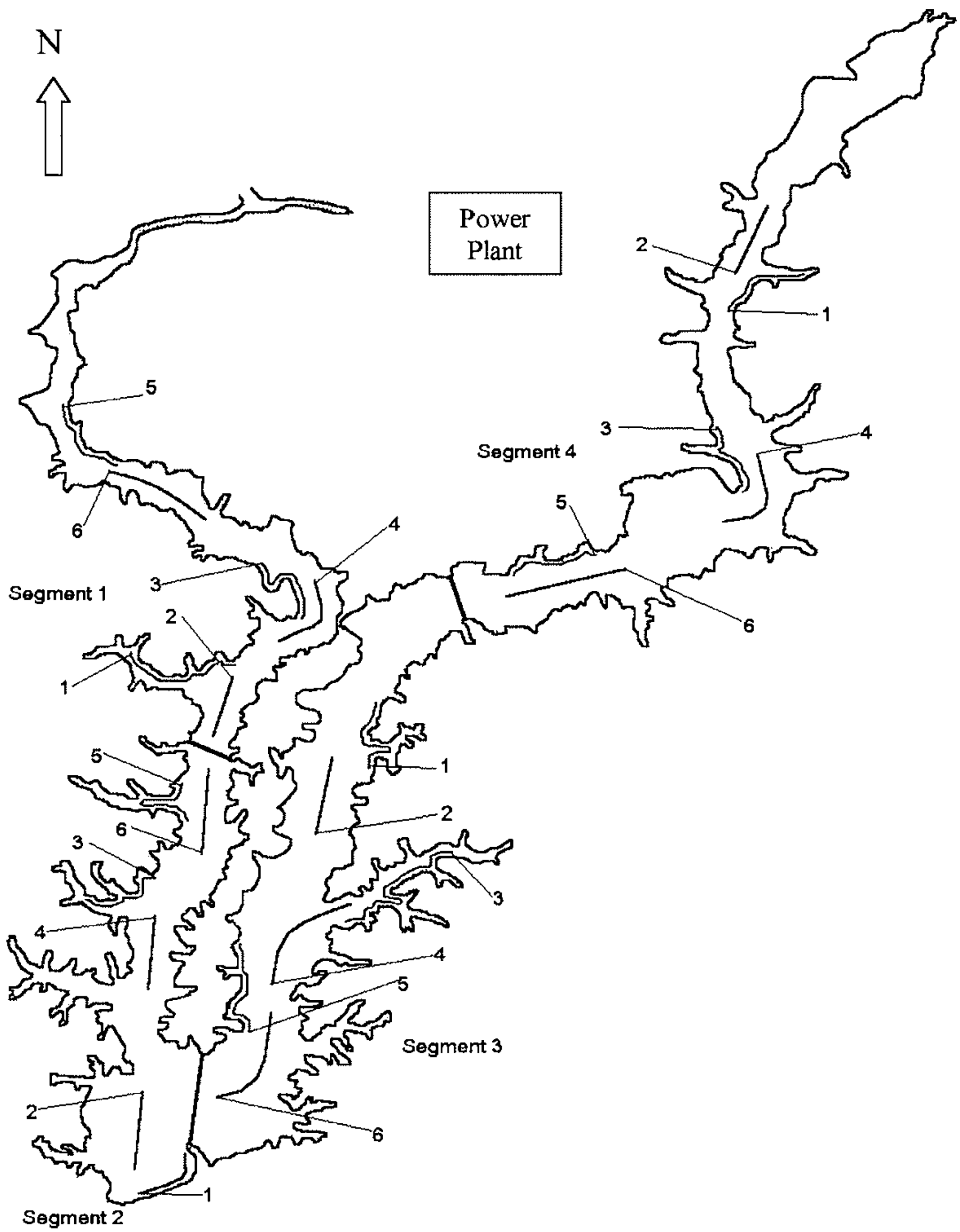

Figure 8.1. Ichthyoplankton sampling stations for net tows in 1997-99 on Newton Lake, IL.

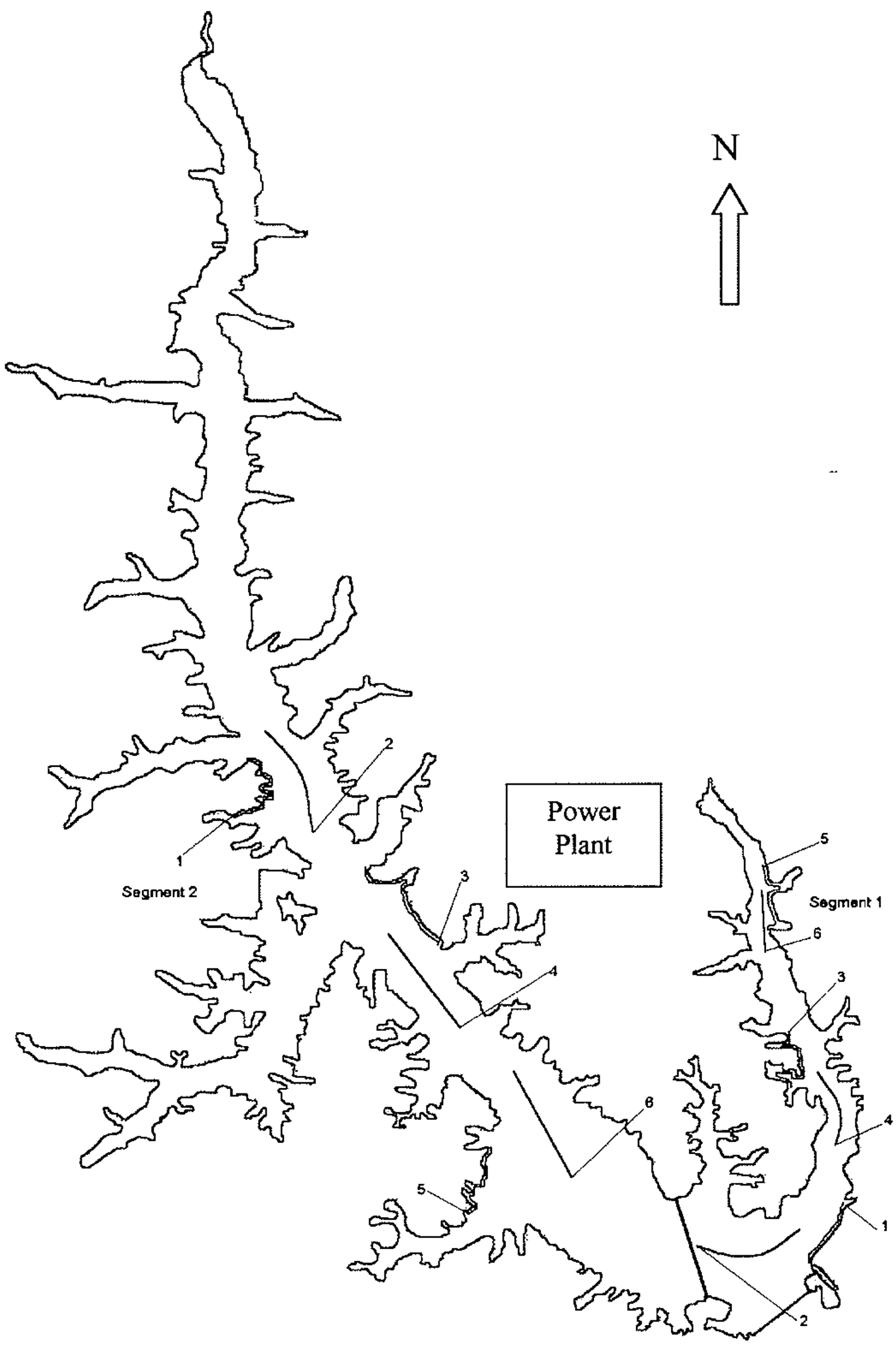

Figure 8.2. Ichthyoplankton sampling stations for net tows in 1997-99 on Coffeen Lake, IL.

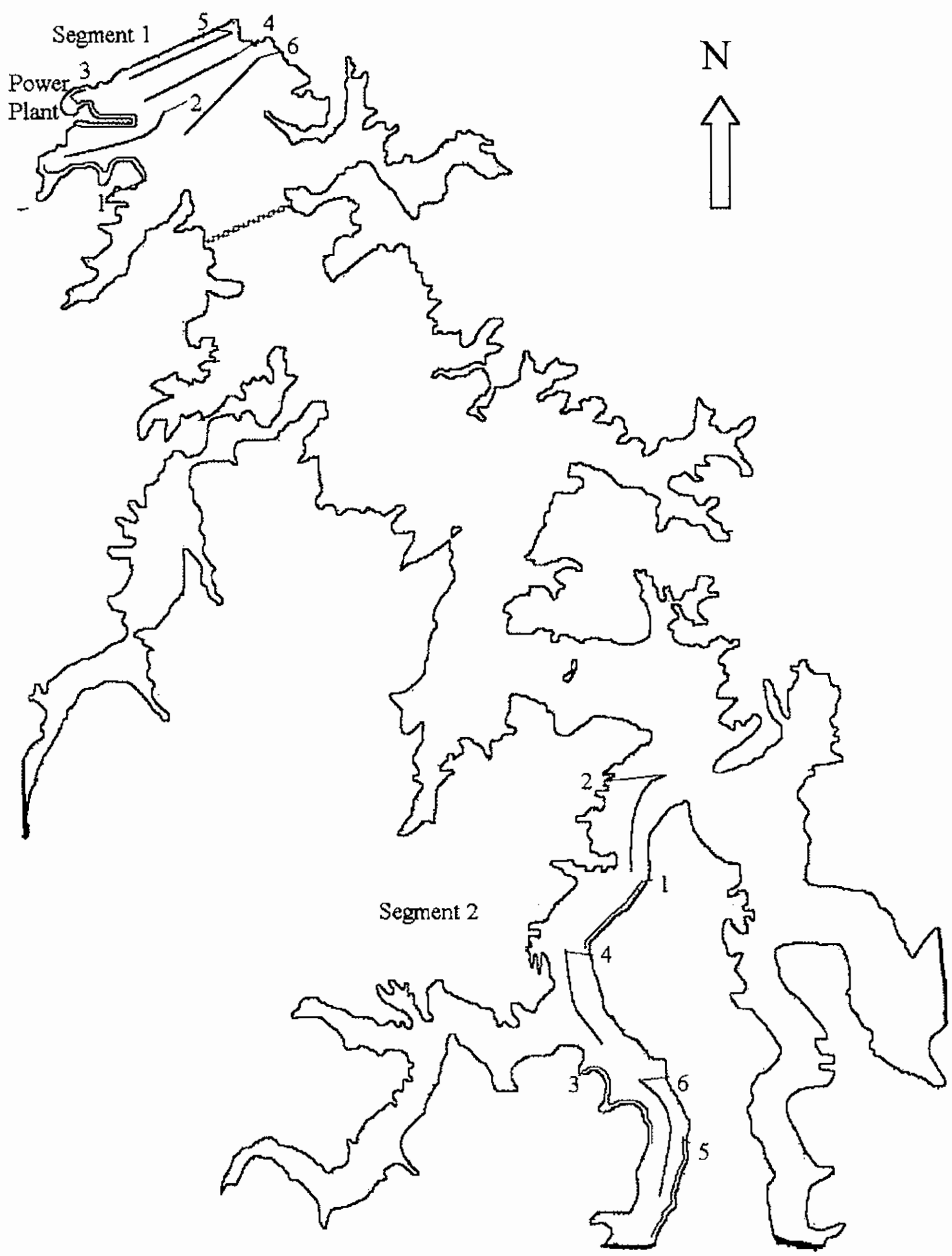

Figure 8.3. Ichthyoplankton sampling stations for net tows in 1997-99 on Lake of Egypt, IL.

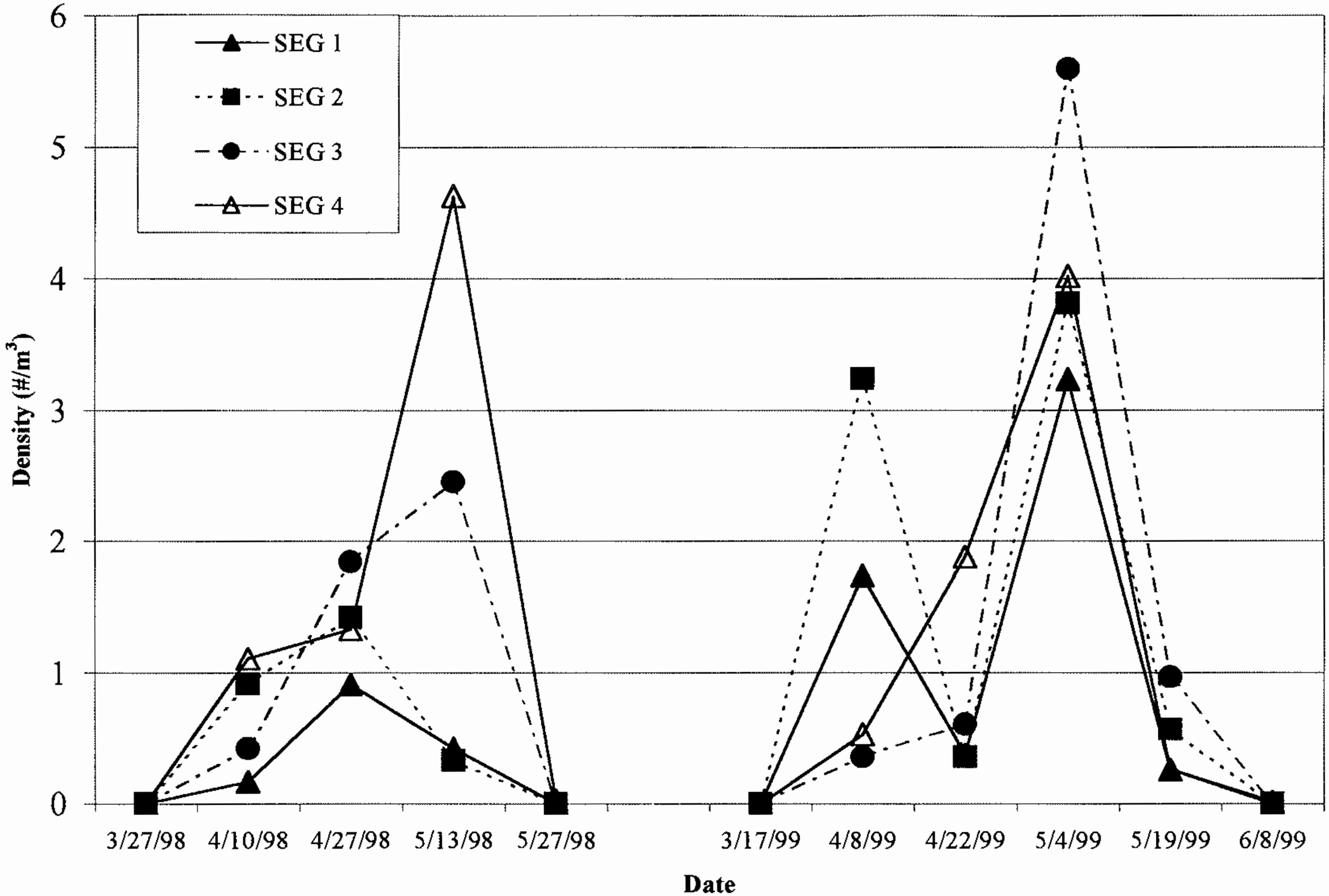

Figure 8.4. Mean densities (#/m^3) of *Dorosoma* sampled with net tows in Newton Lake in 1998-99.

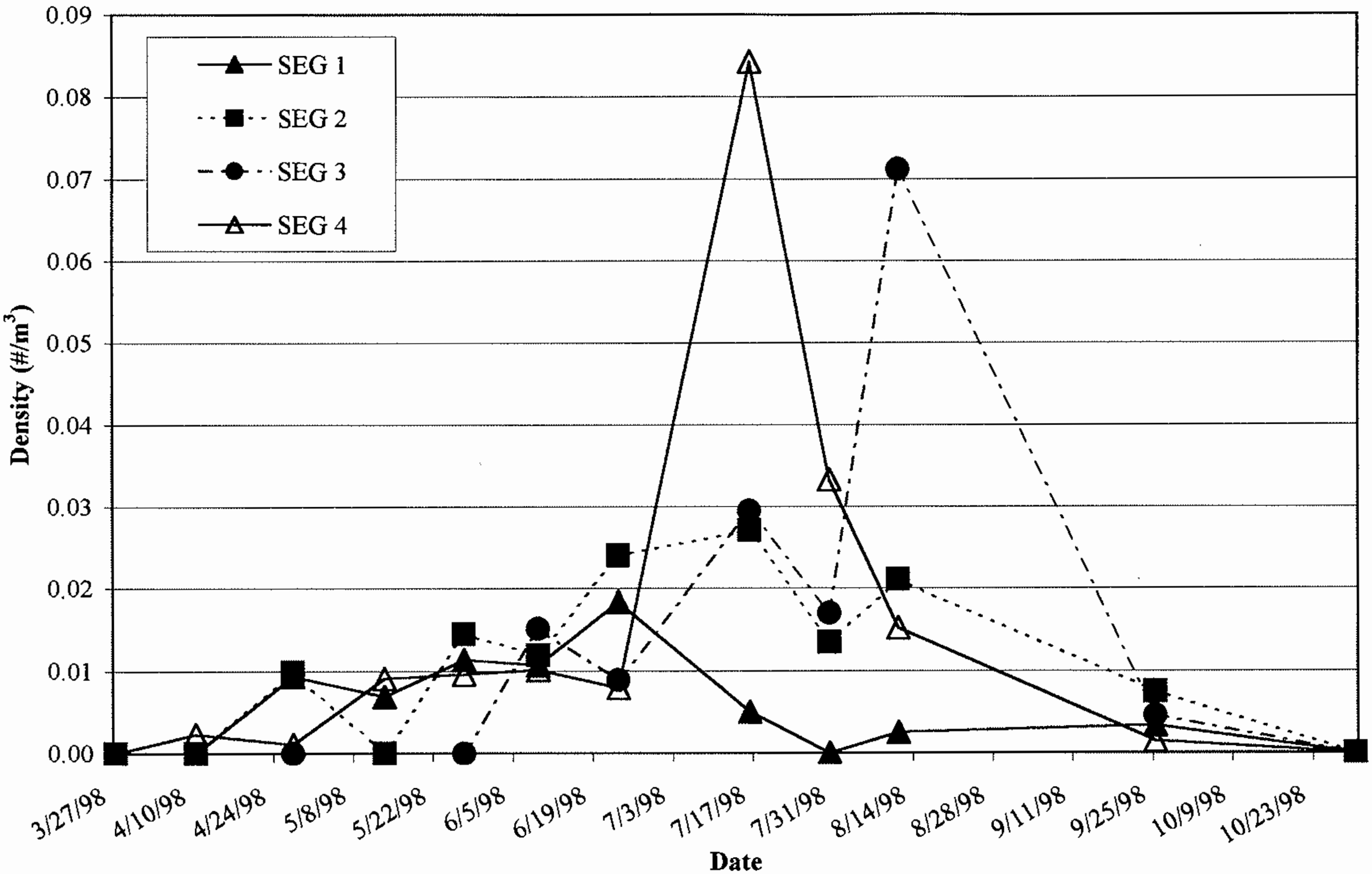

Figure 8.5. Mean densities (#/m^3) of *Lepomis* sampled with net tows in Newton Lake in 1998.

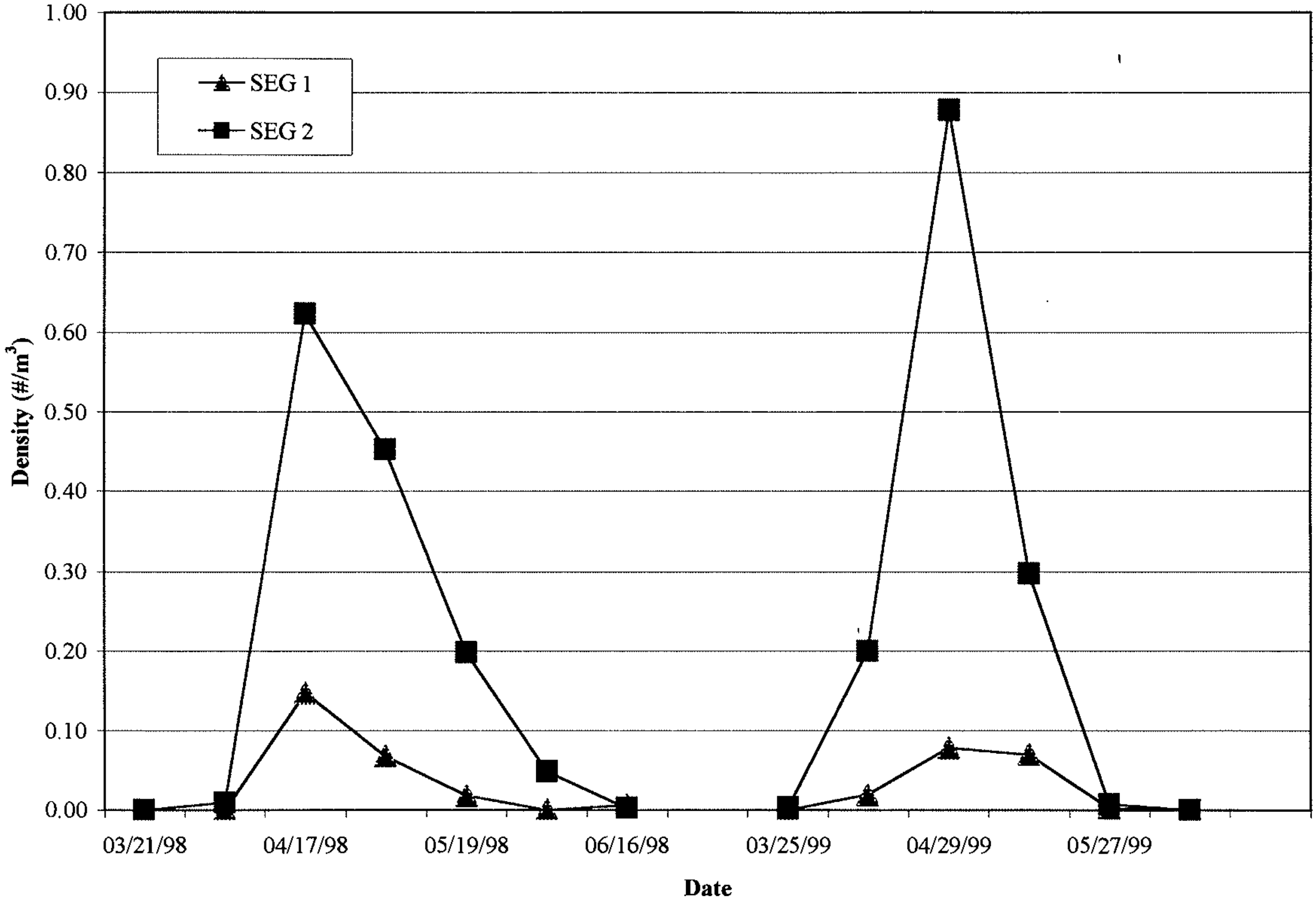

Figure 8.6. Mean densities (#/m^3) of *Dorosoma* sampled with net tows in Coffeen Lake in 1998-99.

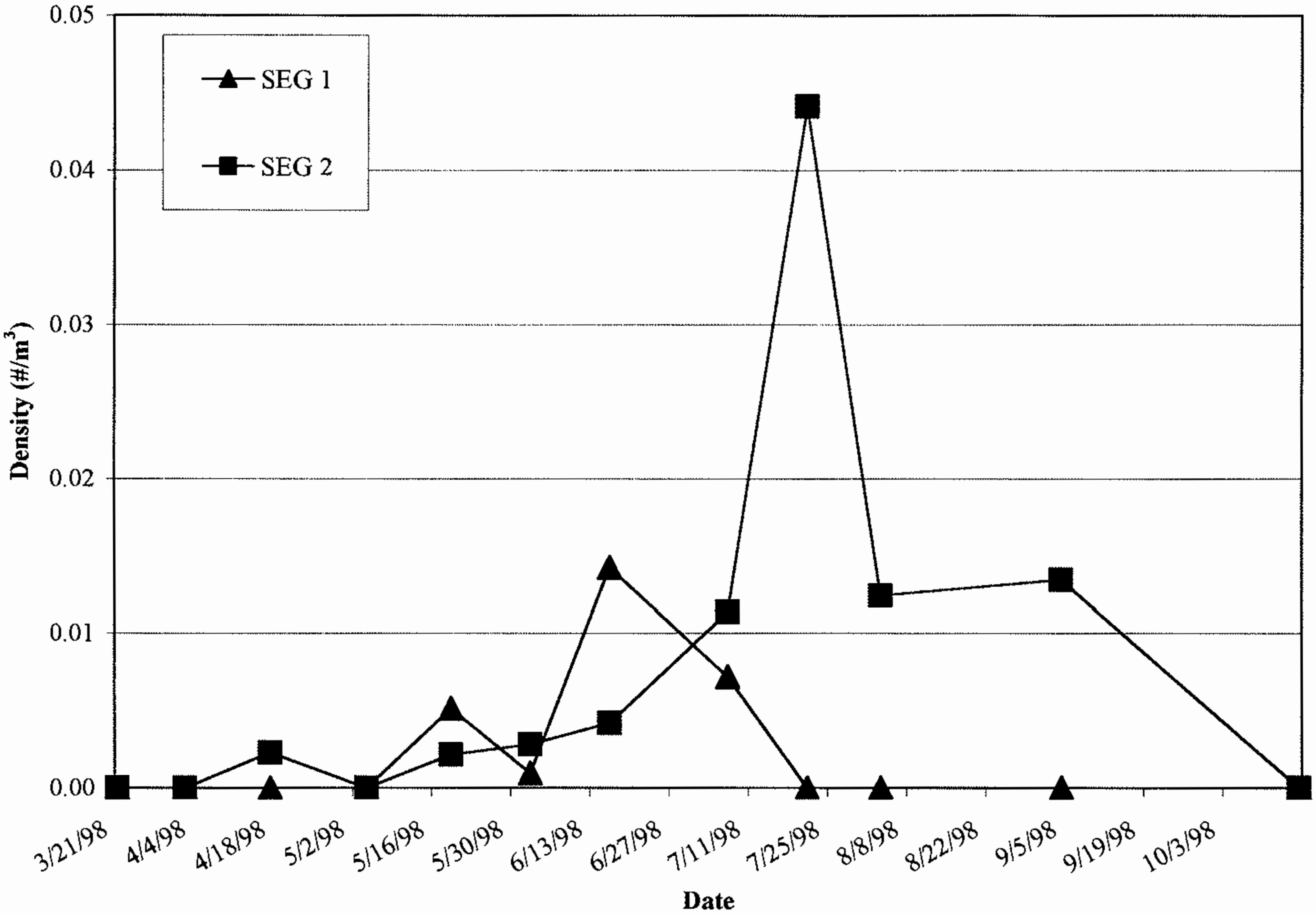

Figure 8.7. Mean densities (#/m^3) of *Lepomis* sampled with net tows in Coffeen Lake in 1998.

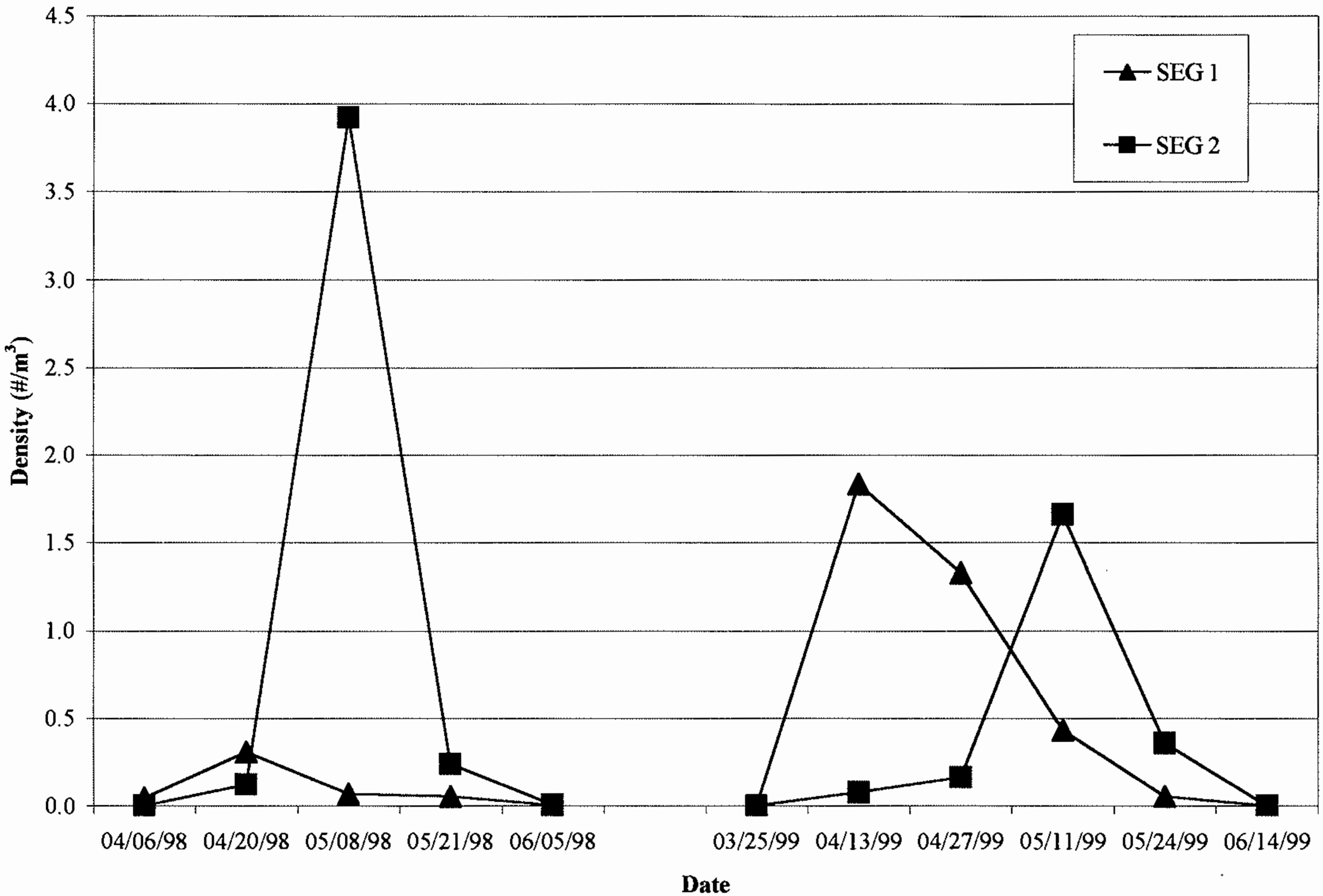

Figure 8.8. Mean densities (#/m^3) of *Dorosoma* sampled with net tows in Lake of Egypt in 1998-99.

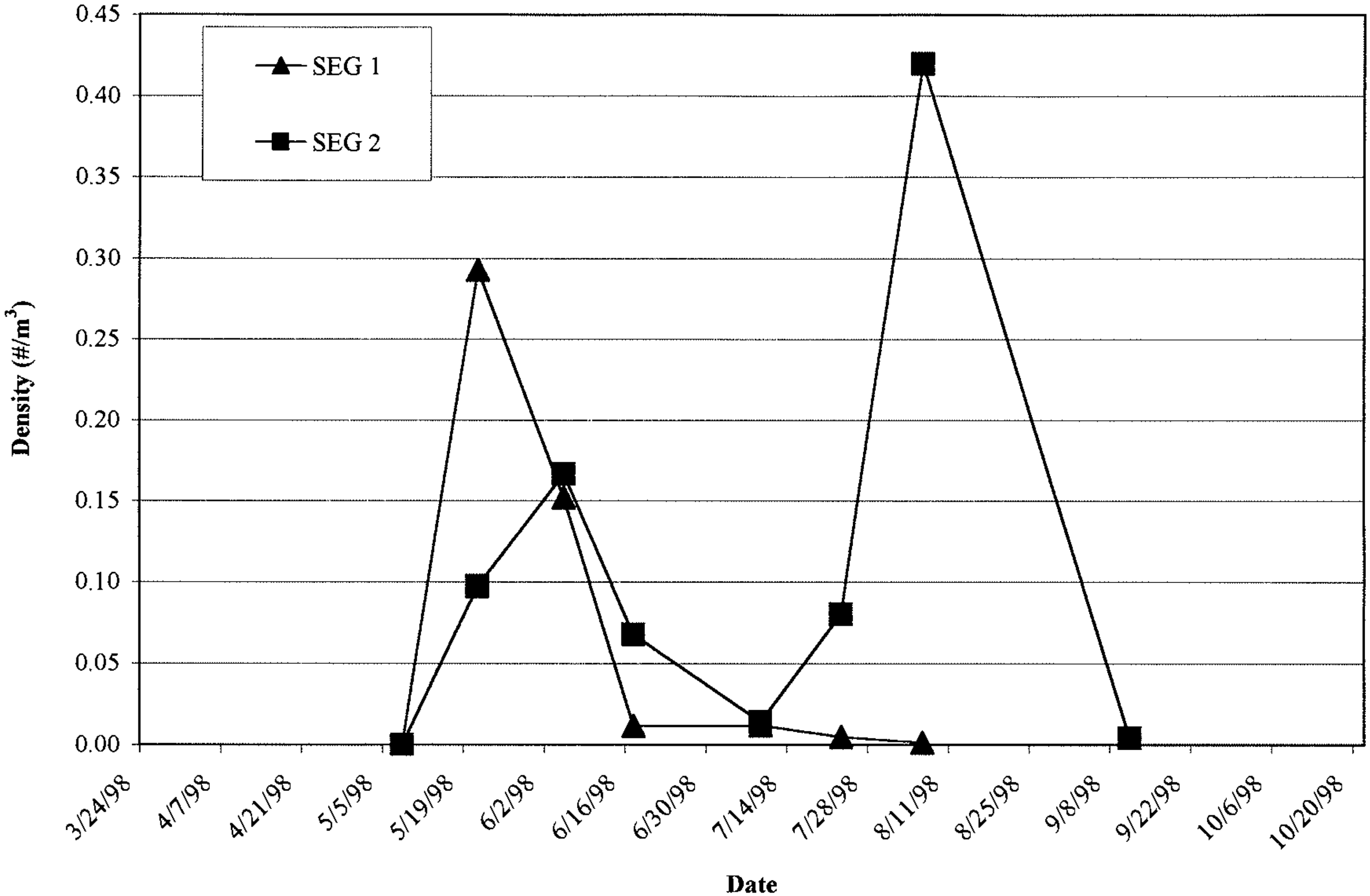

Figure 8.9. Mean densities (#/m^3) of *Lepomis* sampled with net tows in Lake of Egypt in 1998.

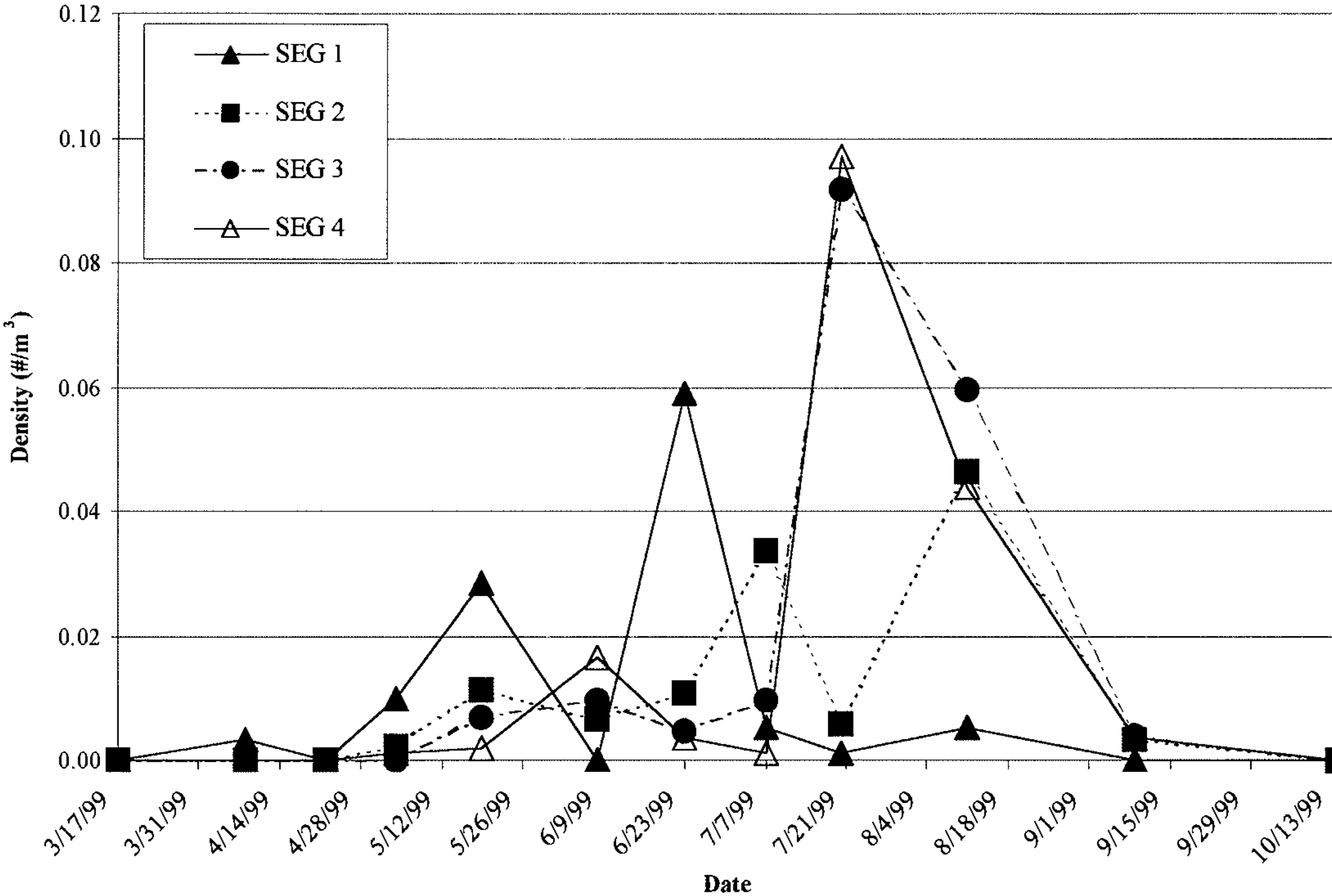

Figure 8.10. Mean densities (#/m^3) of *Lepomis* sampled with net tows in Newton Lake in 1999.

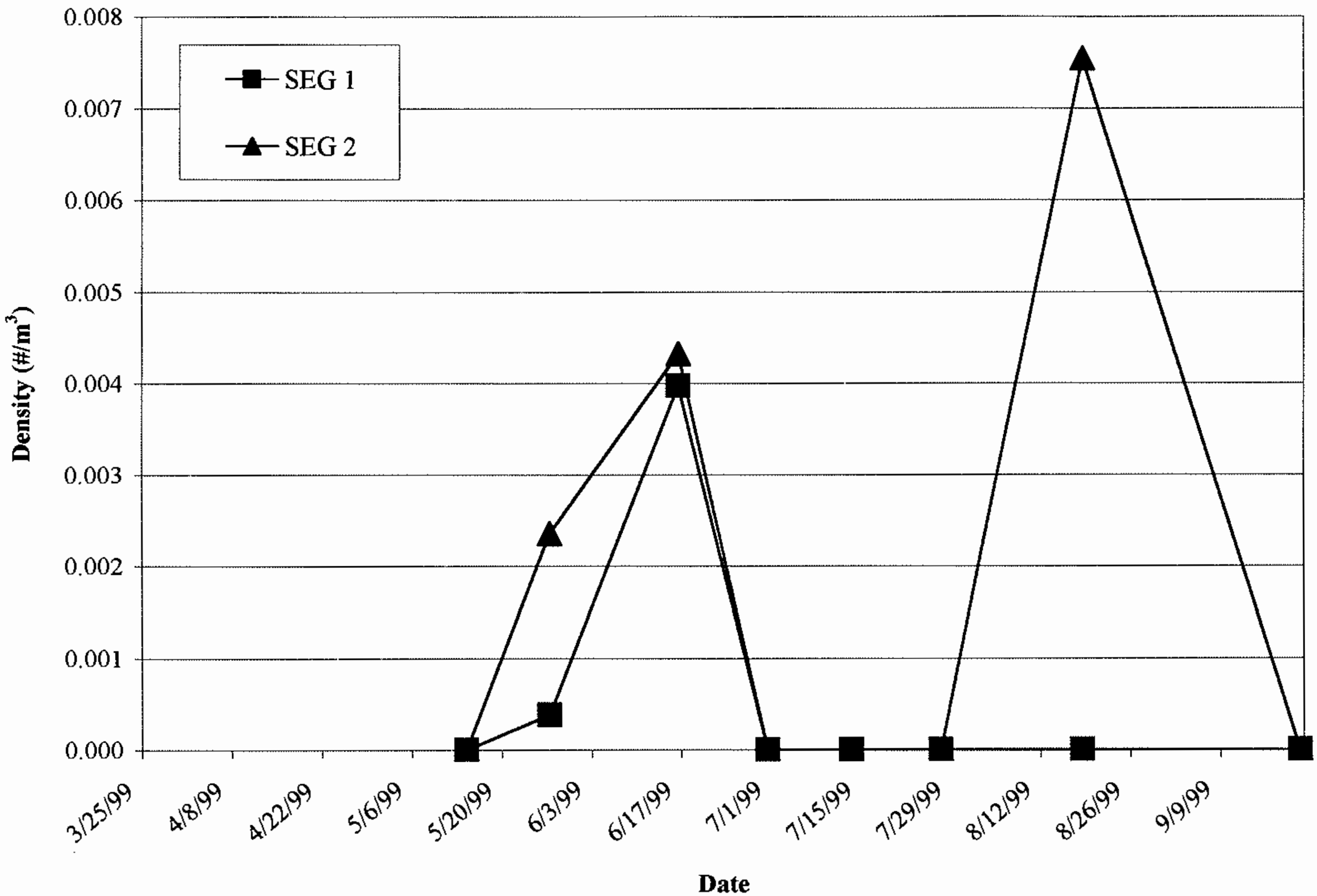

Figure 8.11. Mean densities (#/m^3) of *Lepomis* sampled with net tows in Coffeen Lake in 1999.

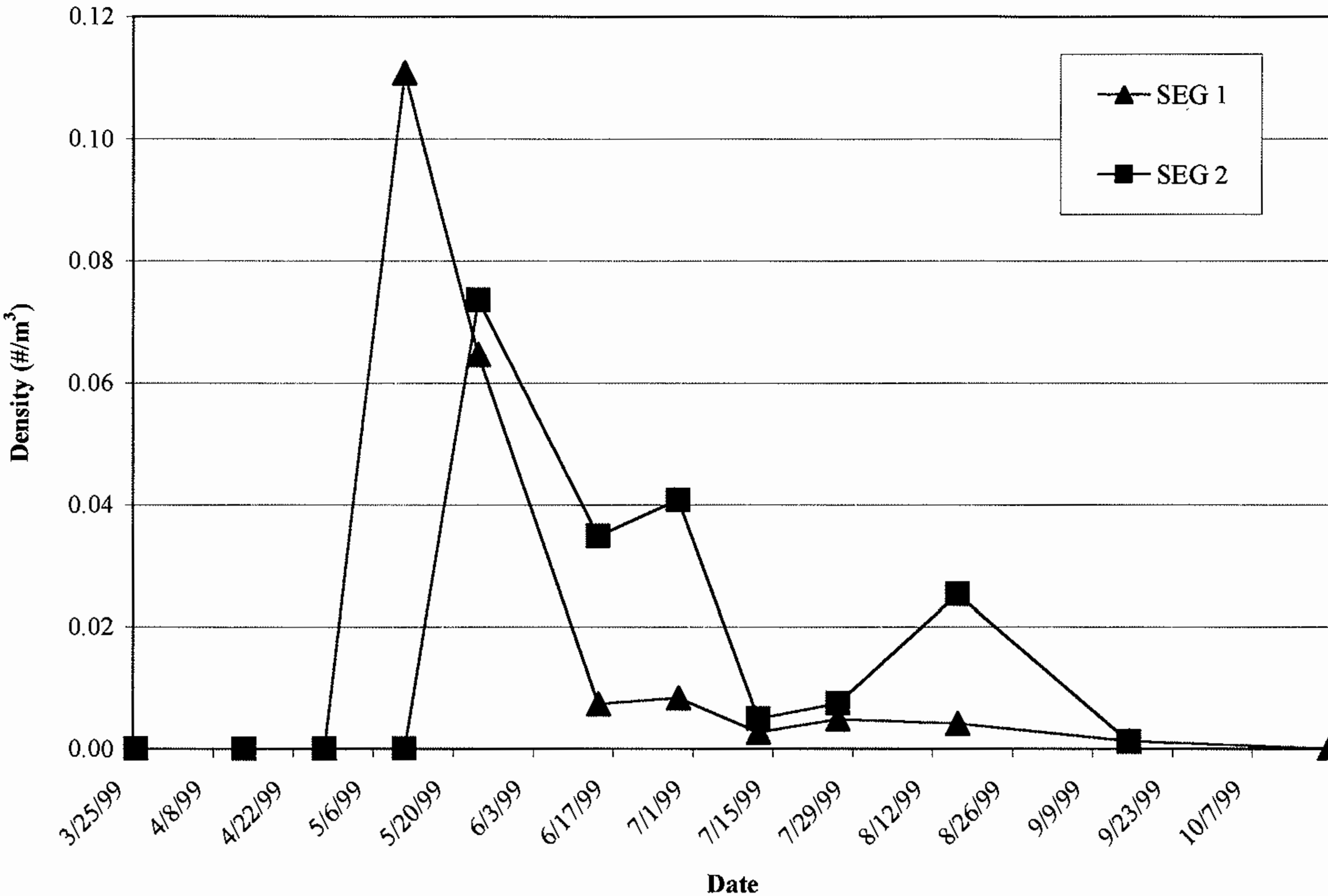

Figure 8.12. Mean densities (#/m^3) of *Lepomis* sampled with net tows in Lake of Egypt in 1999.

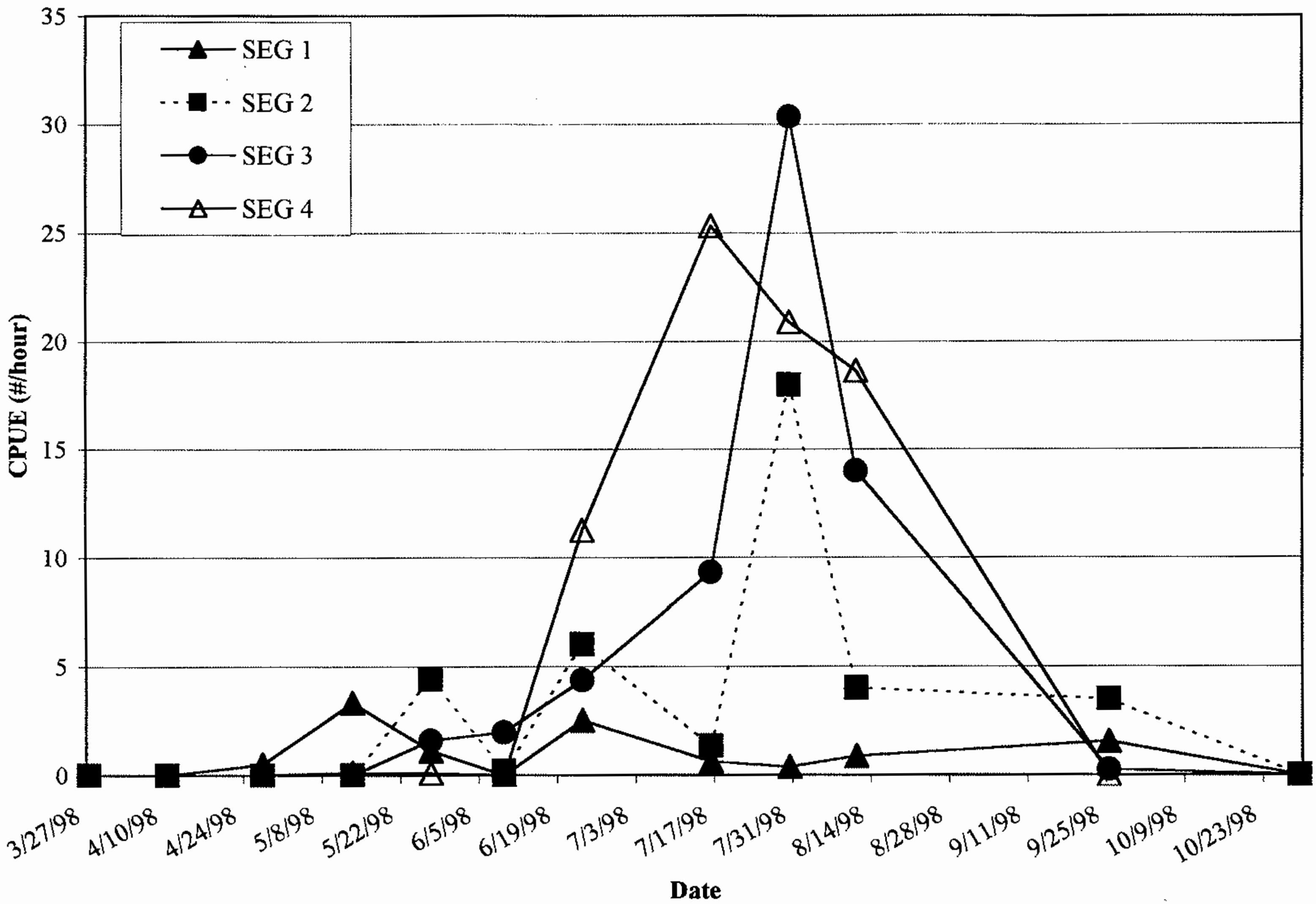

Figure 8.13. Mean CPUE (#/hour) of *Lepomis* sampled with light traps in Newton Lake in 1998.

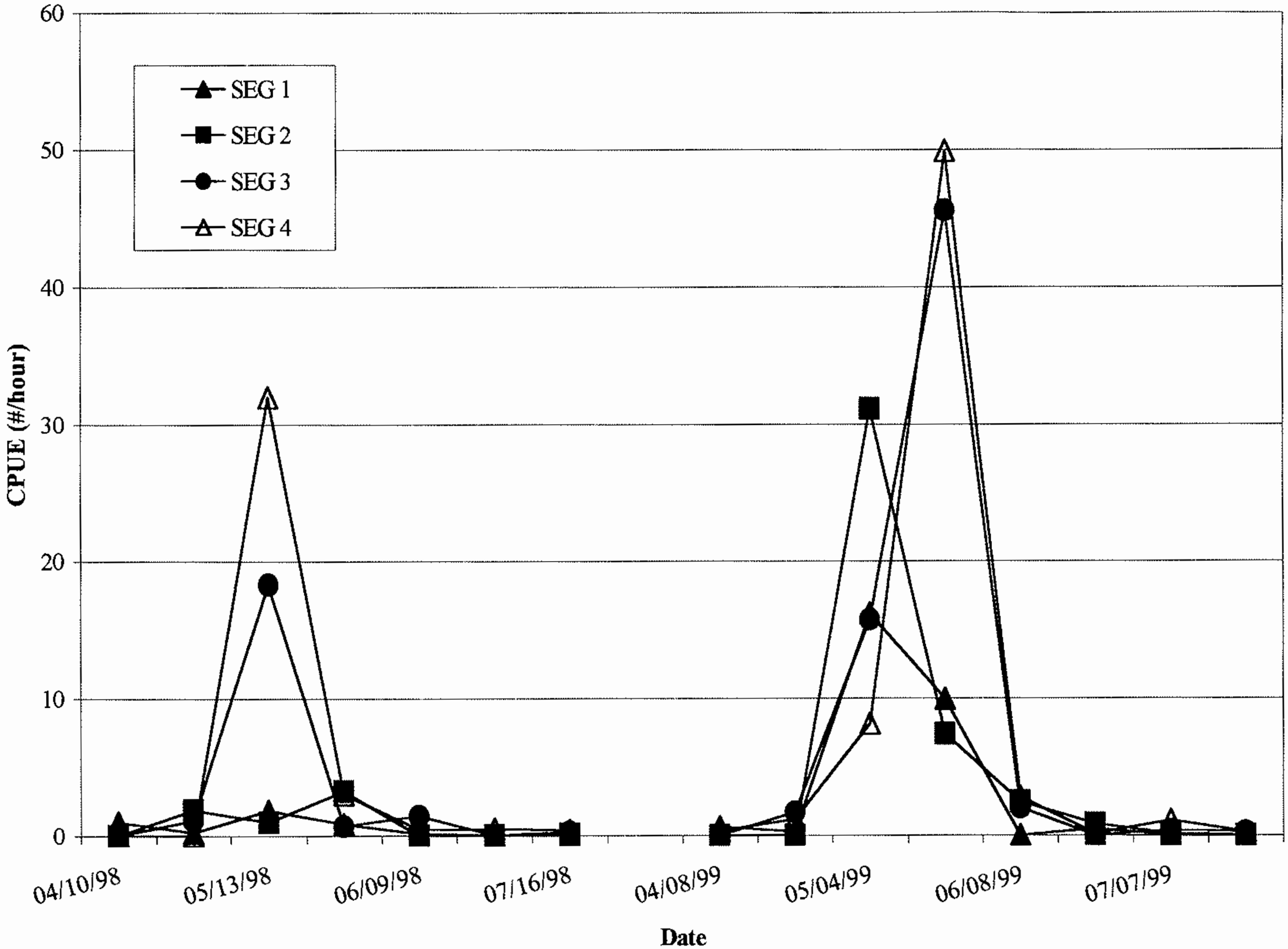

Figure 8.14. Mean CPUE (#/hour) of *Dorosoma* sampled with light traps in Newton Lake in 1998-99.

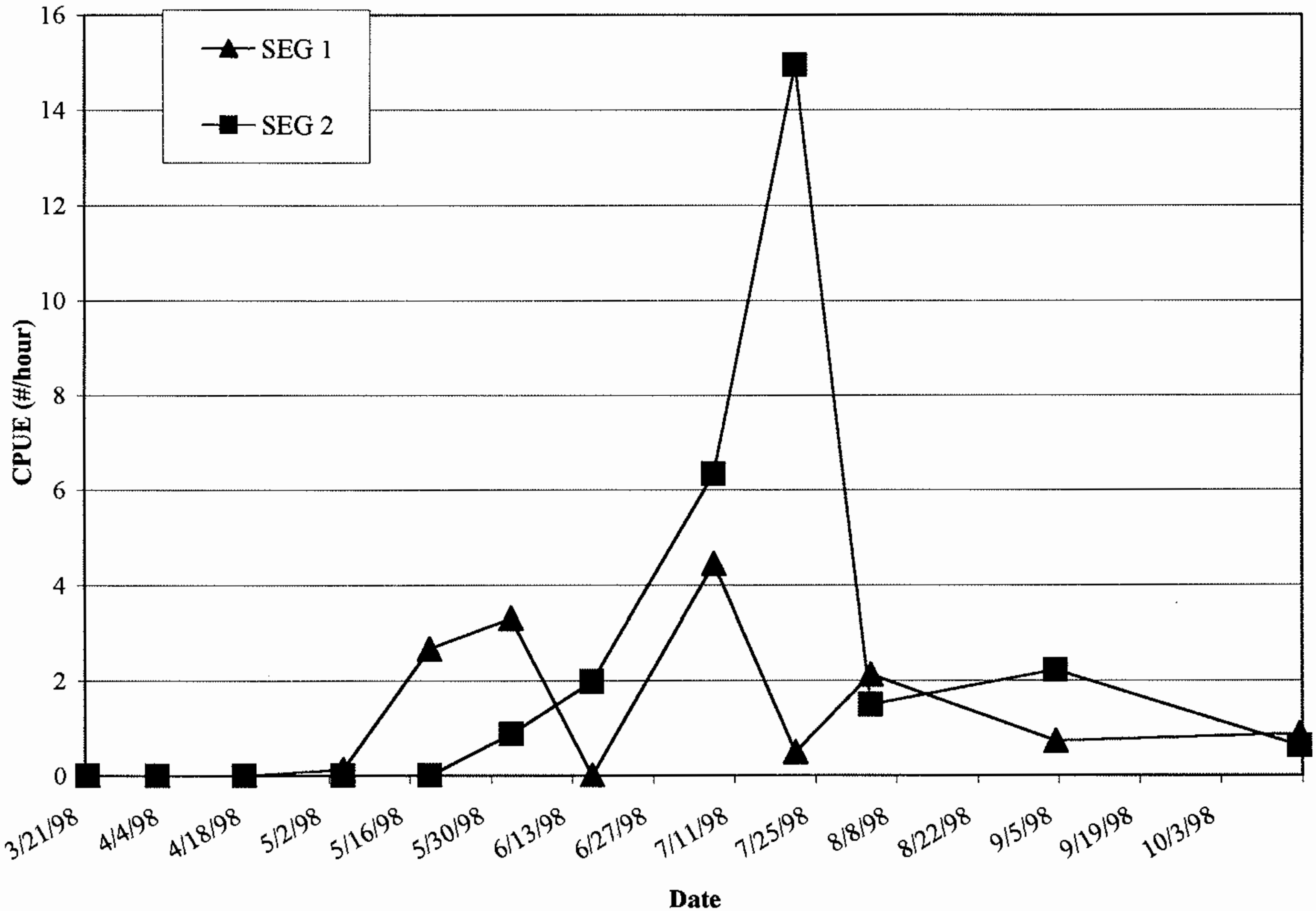

Figure 8.15. Mean CPUE (#/hour) of *Lepomis* sampled with light traps in Coffeen Lake in 1998.

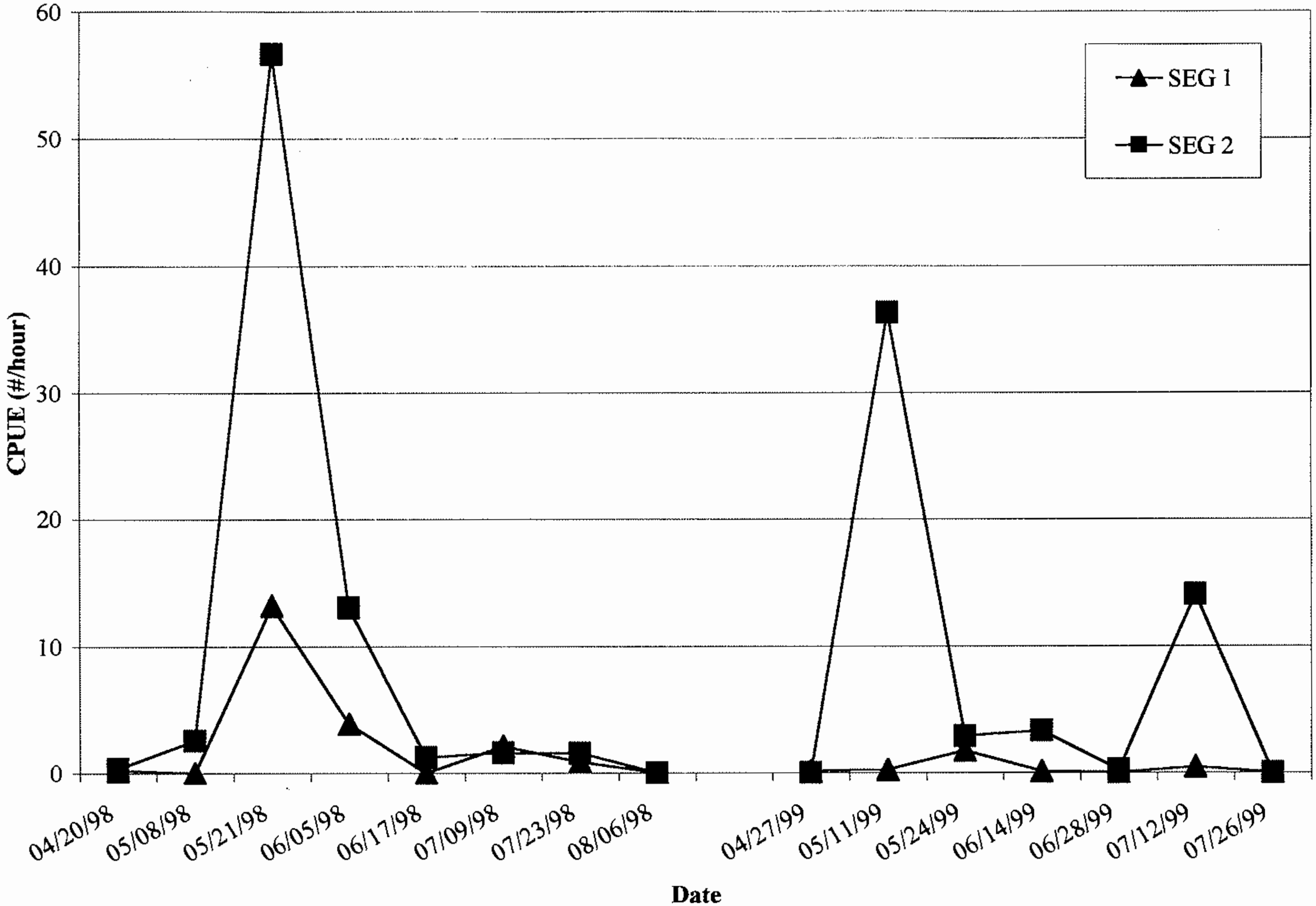

Figure 8.16. Mean CPUE (#/hour) of *Dorosoma* sampled with light traps in Lake of Egypt in 1998-99.

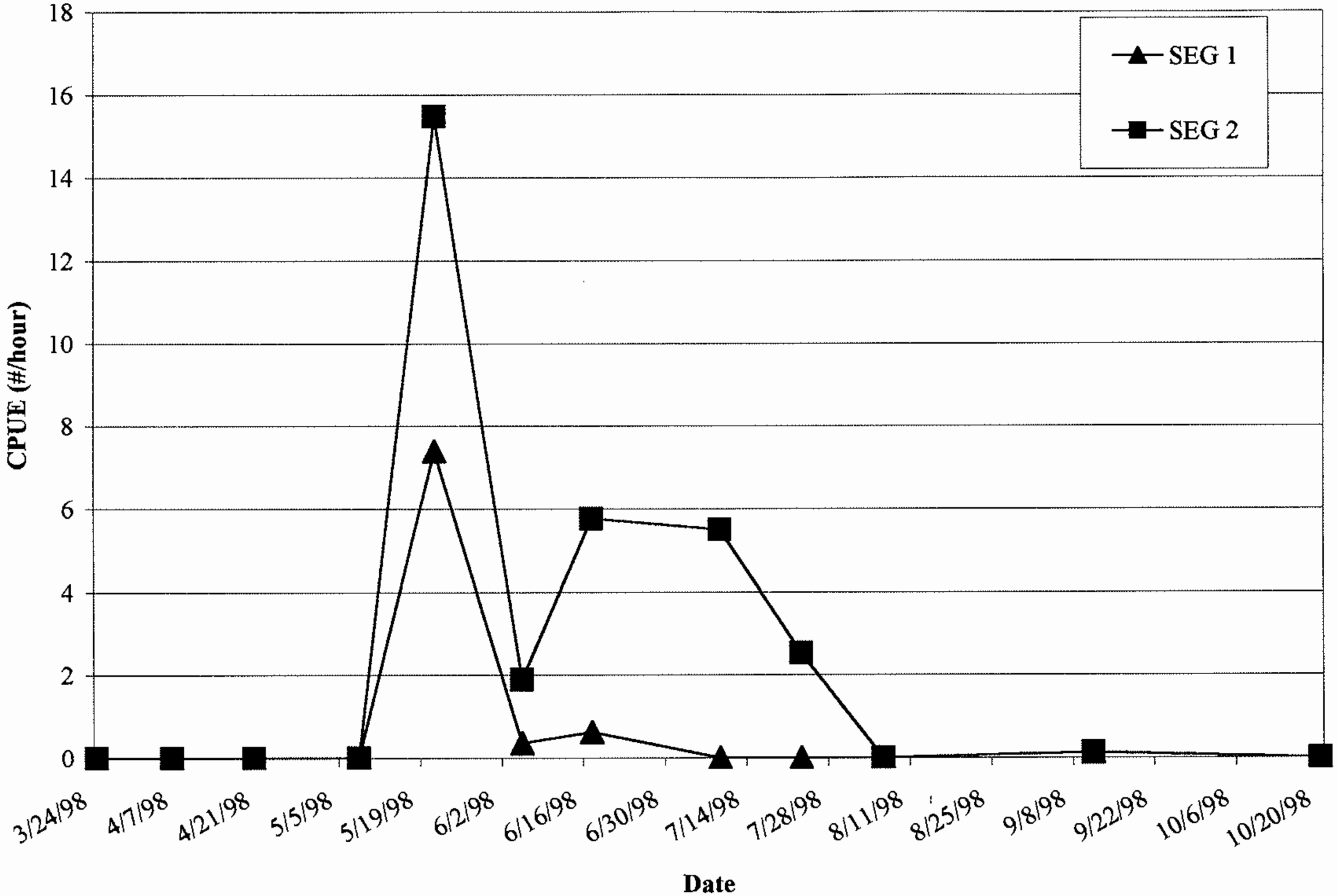

Figure 8.17. Mean CPUE (#/hour) of *Lepomis* sampled with light traps in Lake of Egypt in 1998.

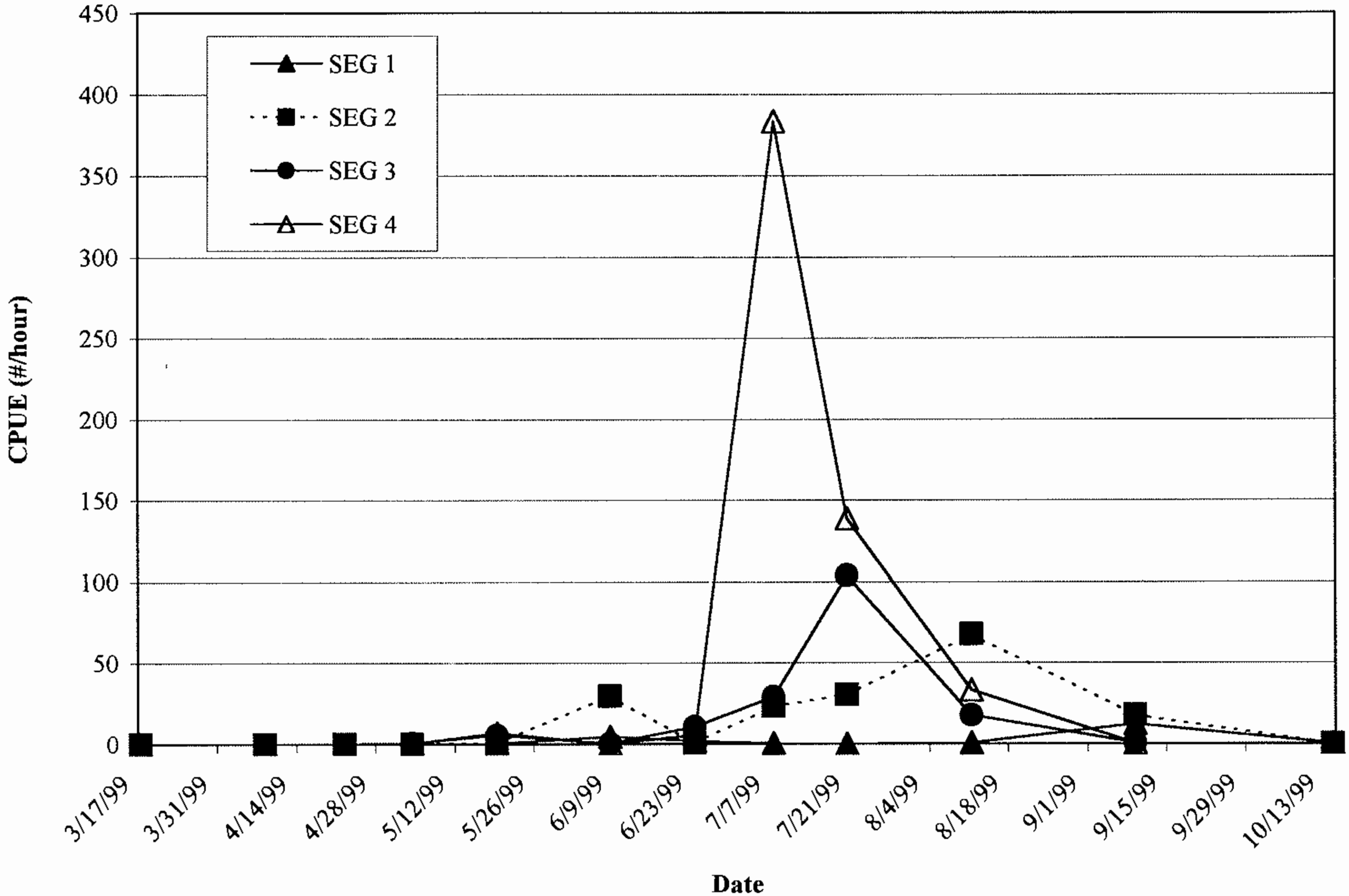

Figure 8.18. Mean CPUE (#/hour) of *Lepomis* sampled with light traps in Newton Lake in 1999.

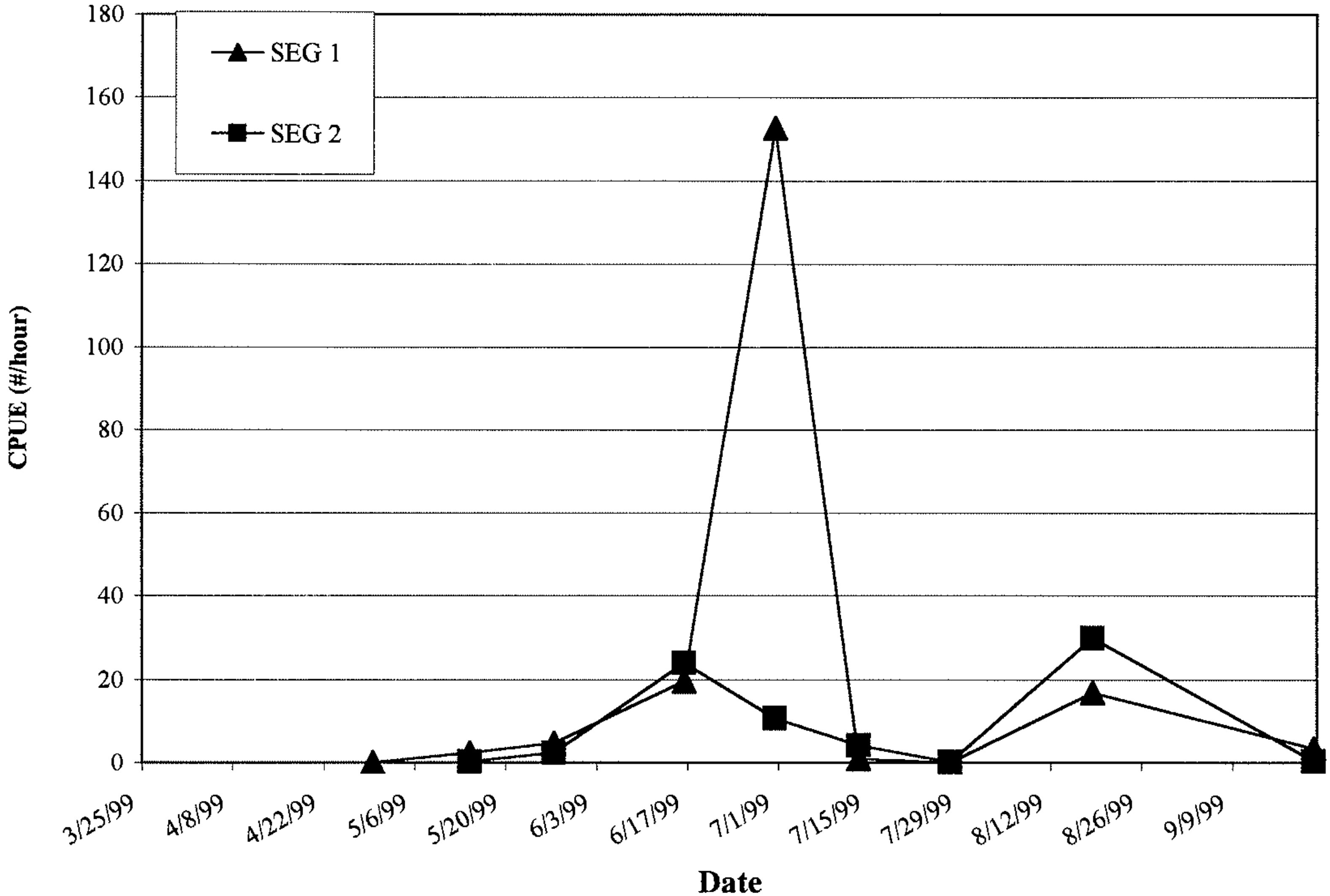

Figure 8.19. Mean CPUE (#/hour) of *Lepomis* sampled with light traps in Coffeen Lake in 1999.

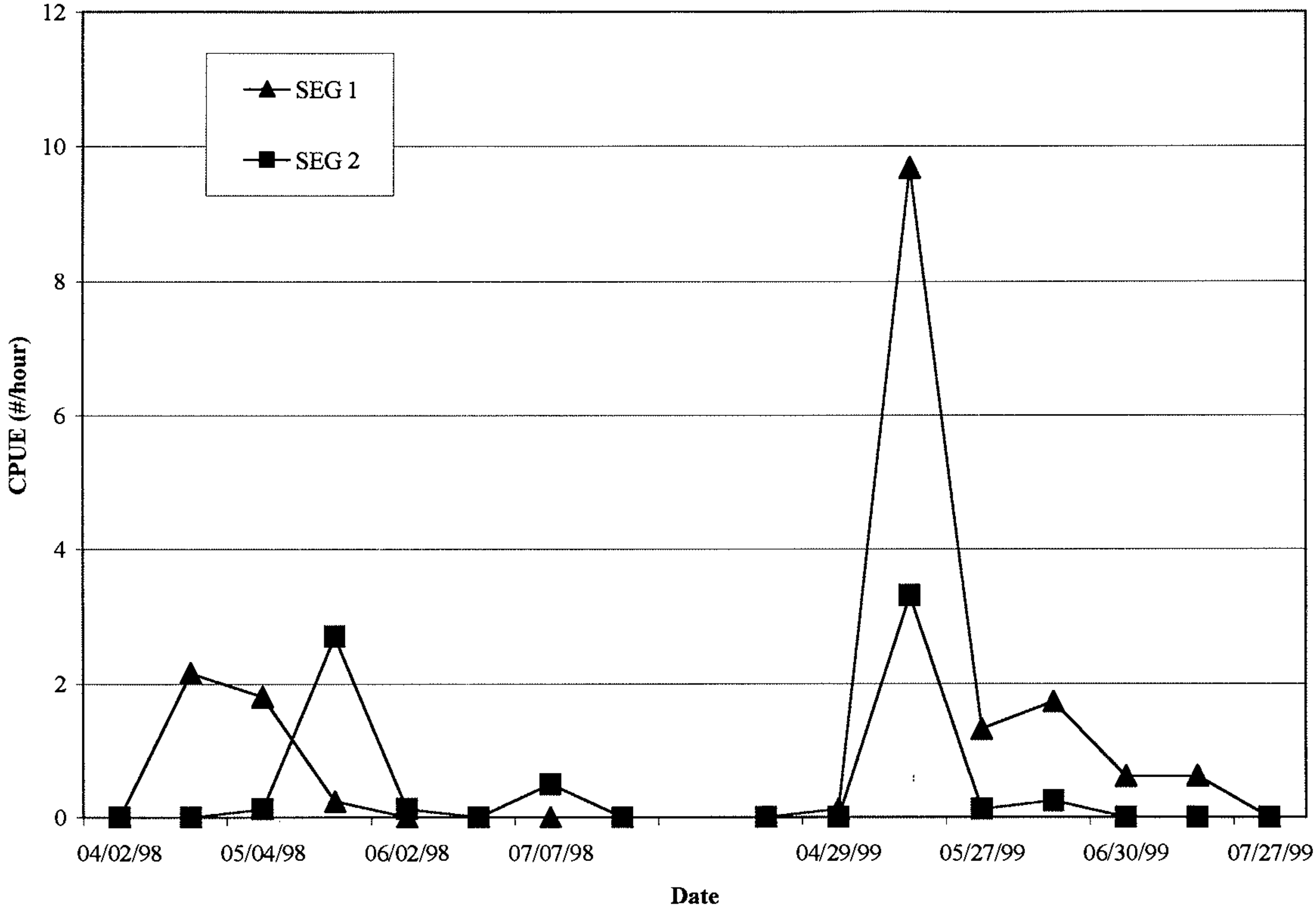

Figure 8.20. Mean CPUE (#/hour) of *Dorosoma* sampled with light traps in Coffeen Lake in 1998-99.

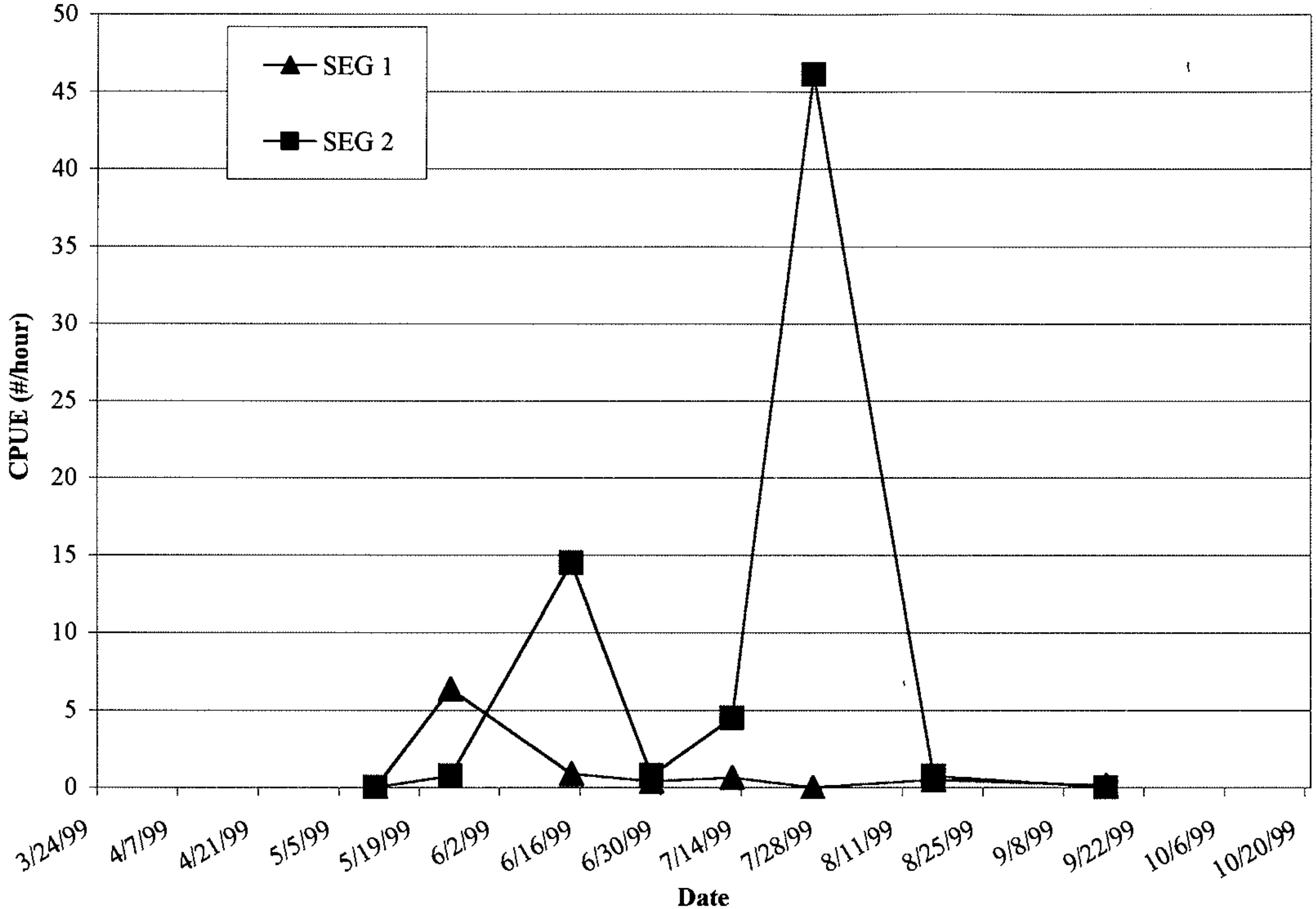

Figure 8.21. Mean CPUE (#/hour) of *Lepomis* sampled with light traps in Lake of Egypt in 1999.

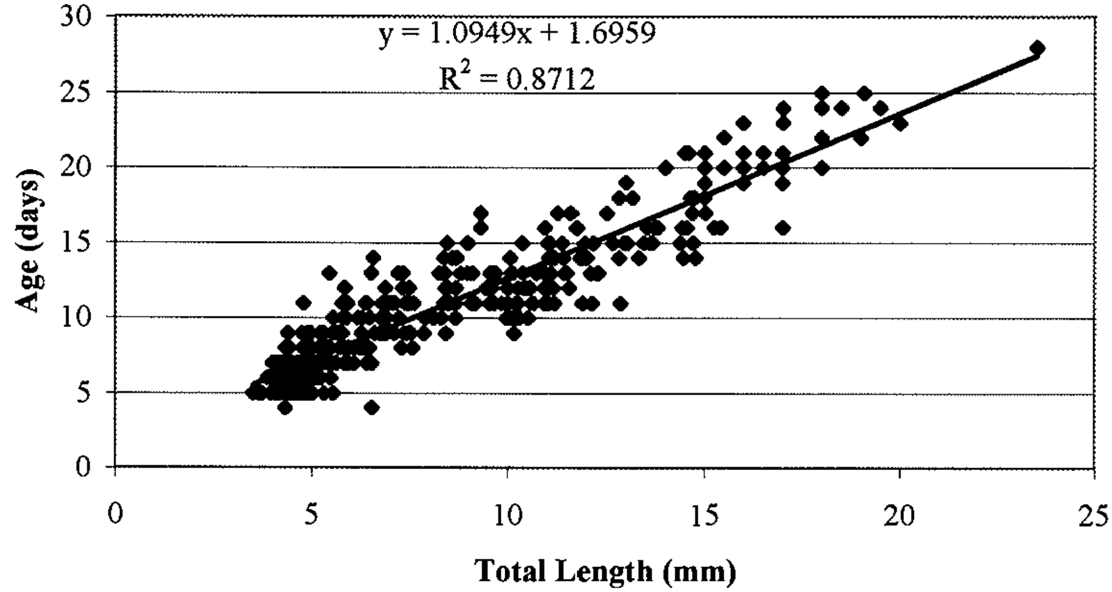

Figure 8.22. Length-age data and regression line of *Lepomis* sampled with net tows and light traps in Newton Lake in 1998. The regression line is significantly positive (P=0.0001).

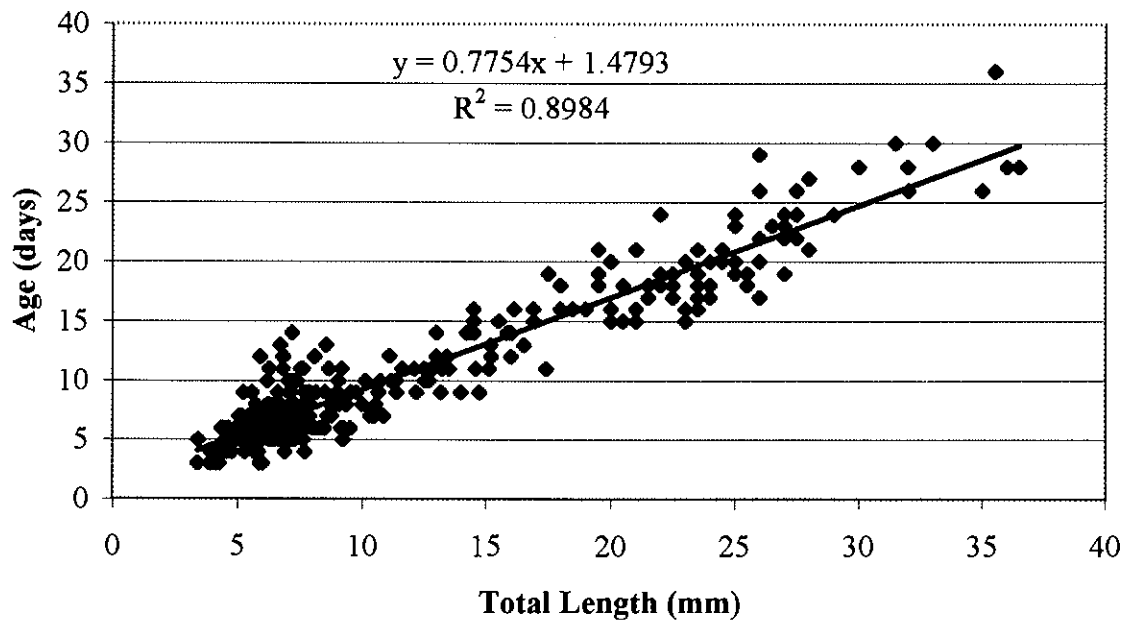

Figure 8.23. Length-age data and regression line of *Dorosoma* sampled with net tows and light traps in Newton Lake in 1998. The regression line is significantly positive (P=0.0001).

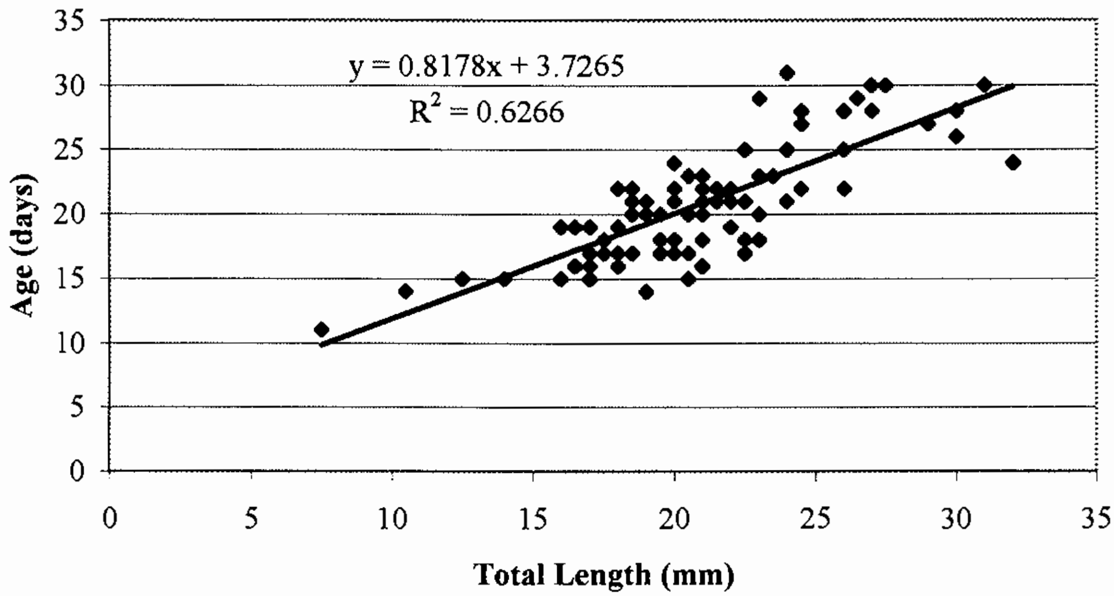

Figure 8.24. Length-age data and regression line of largemouth bass sampled with net tows and light traps in Newton Lake in 1998. The regression line is significantly positive (P=0.0001).

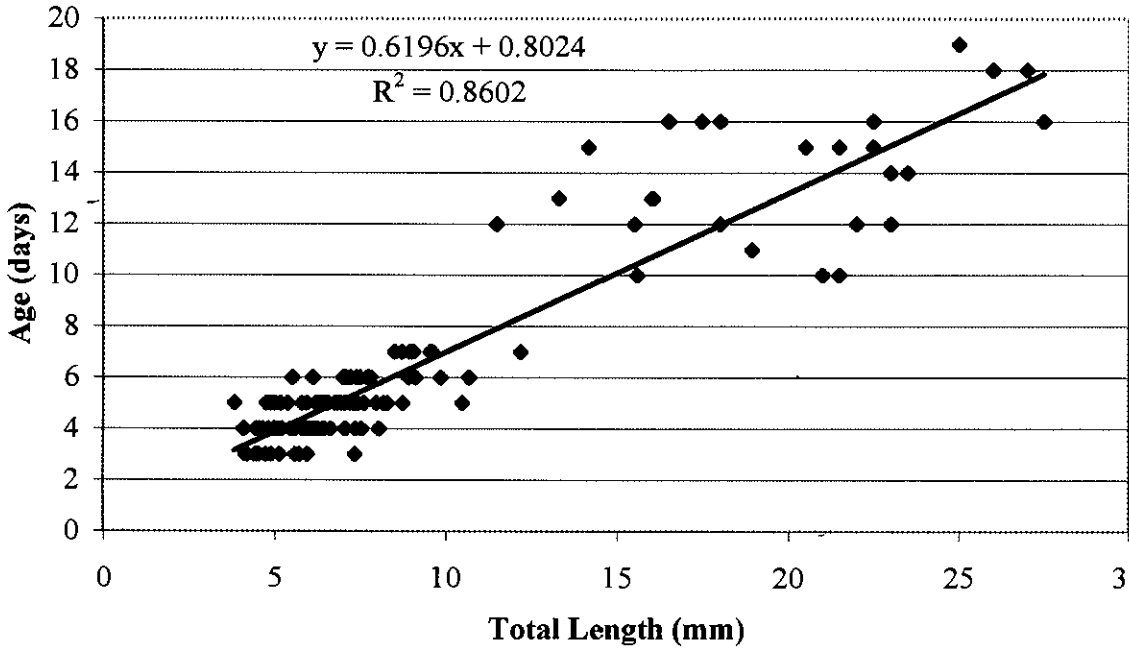

Figure 8.25. Length-age data and regression line of *Dorosoma* sampled with net tows and light traps in Coffeen Lake in 1998. The regression line is significantly positive (P=0.0001).

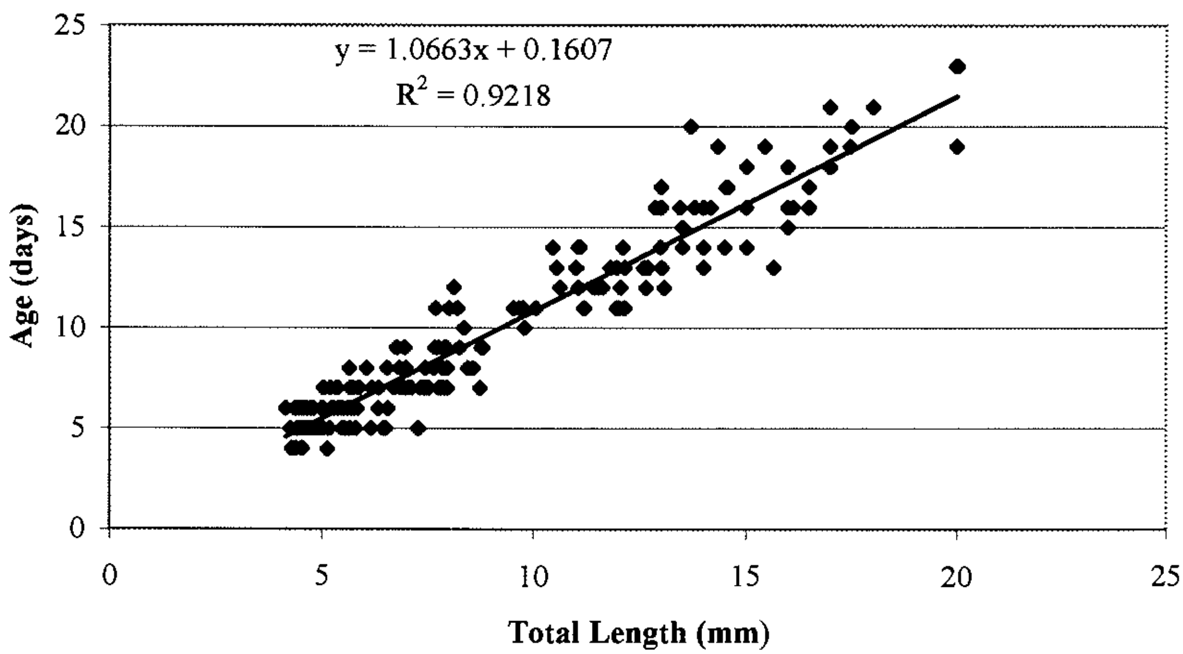

Figure 8.26. Length-age data and regression line of *Lepomis* sampled with net tows and light traps in Coffeen Lake in 1998. The regression line is significantly positive (P=0.0001).

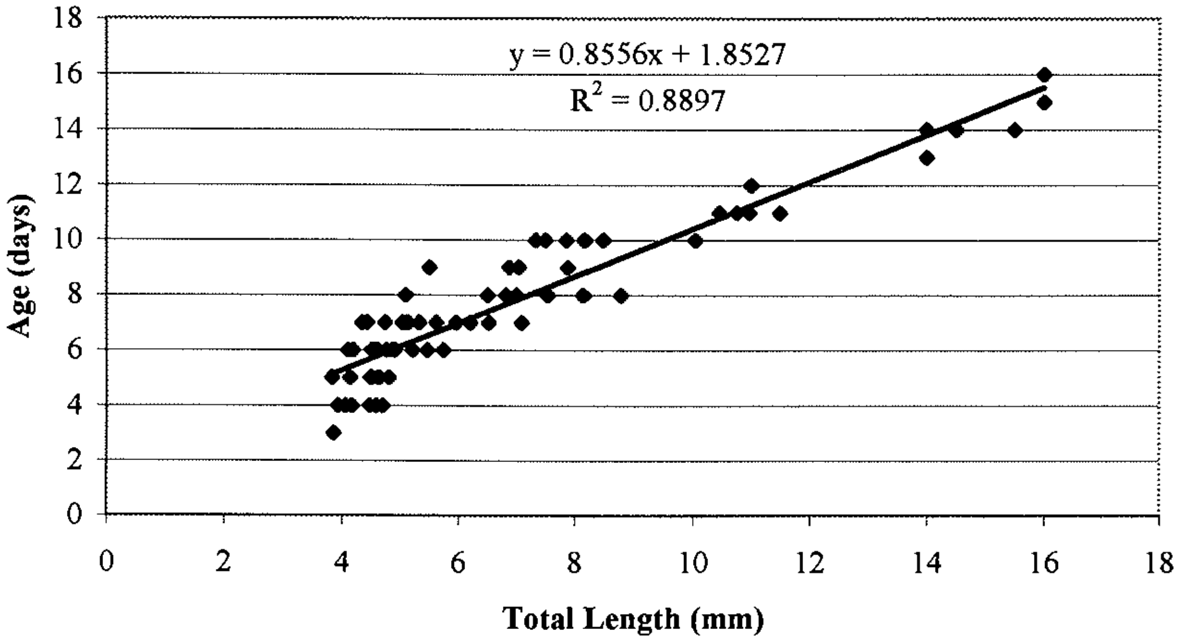

Figure 8.27. Length-age data and regression line of *Pomoxis* sampled with net tows and light traps in Coffeen Lake in 1998. The regression line is significantly positive (P=0.0001).

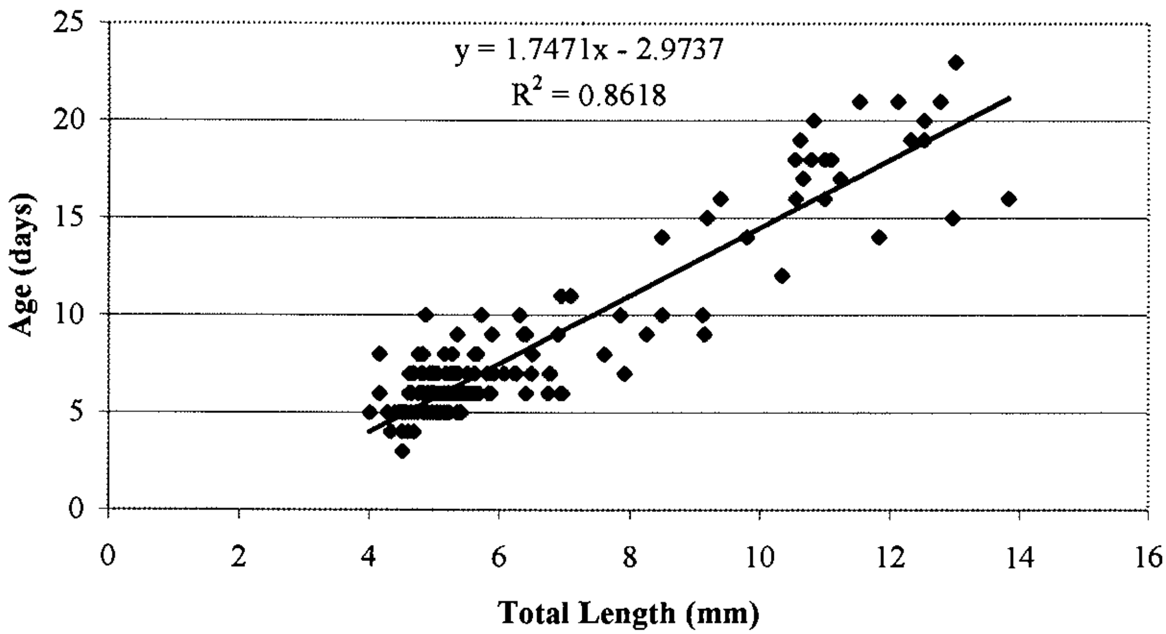

Figure 8.28. Length-age data and regression line of *Lepomis* sampled with net tows and light traps in Lake of Egypt in 1998. The regression line is significantly positive (P=0.0001).

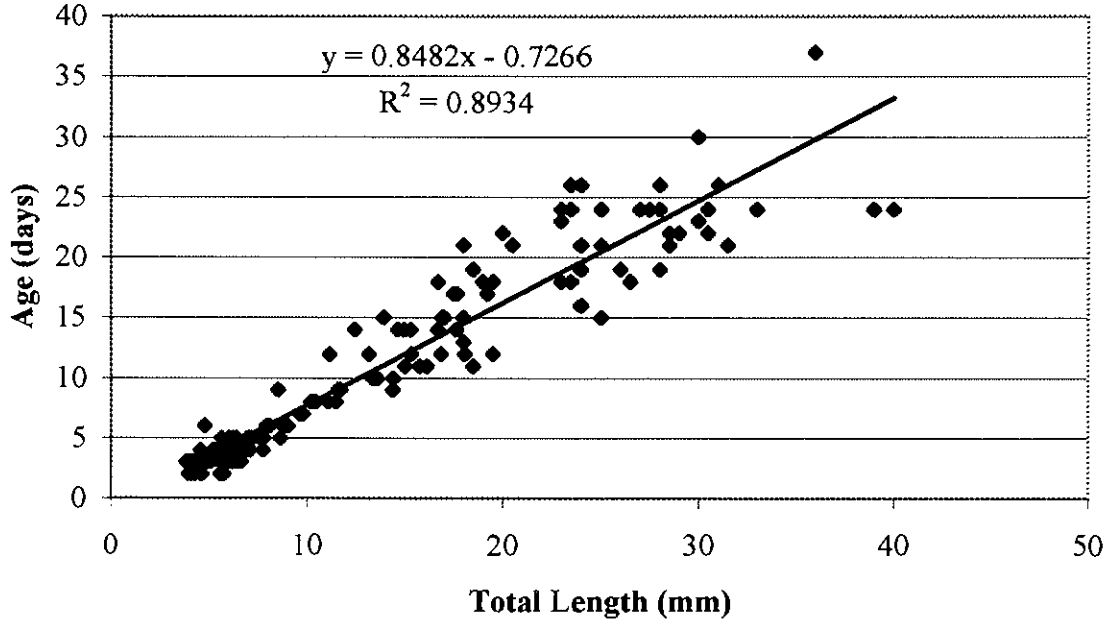

Figure 8.29. Length-age data and regression line of *Dorosoma* sampled with net tows and light traps in Lake of Egypt in 1998. The regression line is significantly positive (P=0.0001).

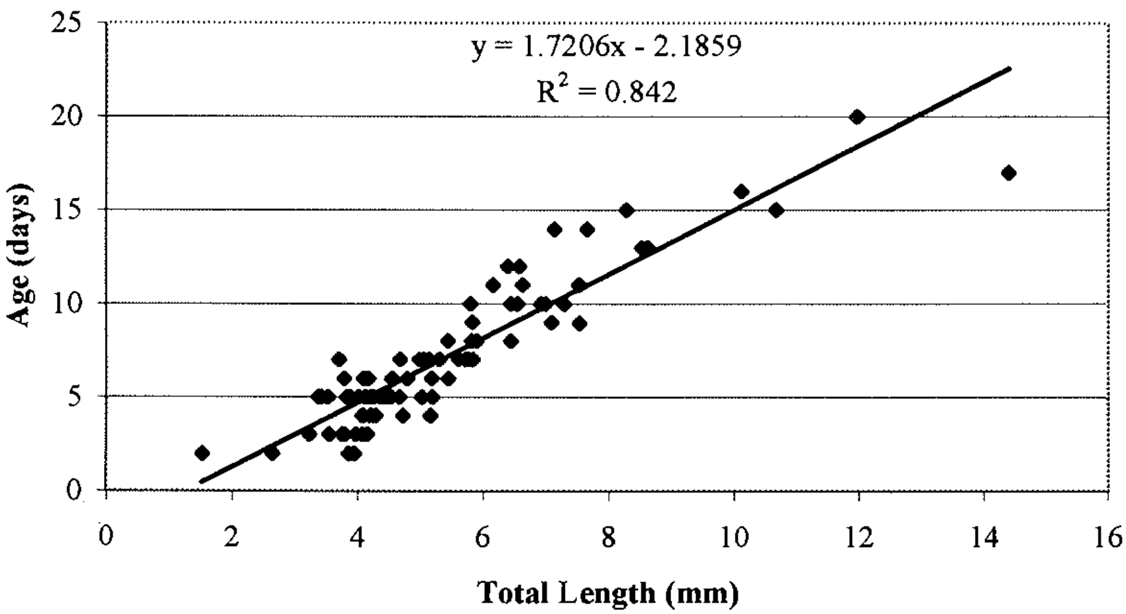

Figure 8.30. Length-age data and regression line of *Pomoxis* sampled with net tows and light traps in Lake of Egypt in 1998. The regression line is significantly positive (P=0.0001).

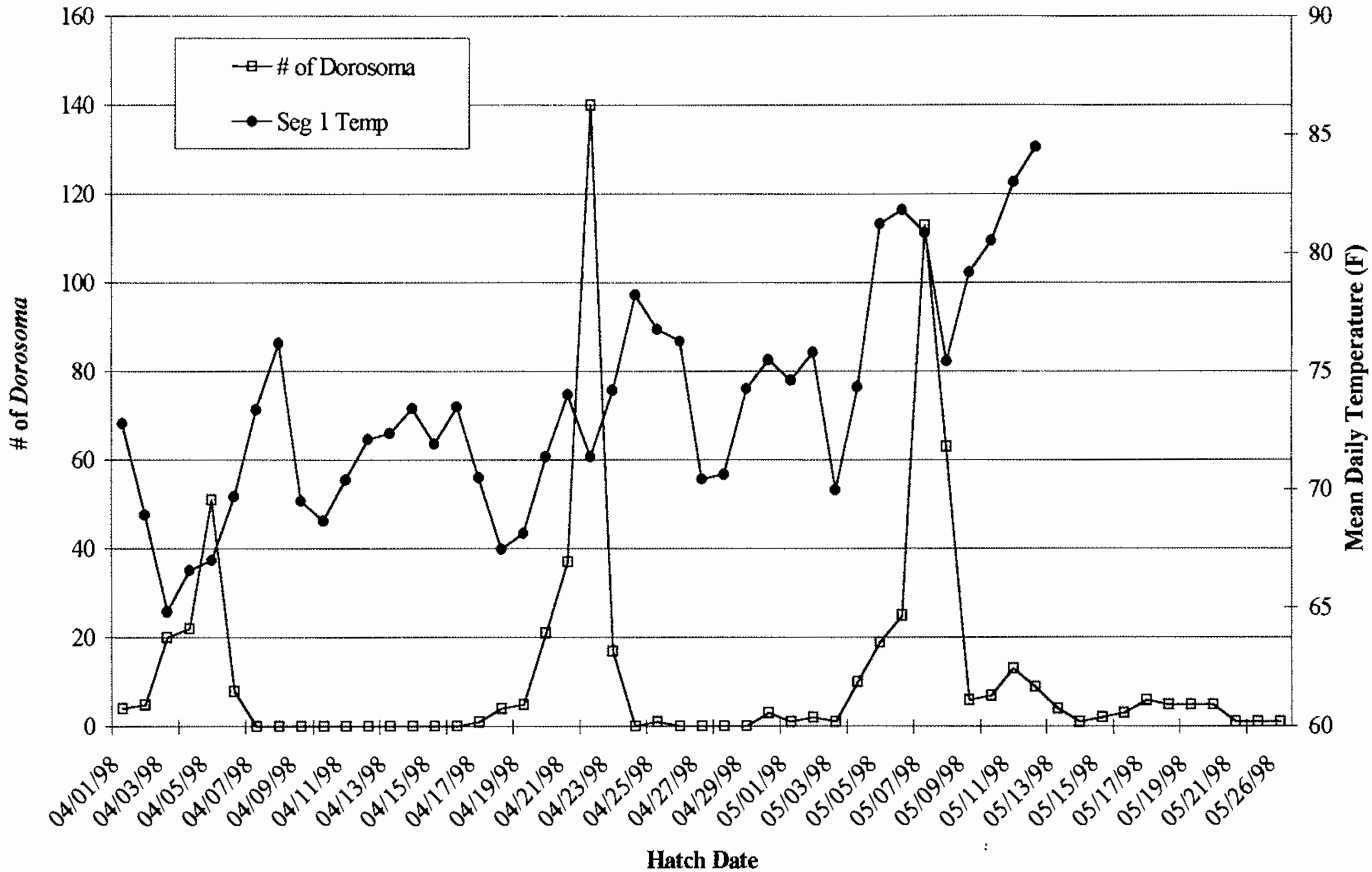

Figure 8.31. Number of *Dorosoma* by hatch date in Newton Lake (segment 1) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

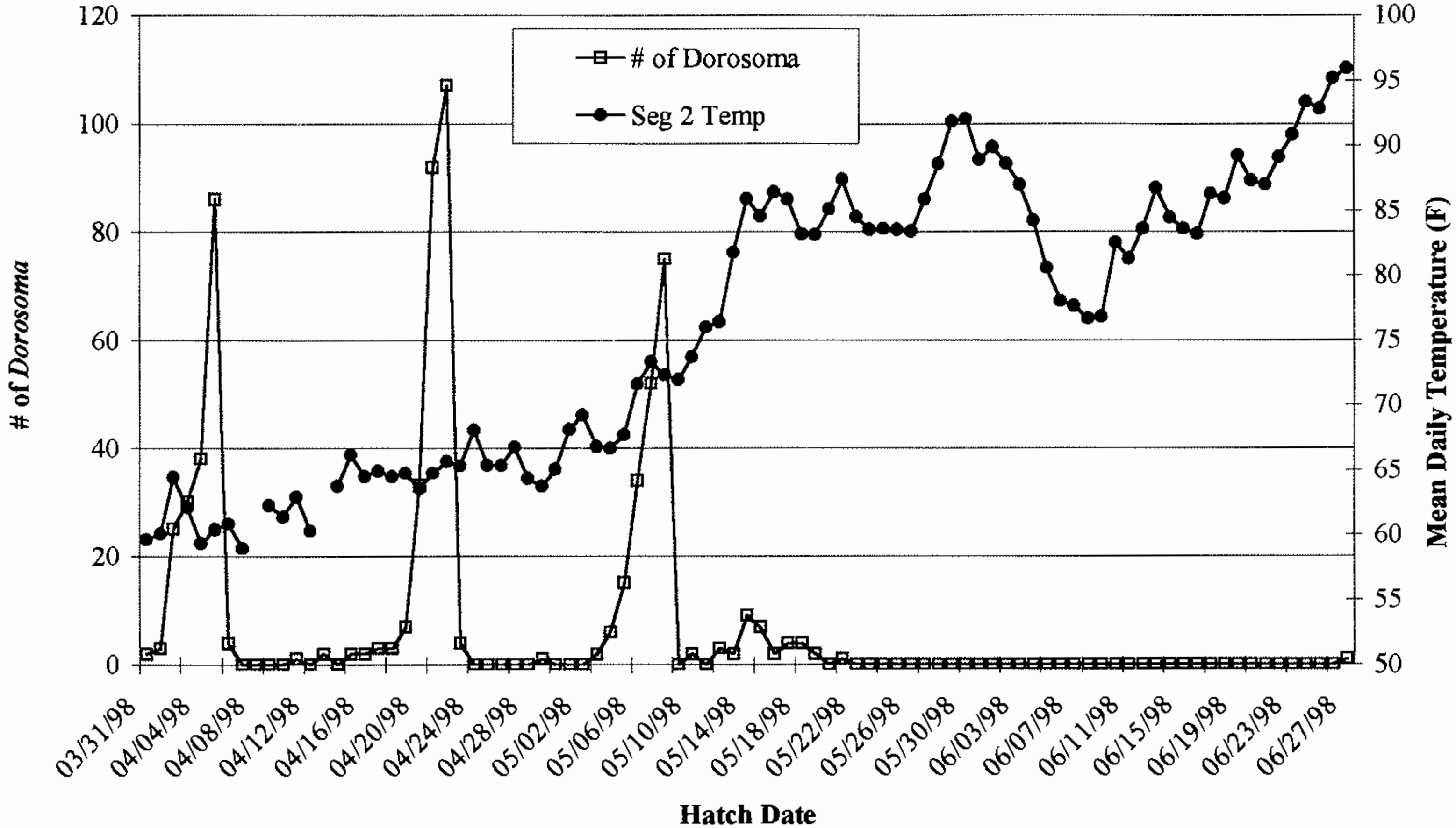

Figure 8.32. Number of *Dorosoma* by hatch date in Newton Lake (segment 2) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

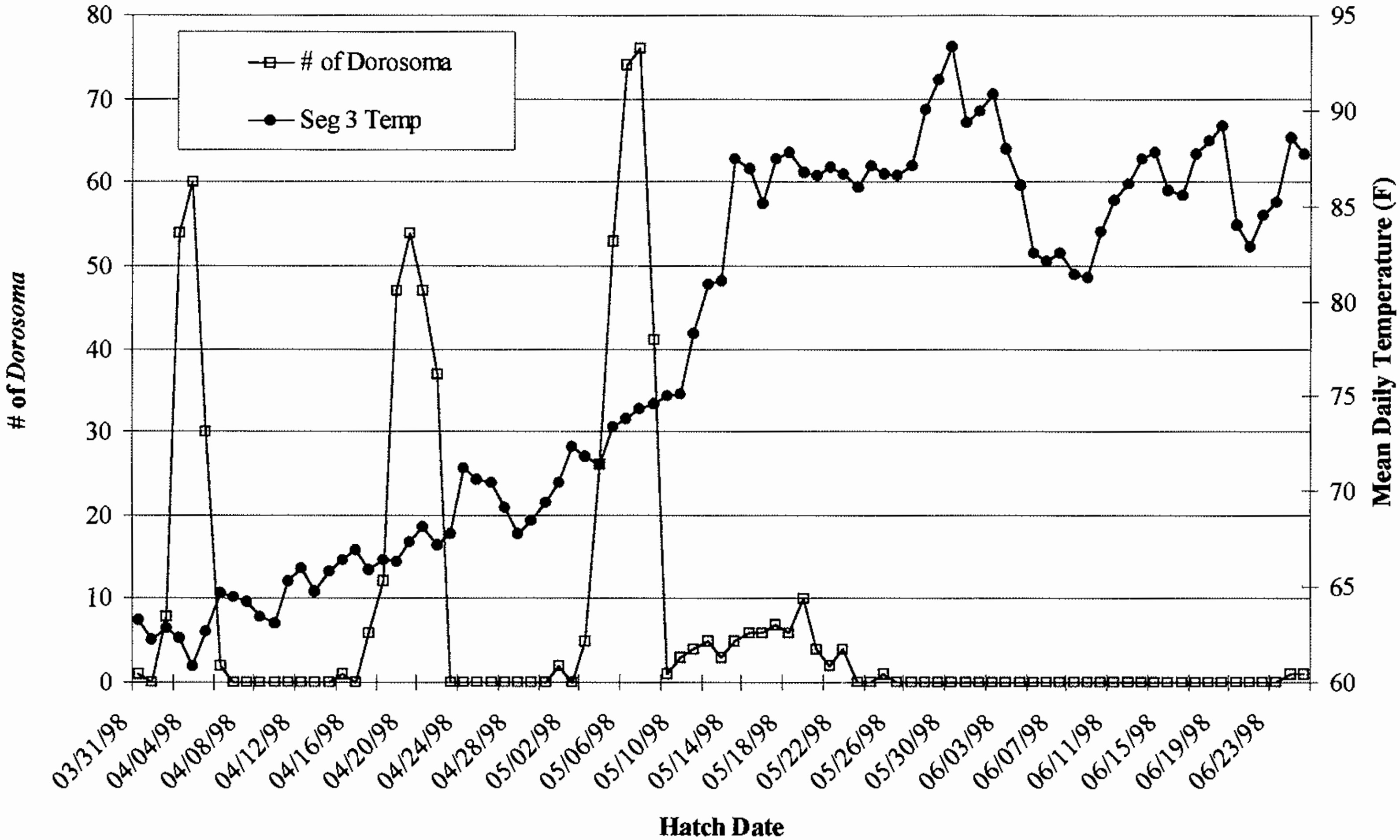

Figure 8.33. Number of *Dorosoma* by hatch date in Newton Lake (segment 3) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

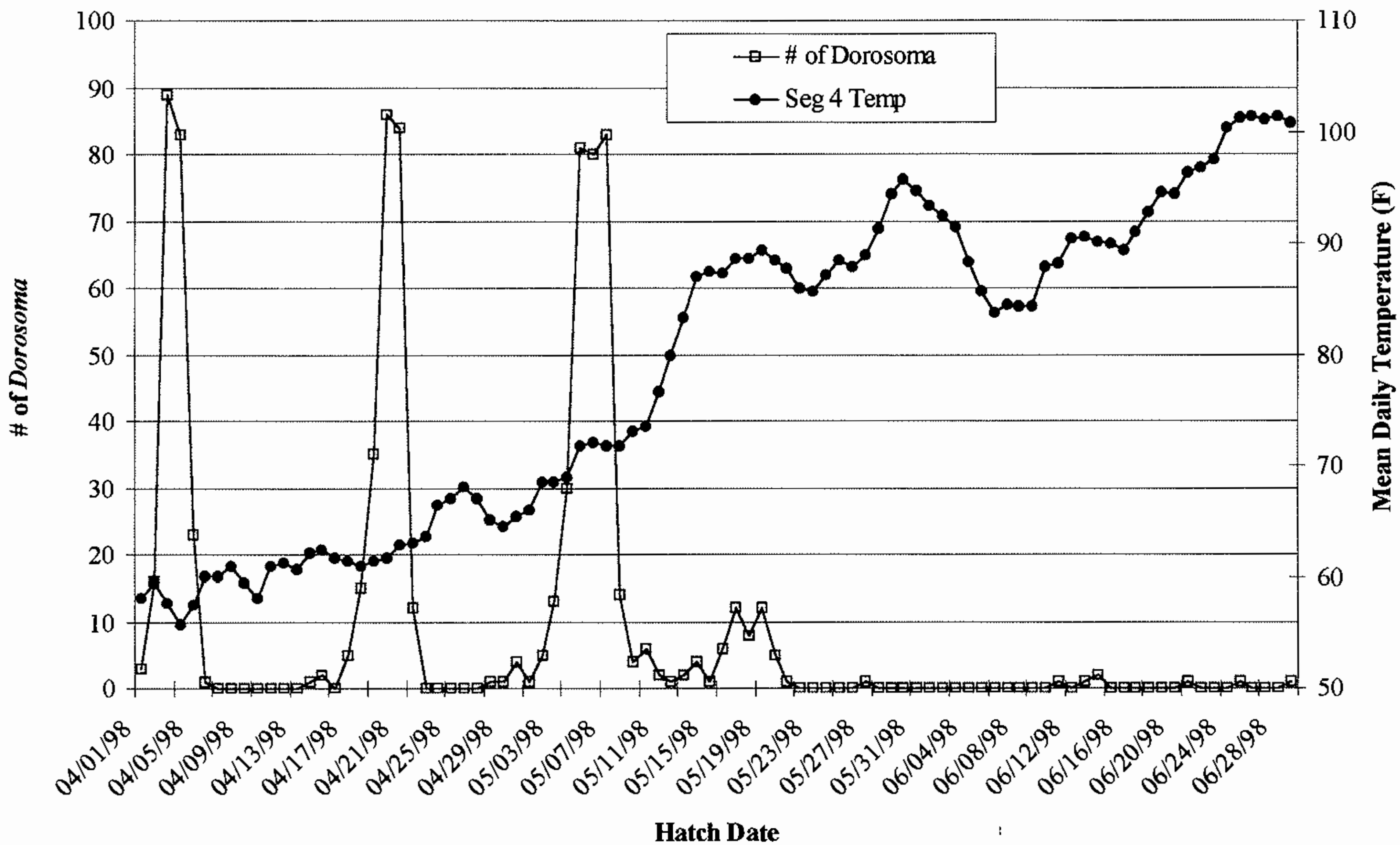

Figure 8.34. Number of *Dorosoma* by hatch date in Newton Lake (segment 4) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

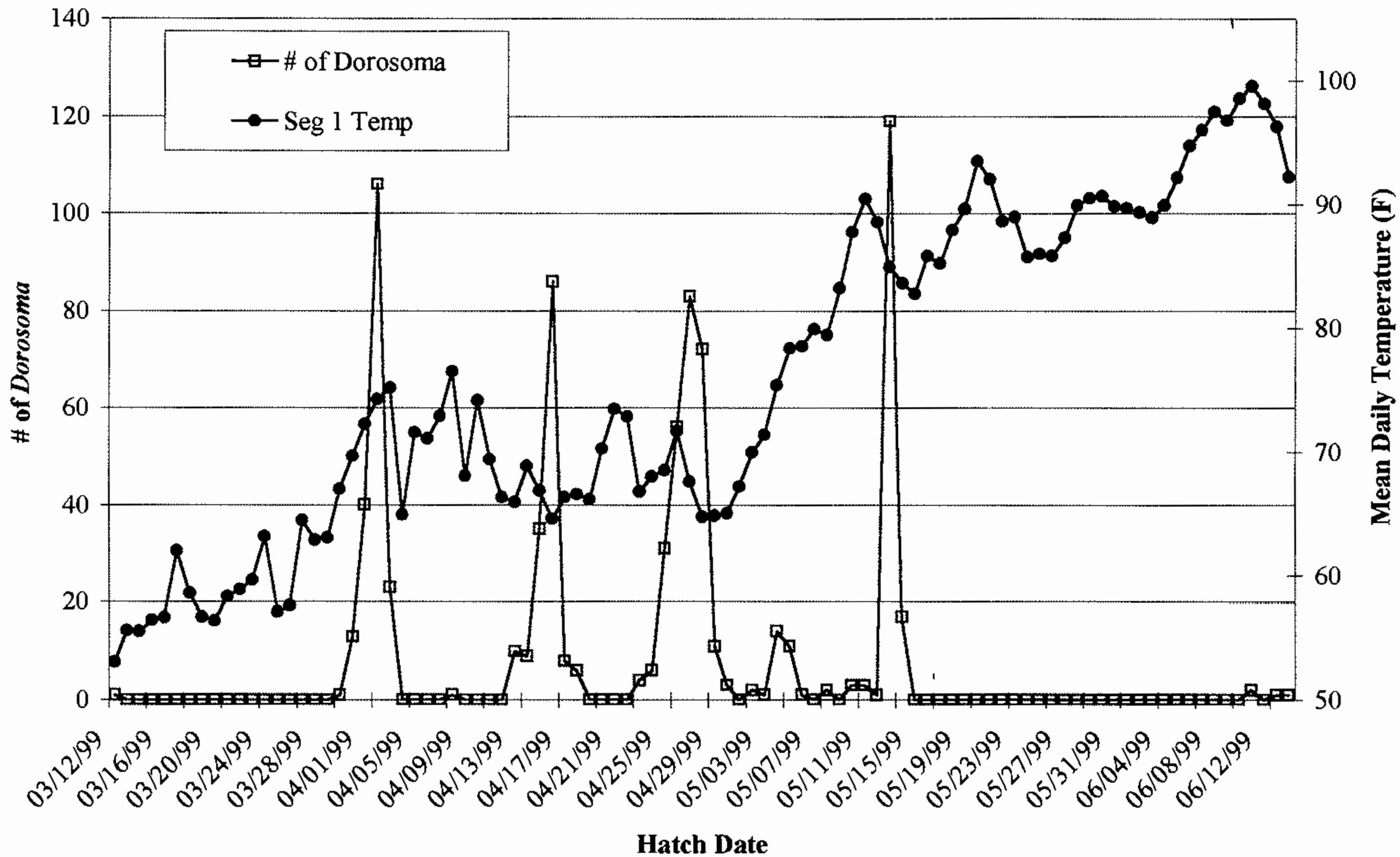

Figure 8.35. Number of *Dorosoma* by hatch date in Newton Lake (segment1) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

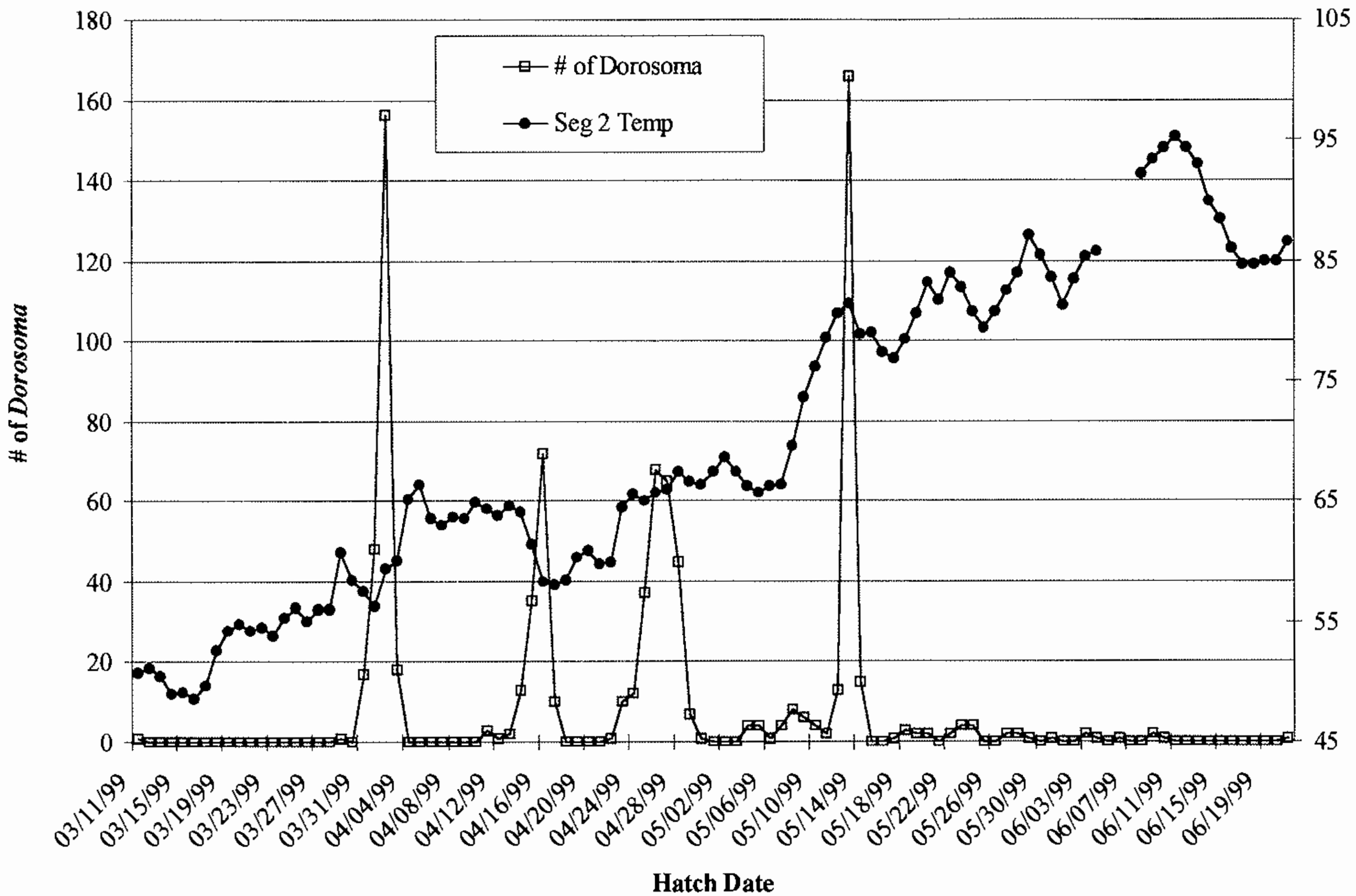

Figure 8.36. Number of *Dorosoma* by hatch date in Newton Lake (segment 2) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

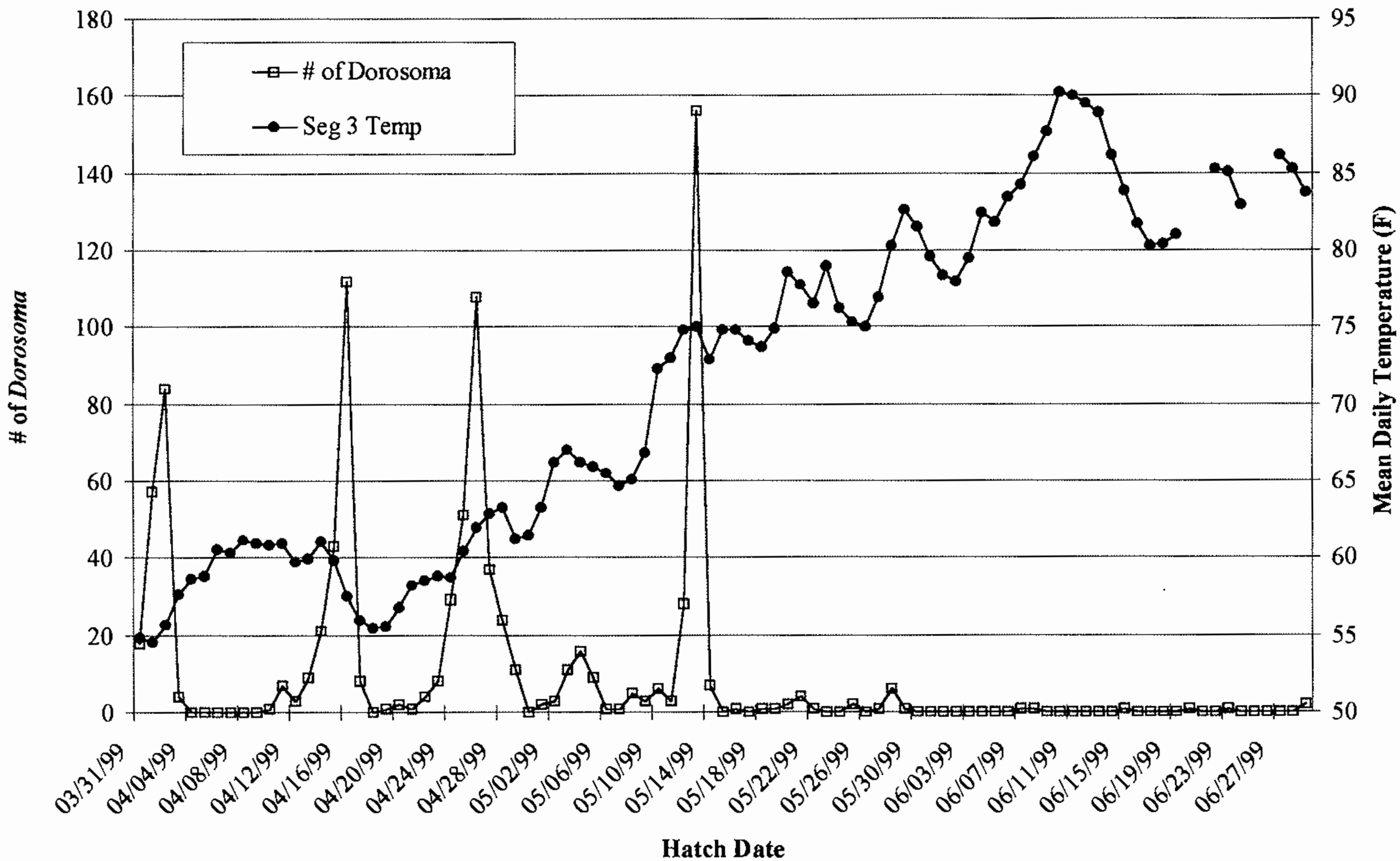

Figure 8.37. Number of *Dorosoma* by hatch date in Newton Lake (segment 3) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

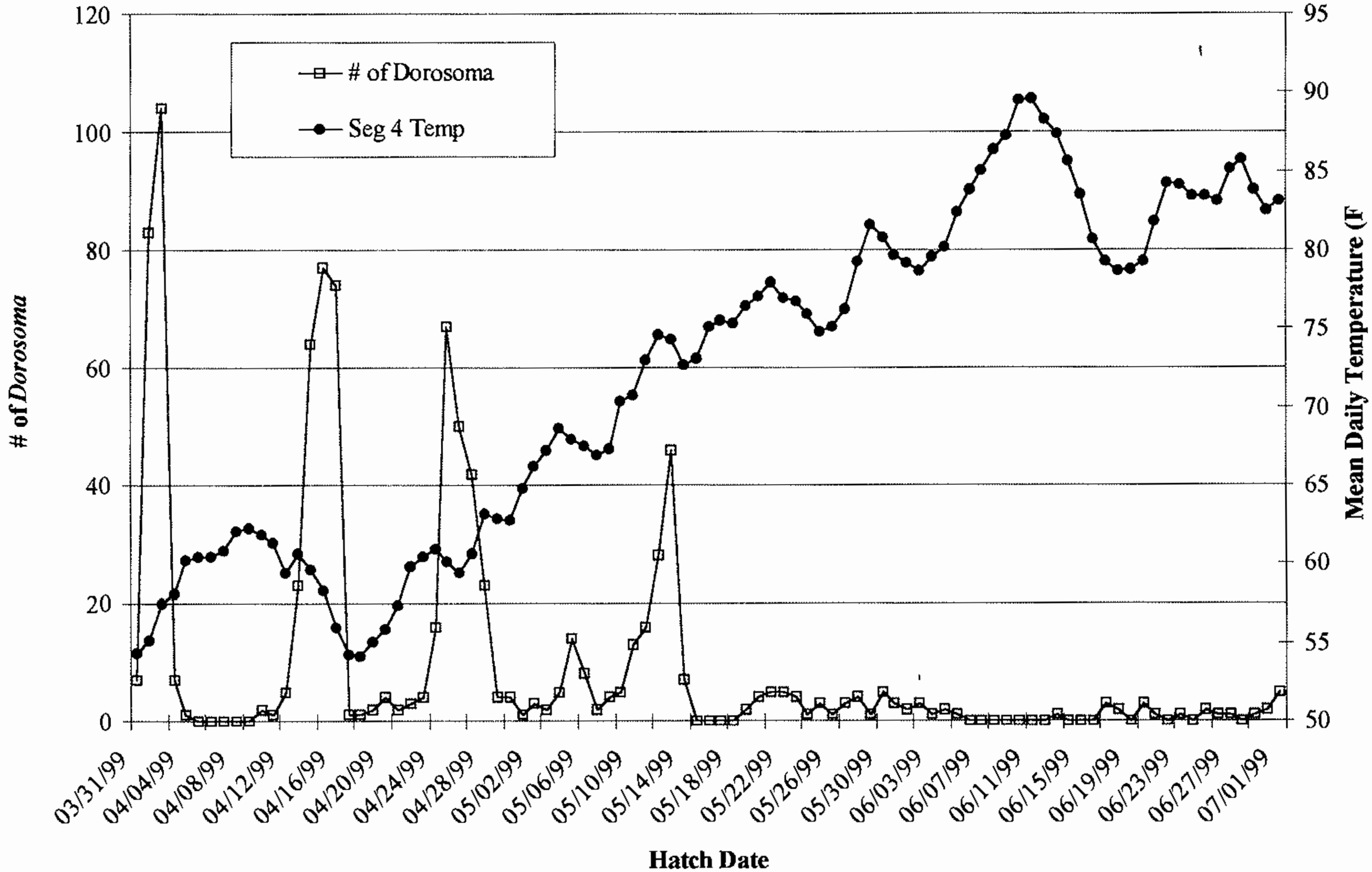

Figure 8.38. Number of *Dorosoma* by hatch date in Newton Lake (segment 4) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

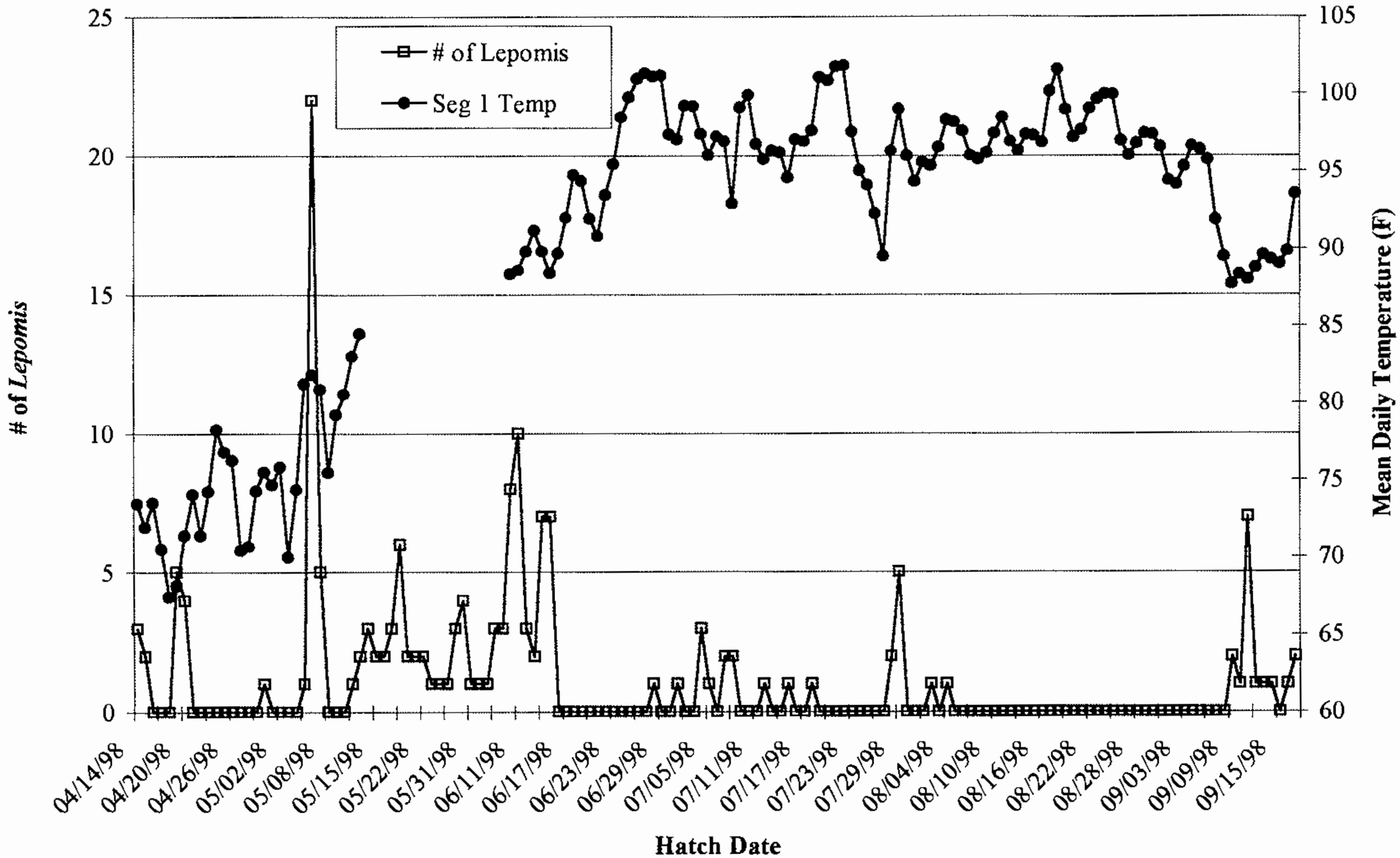

Figure 8.39. Number of *Lepomis* by hatch date in Newton Lake (segment 1) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

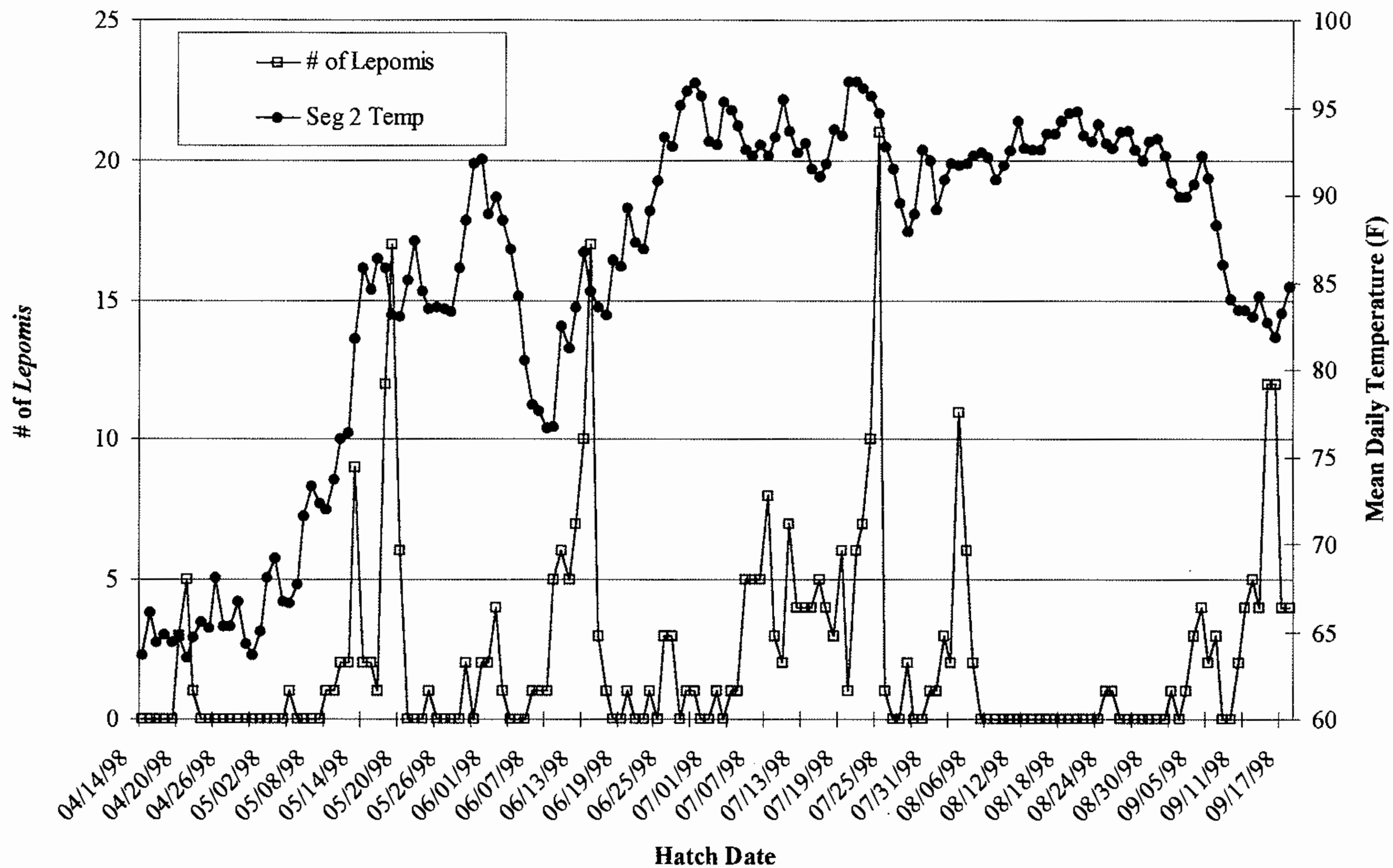

Figure 8.40. Number of *Lepomis* by hatch date in Newton Lake (segment 2) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch date were calculated by subtracting the age (days) from the collection date.

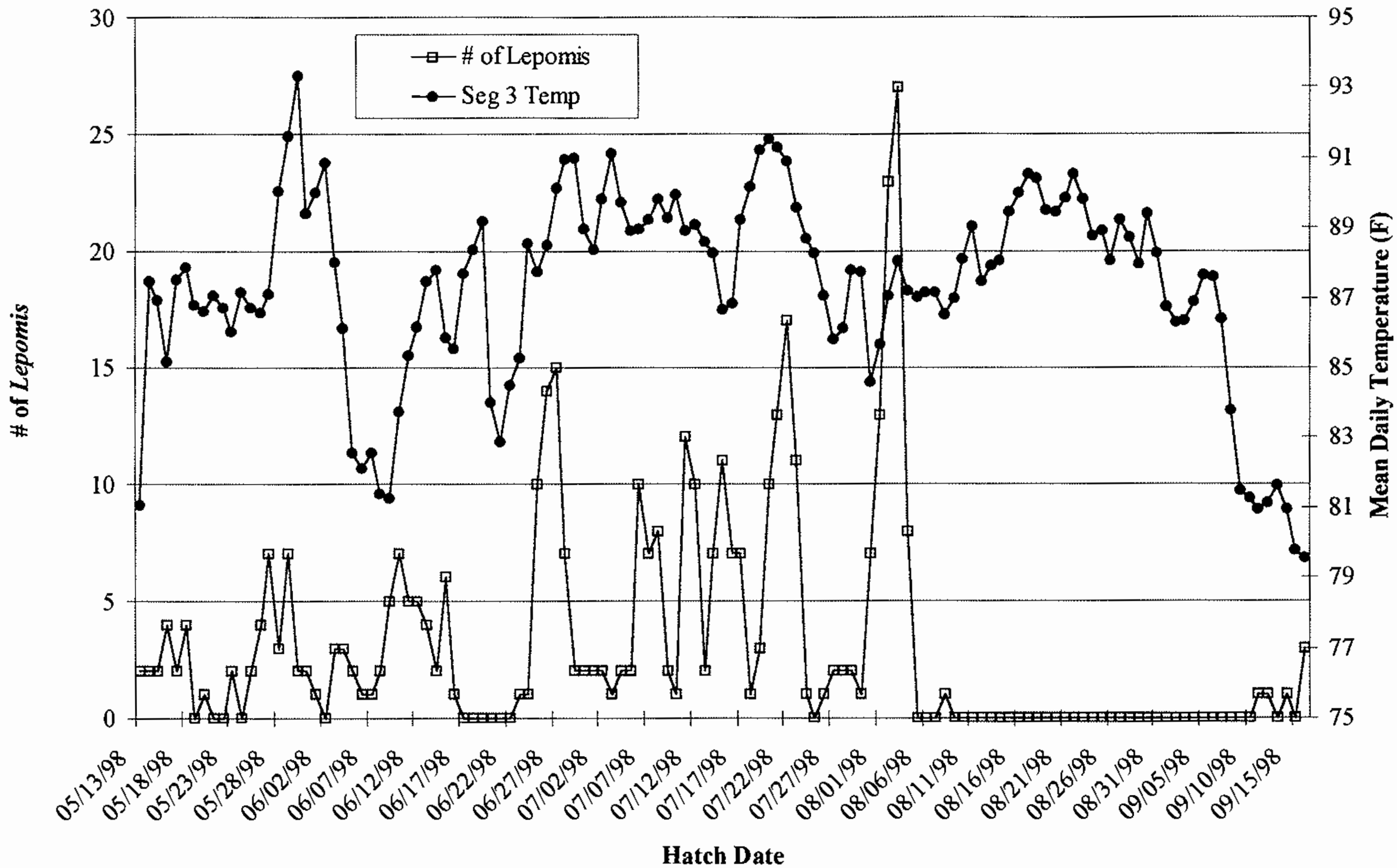

Figure 8.41. Number of *Lepomis* by hatch date in Newton Lake (segment 3) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

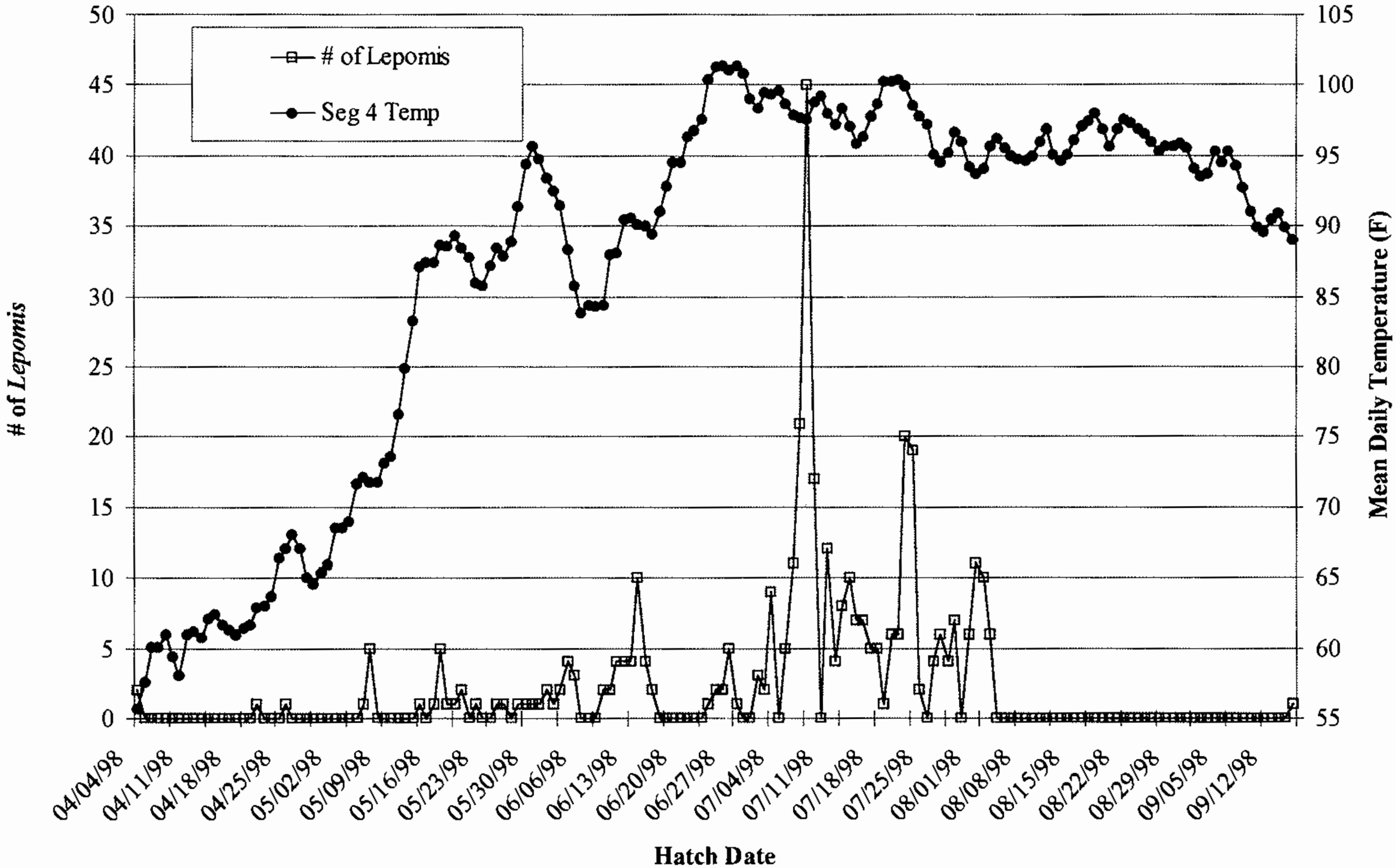

Figure 8.42. Number of *Lepomis* by hatch date in Newton Lake (segment 4) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

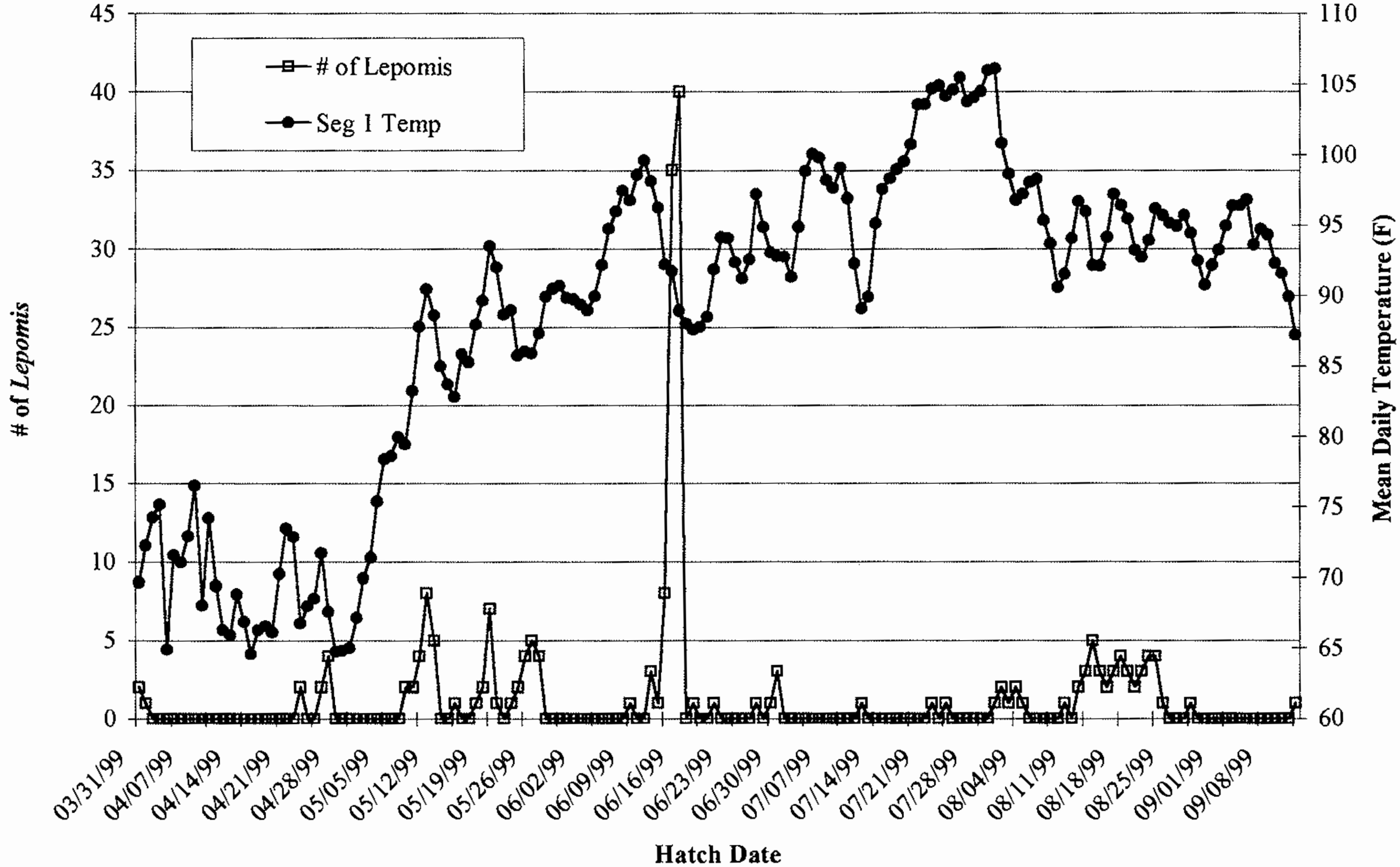

Figure 8.43. Number of *Lepomis* by hatch date in Newton Lake (segment 1) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

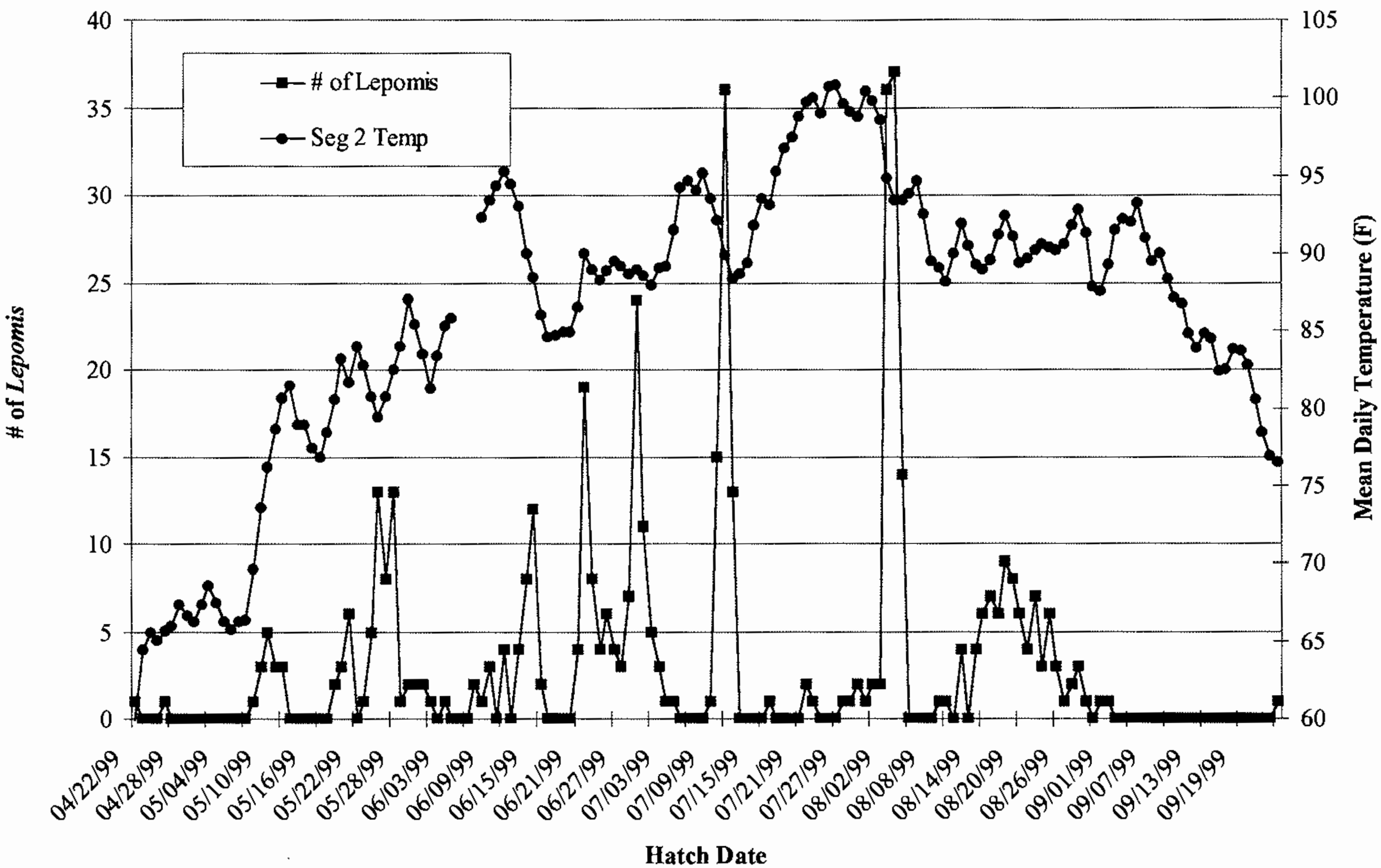

Figure 8.44. Number of *Lepomis* by hatch date in Newton Lake (segment 2) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

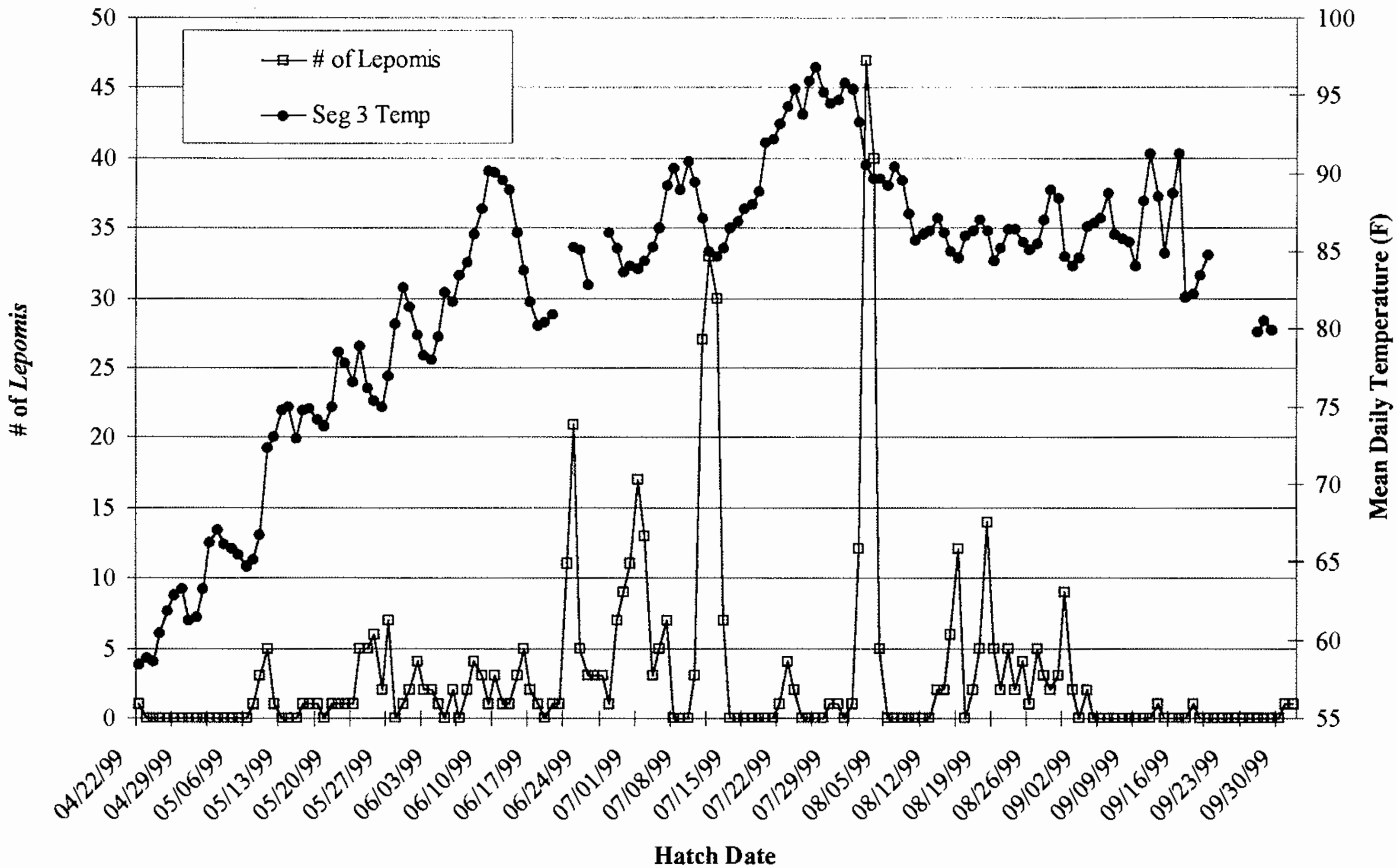

Figure 8.45. Number of *Lepomis* by hatch date in Newton Lake (segment 3) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

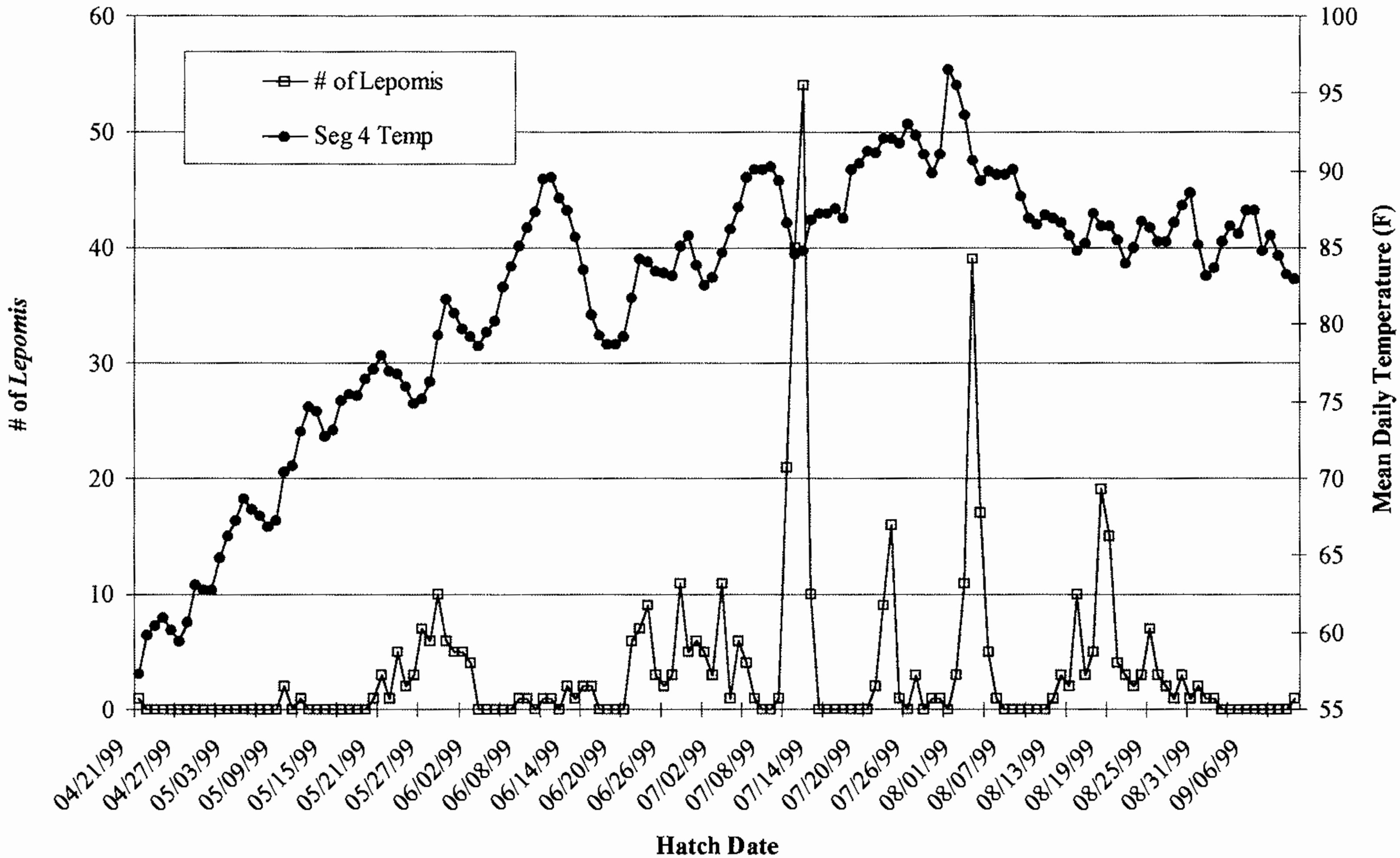

Figure 8.46. Number of *Lepomis* by hatch date in Newton Lake (segment 4) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

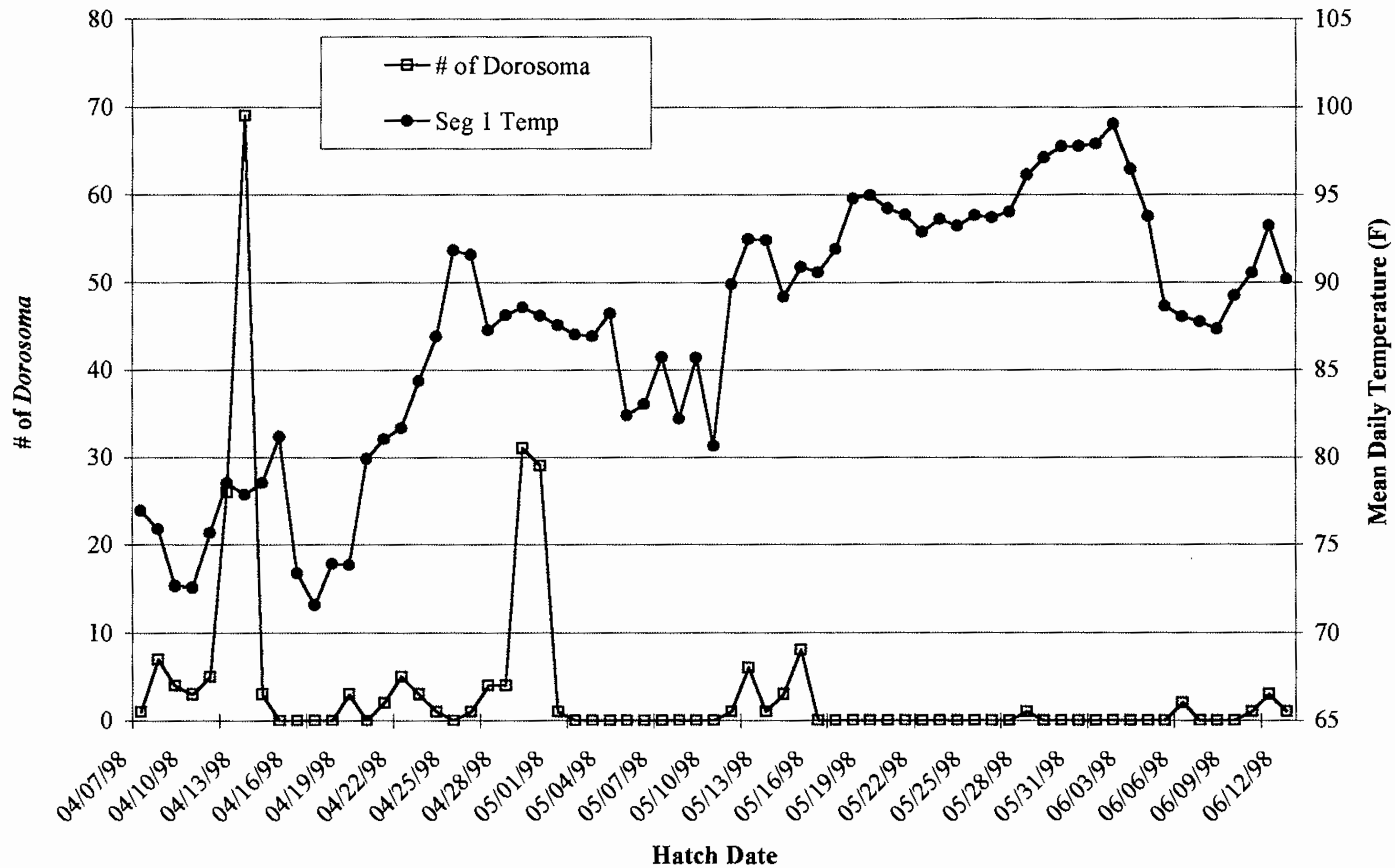

Figure 8.47. Number of *Dorosoma* by hatch date in Coffeen Lake (segment 1) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

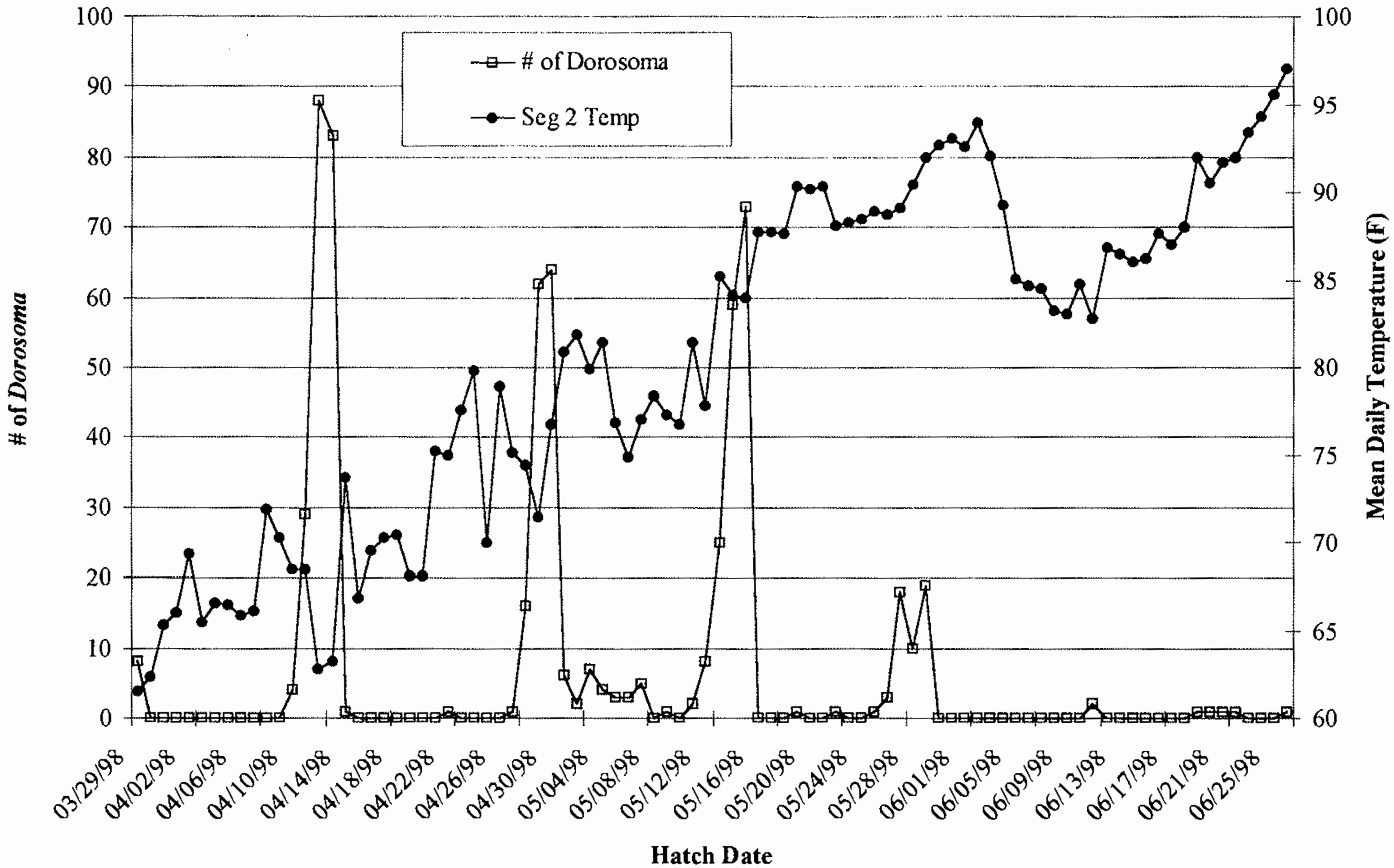

Figure 8.48. Number of *Dorosoma* by hatch in Coffeen Lake (segment 2) in 1998. Mean daily temperatures were from the surface or (if available) 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

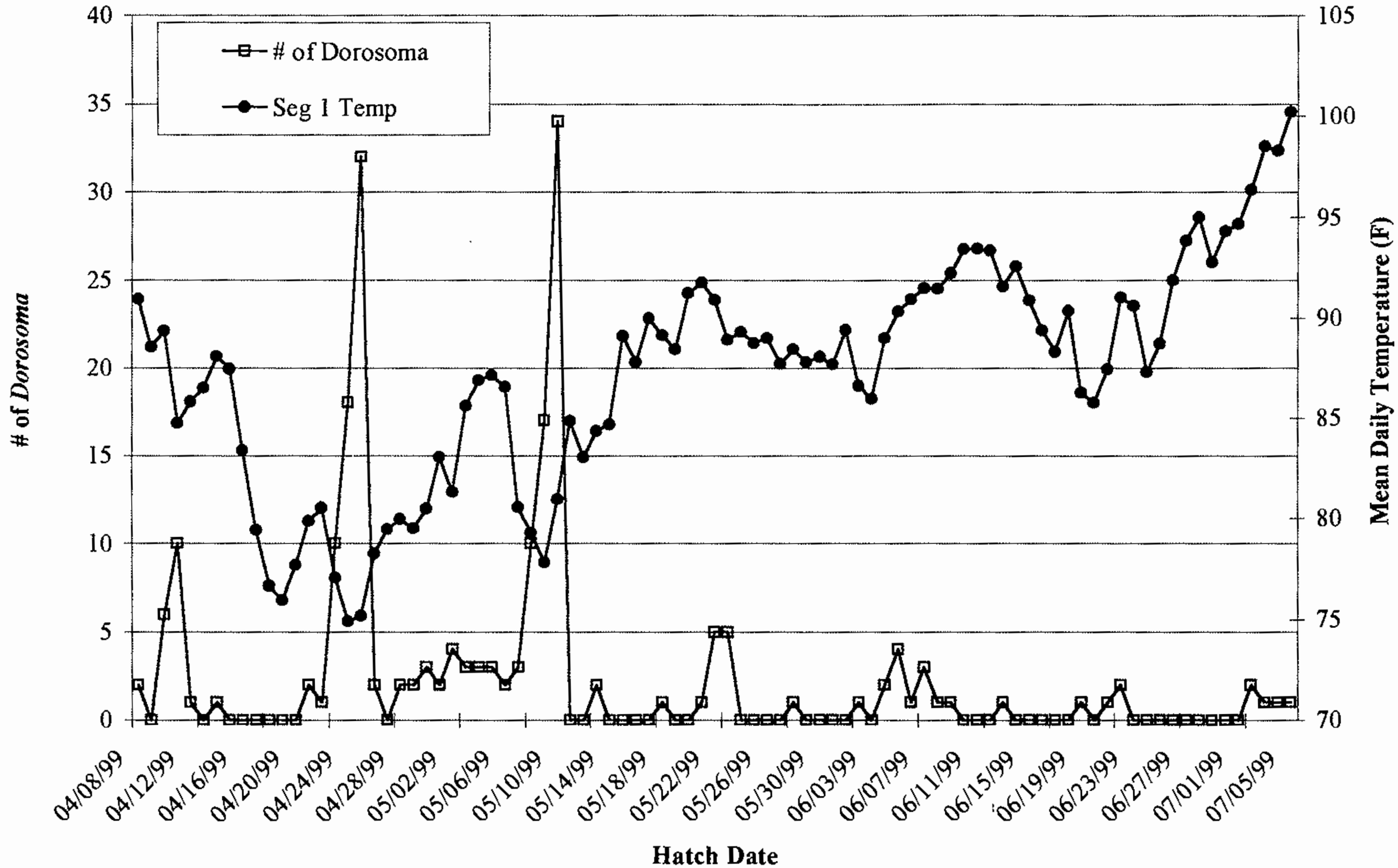

Figure 8.49. Number of *Dorosoma* by hatch date in Coffeen Lake (segment 1) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

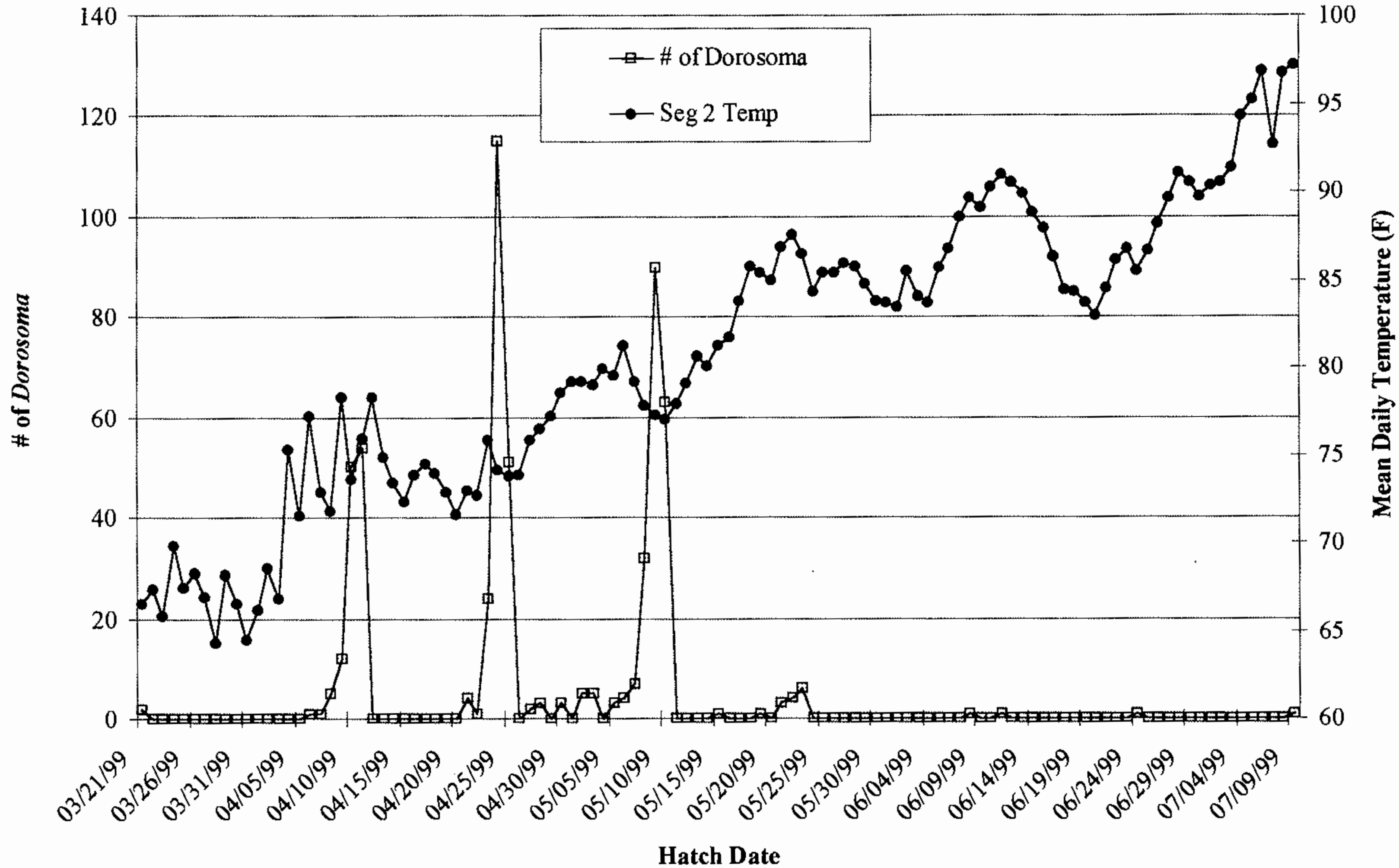

Figure 8.50. Number of *Dorosoma* by hatch date in Coffeen Lake (segment 2) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

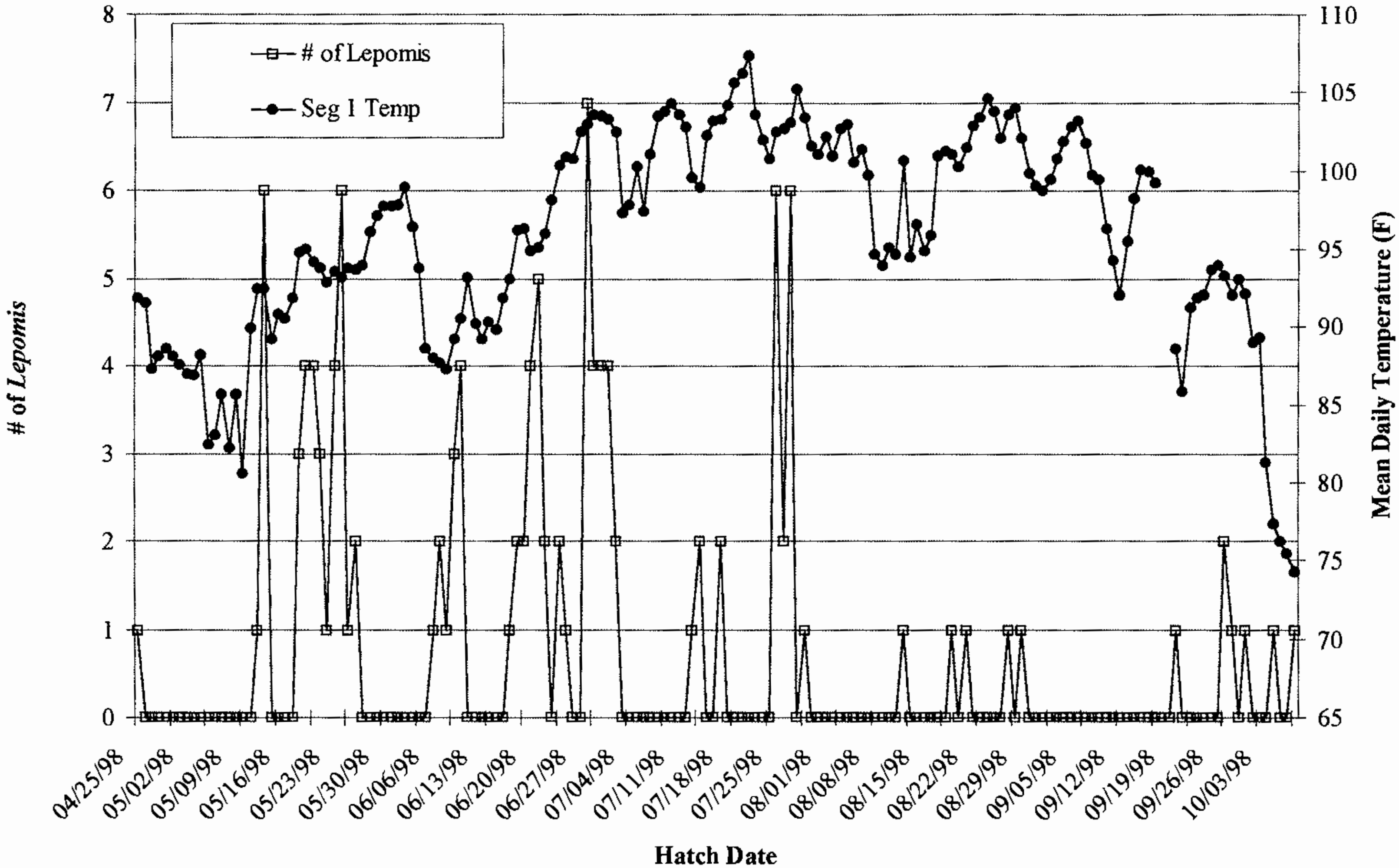

Figure 8.51. Number of *Lepomis* by hatch date in Coffeen Lake (segment 1) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

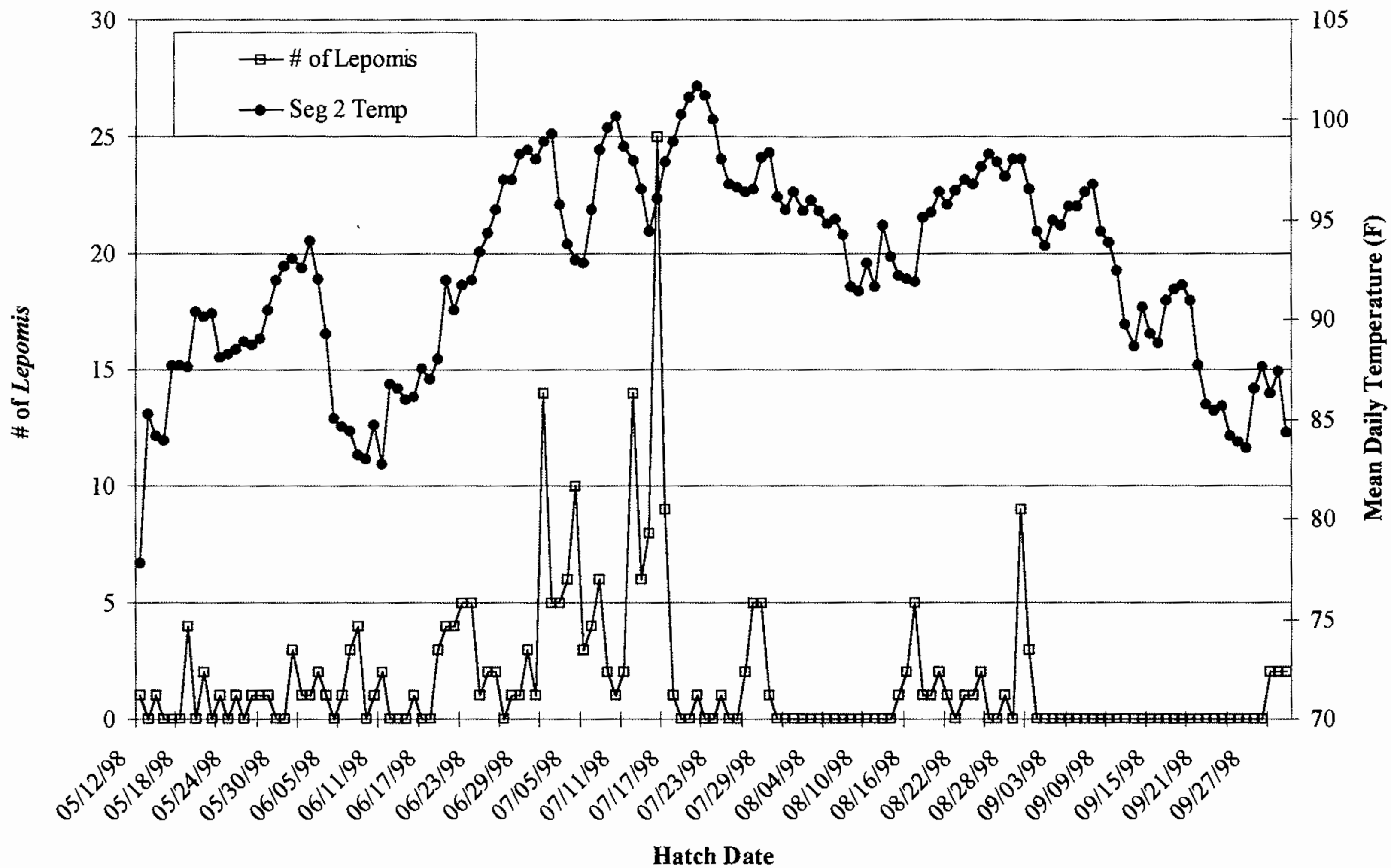

Figure 8.52. Number of *Lepomis* by hatch date in Coffeen Lake (segment 2) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

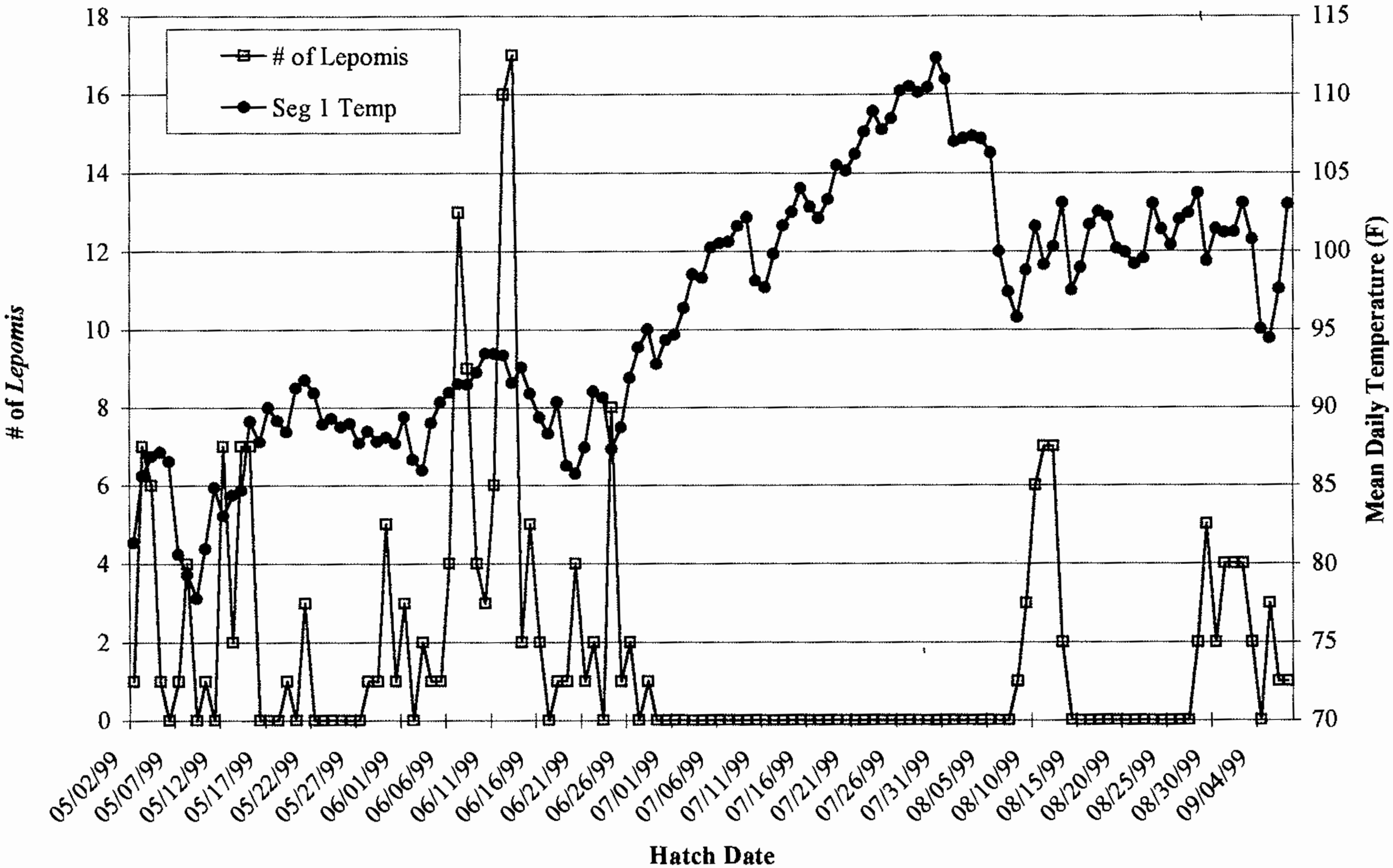

Figure 8.53. Number of *Lepomis* of hatch date in Coffeen Lake (segment 1) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

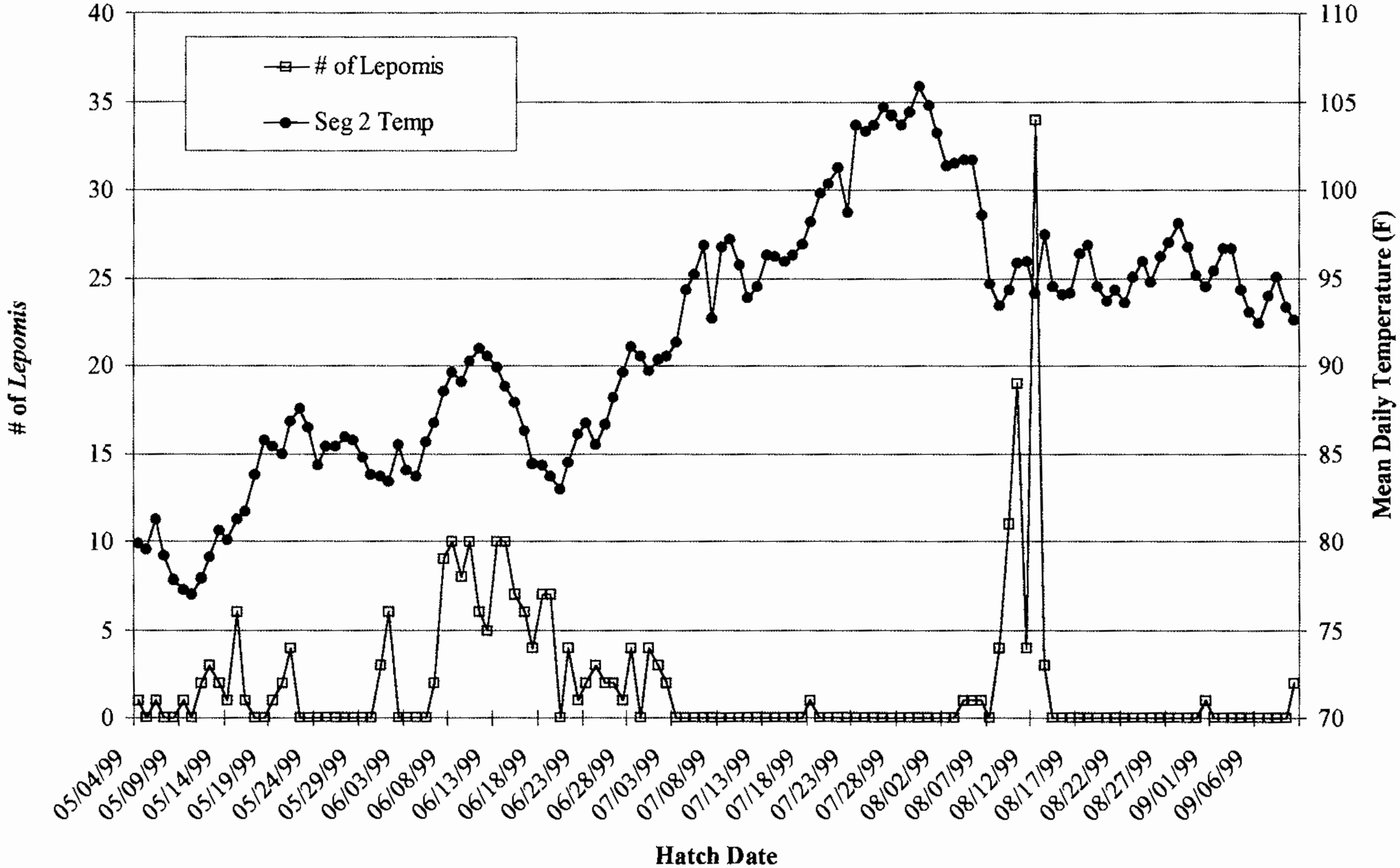

Figure 8.54. Number of *Lepomis* by hatch date in Coffeen Lake (segment 2) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

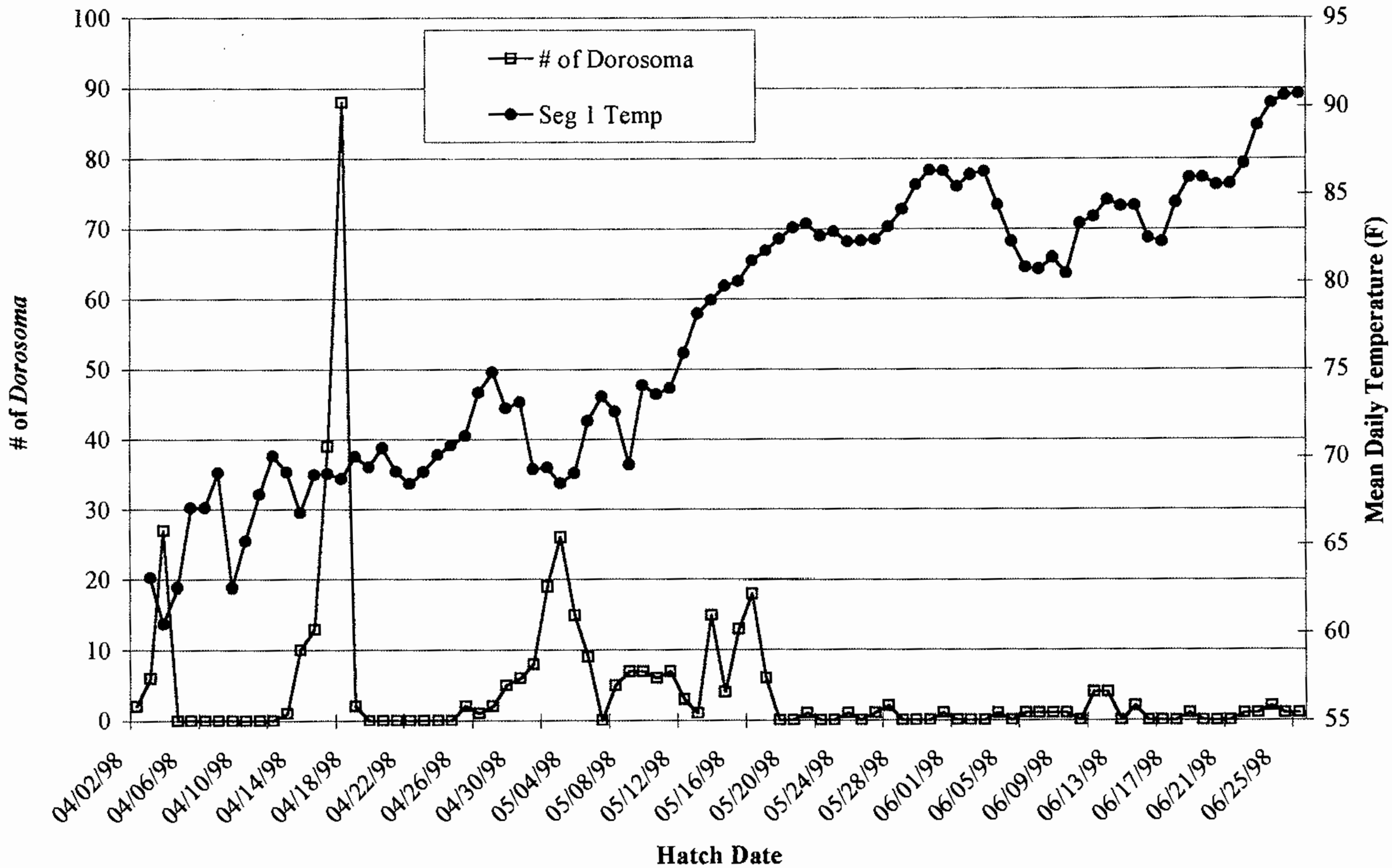

Figure 8.55. Number of *Dorosoma* by hatch date in Lake of Egypt (segment 1) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

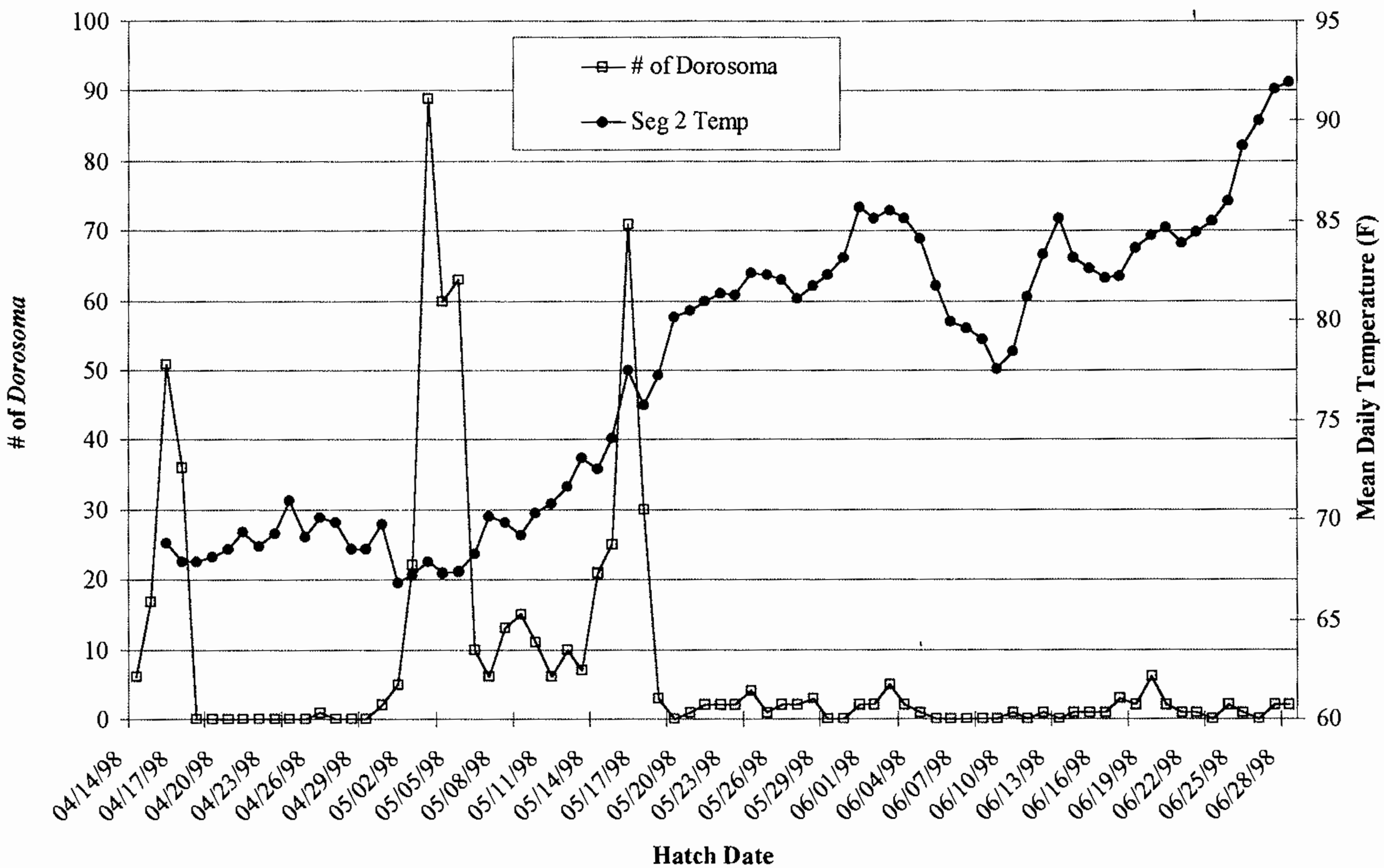

Figure 8.56. Number of *Dorosoma* by hatch date in Lake of Egypt (segment 2) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

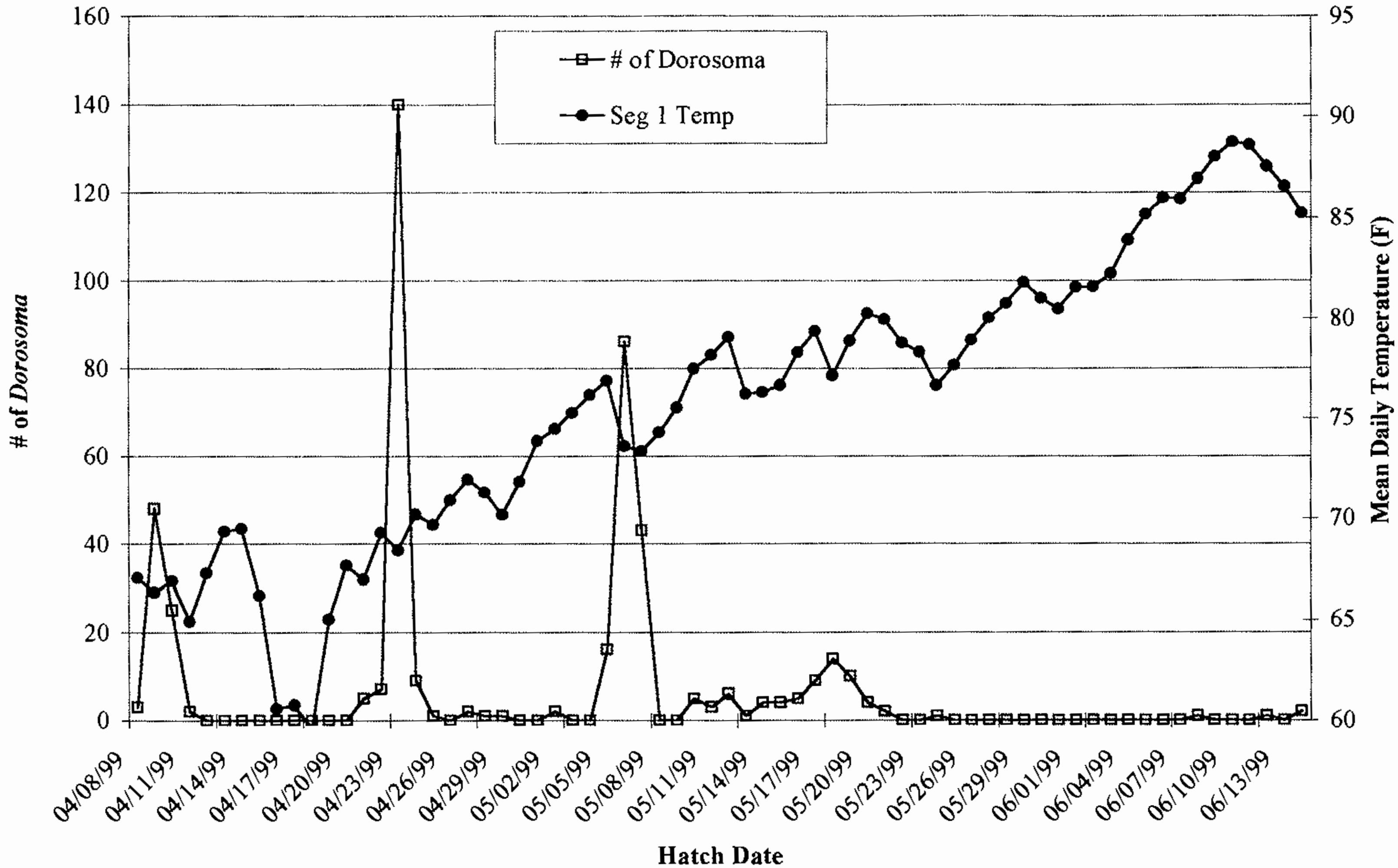

Figure 8.57. Number of *Dorosoma* by hatch date in Lake of Egypt (segment 1) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

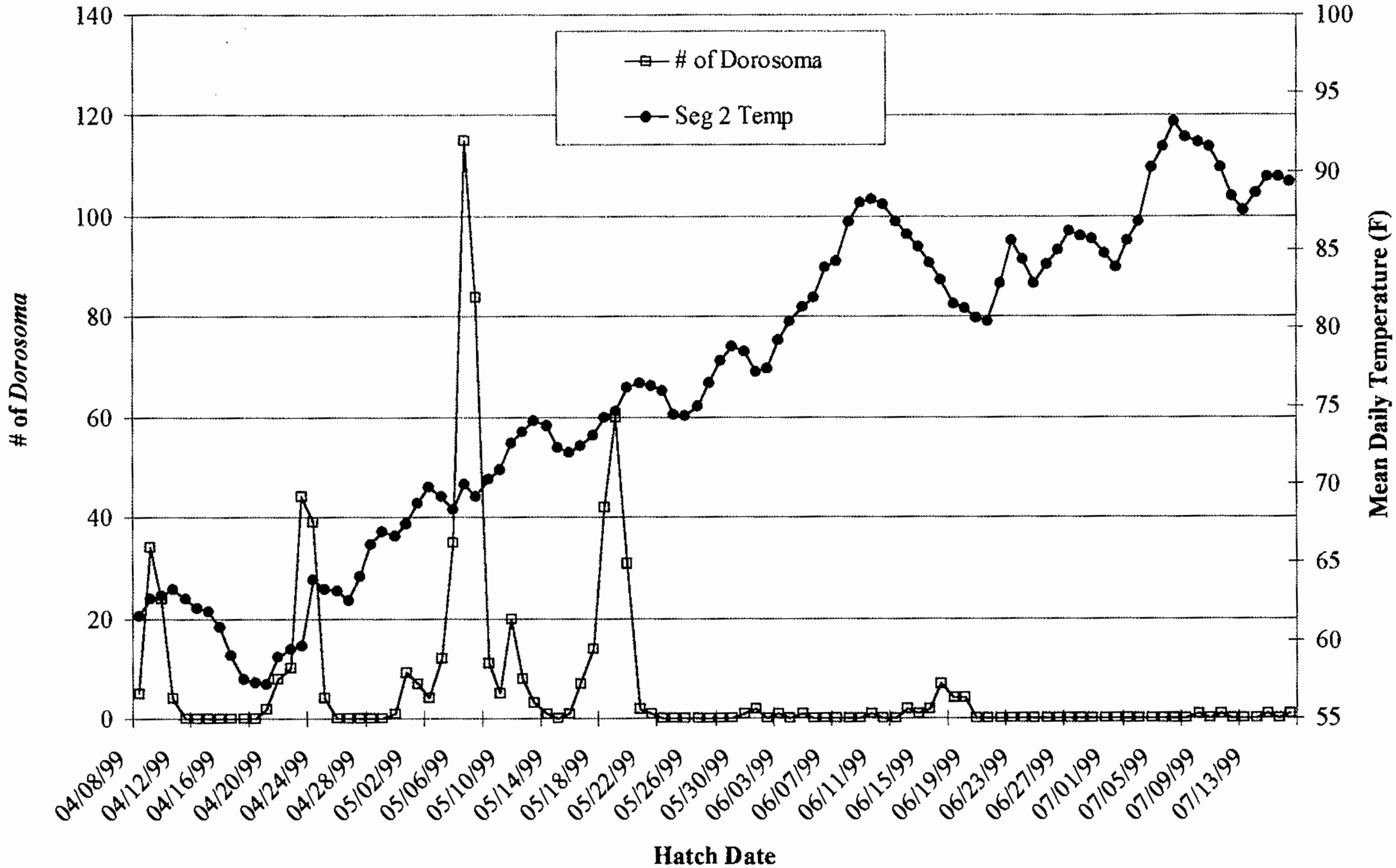

Figure 8.58. Number of *Dorosoma* by hatch date in Lake of Egypt (segment 2) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

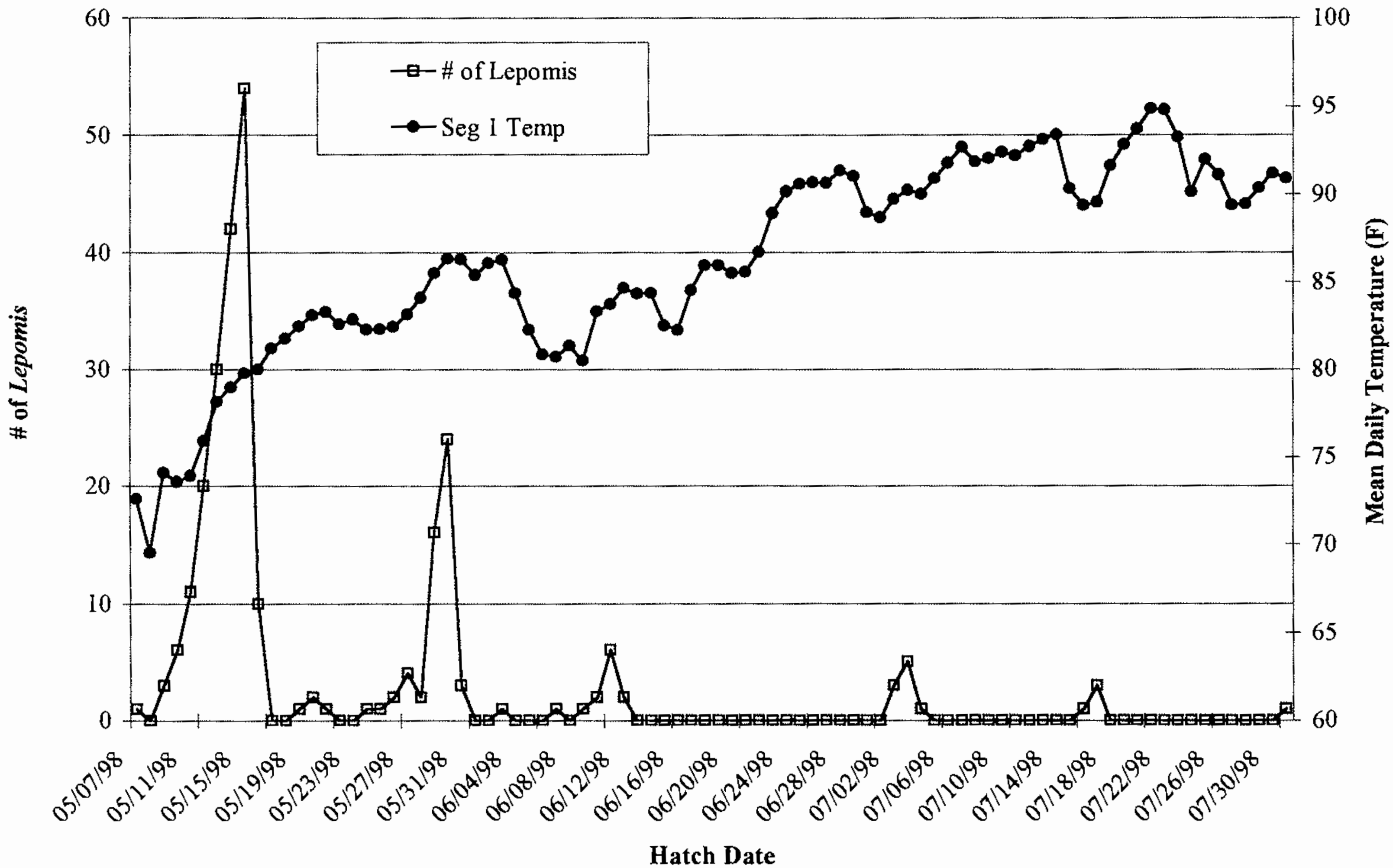

Figure 8.59. Number of *Lepomis* by hatch date in Lake of Egypt (segment 1) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

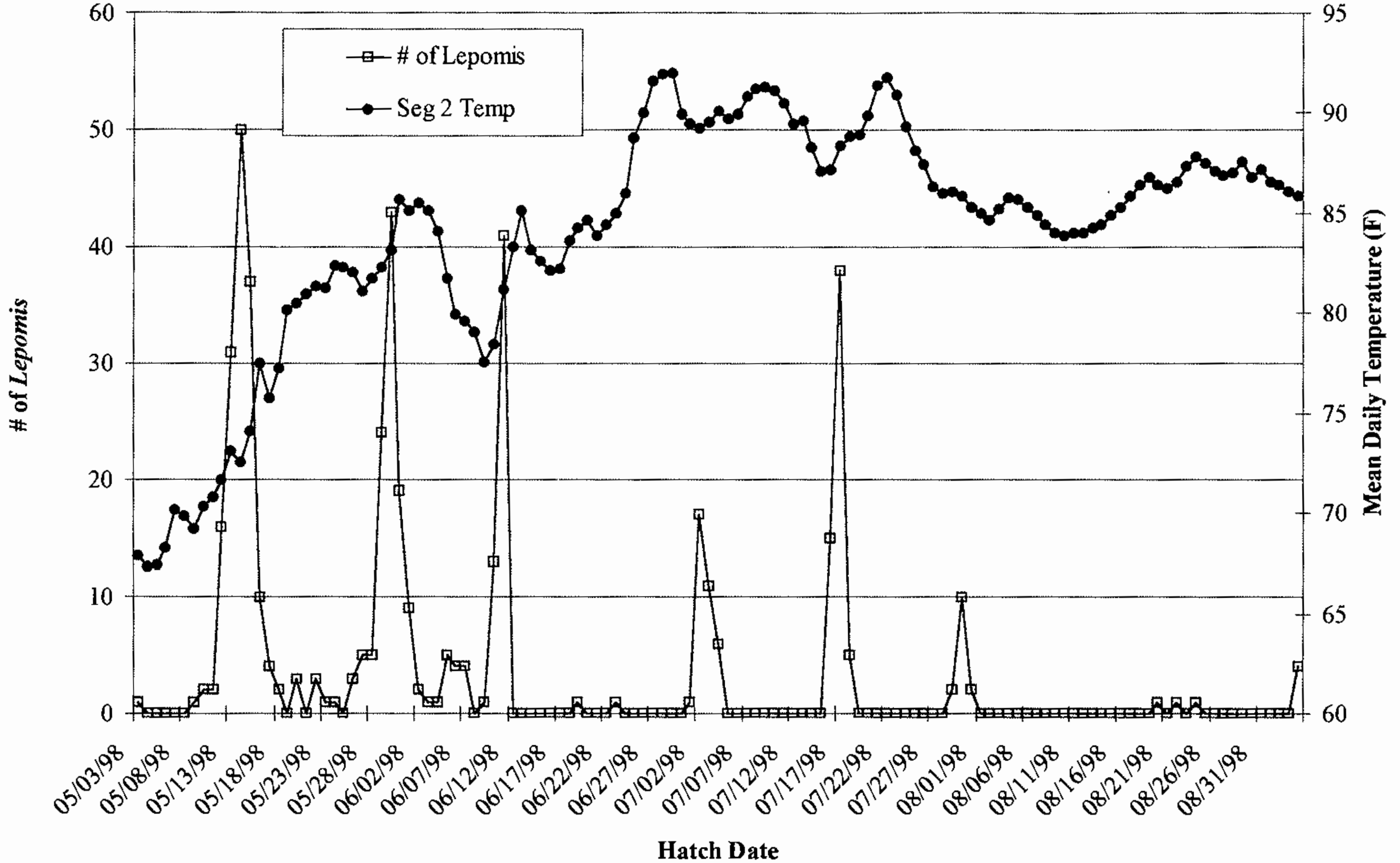

Figure 8.60. Number of *Lepomis* by hatch date in Lake of Egypt (segment 2) in 1998. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

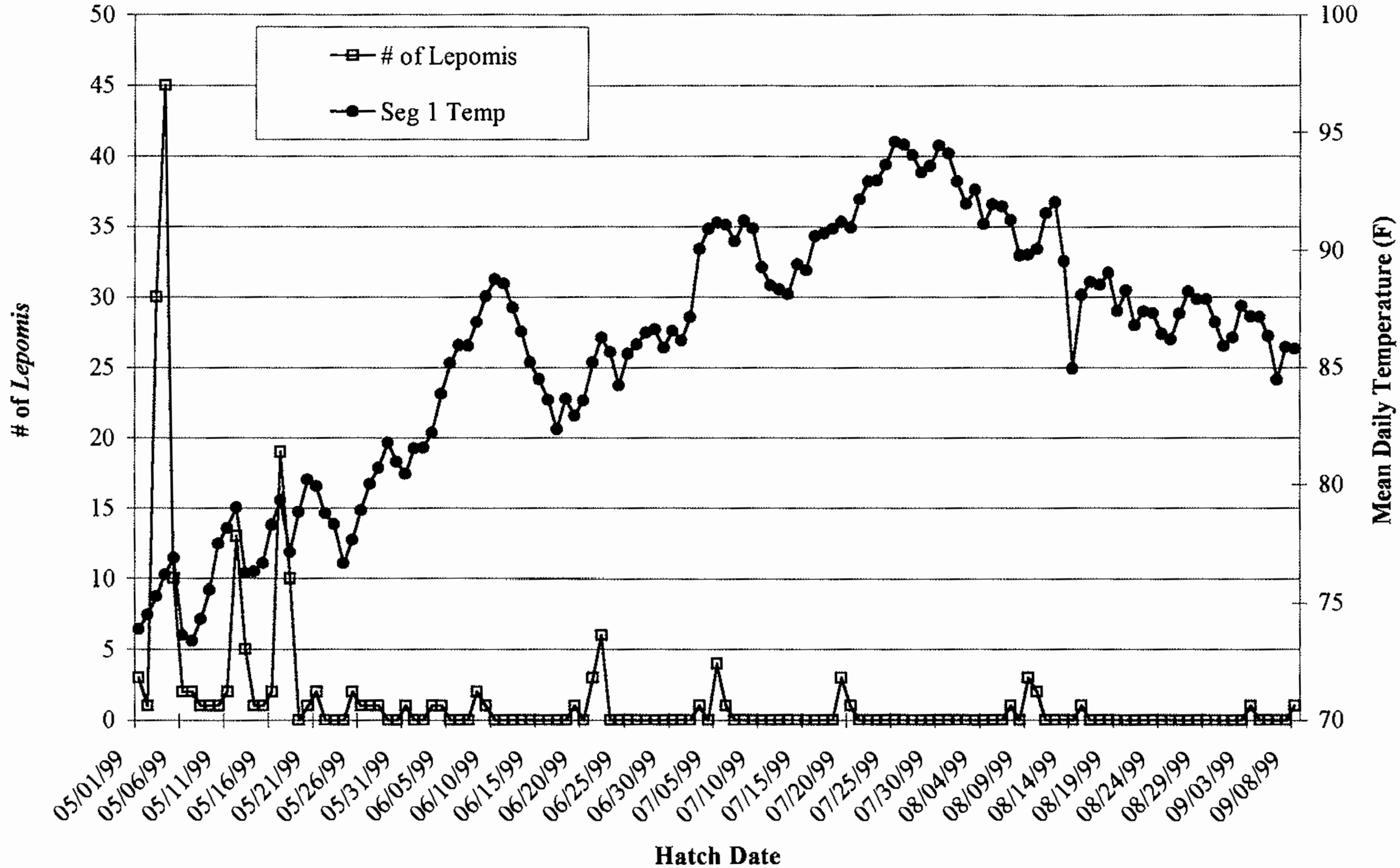

Figure 8.61. Number of *Lepomis* by hatch date in Lake of Egypt (segment 1) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

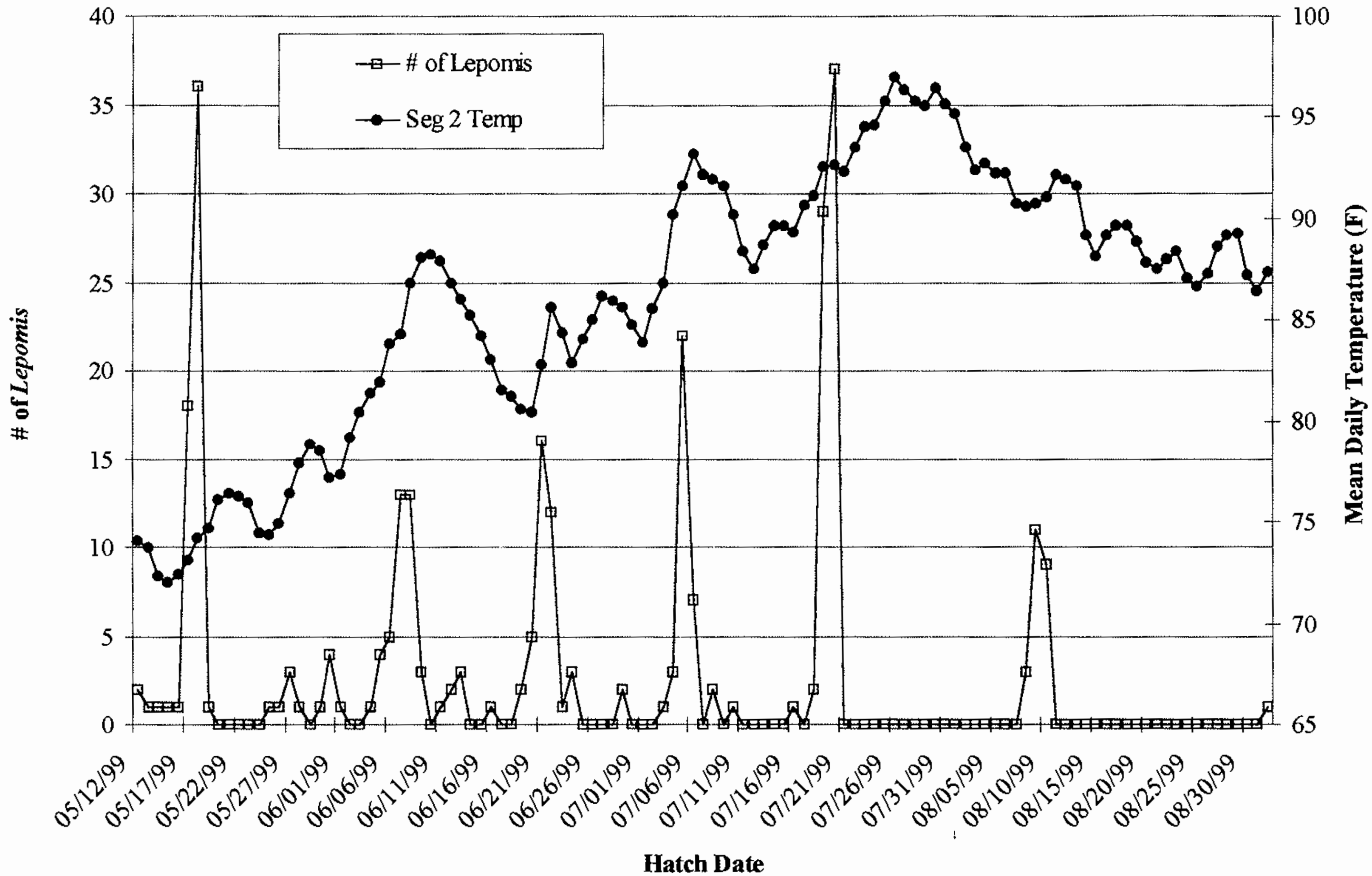

Figure 8.62. Number of *Lepomis* by hatch date in Lake of Egypt (segment 2) in 1999. Mean daily temperatures were from the surface (if available) or 1.5m depth. Hatch dates were calculated by subtracting the age (days) from the collection date.

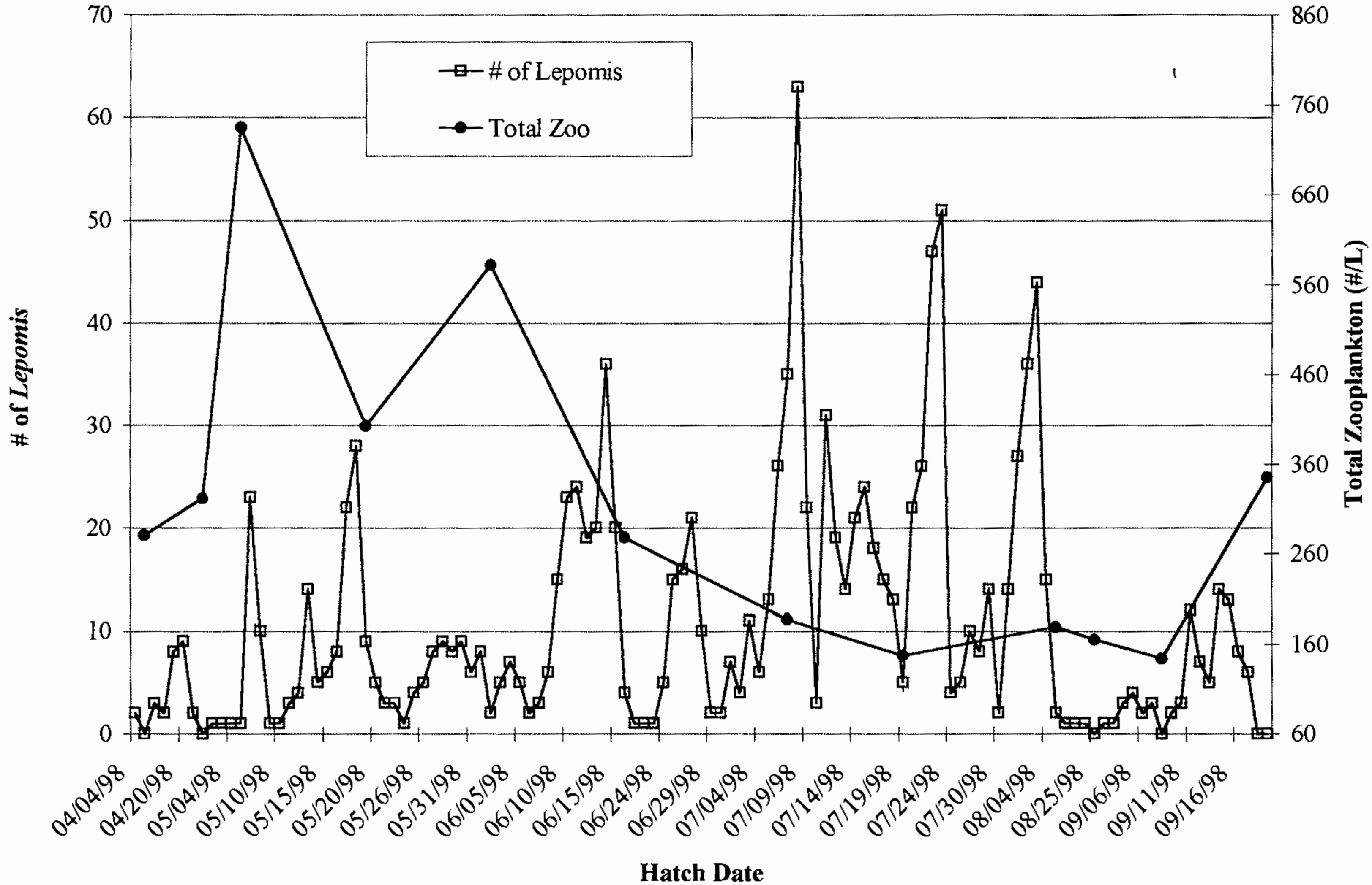

Figure 8.63. Number of *Lepomis* by hatch date in Newton Lake (all segments combined) in 1998. Total zooplankton (#/L) is from bi-monthly samples in 1998. Hatch dates were calculated by subtracting the age (days) from the collection date.

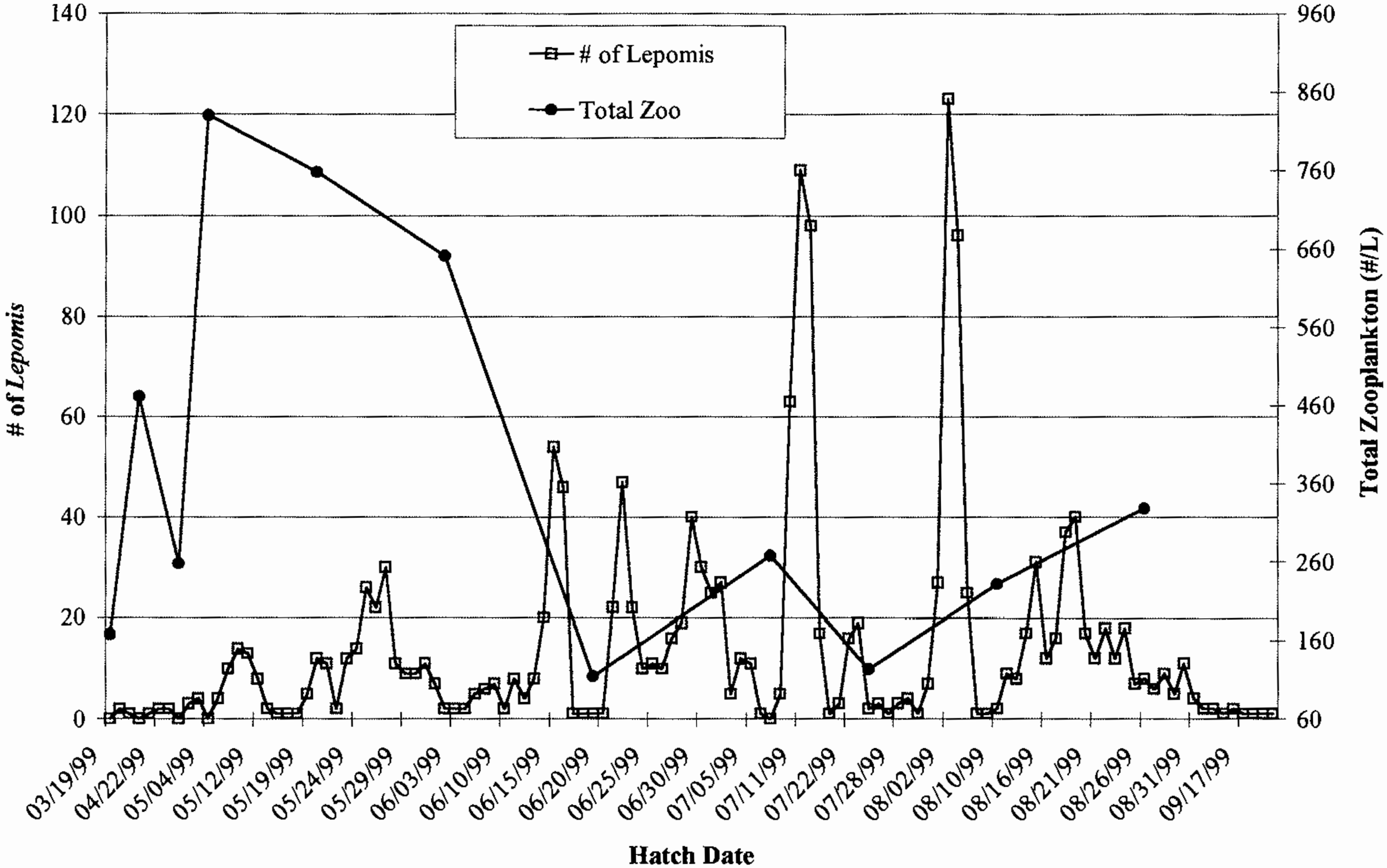

Figure 8.64. Number of *Lepomis* by hatch date in Newton Lake (all segments combined) in 1999. Total zooplankton (#/L) is from bi-monthly samples in 1999. Hatch dates were calculated by subtracting the age (days) from the collection date.

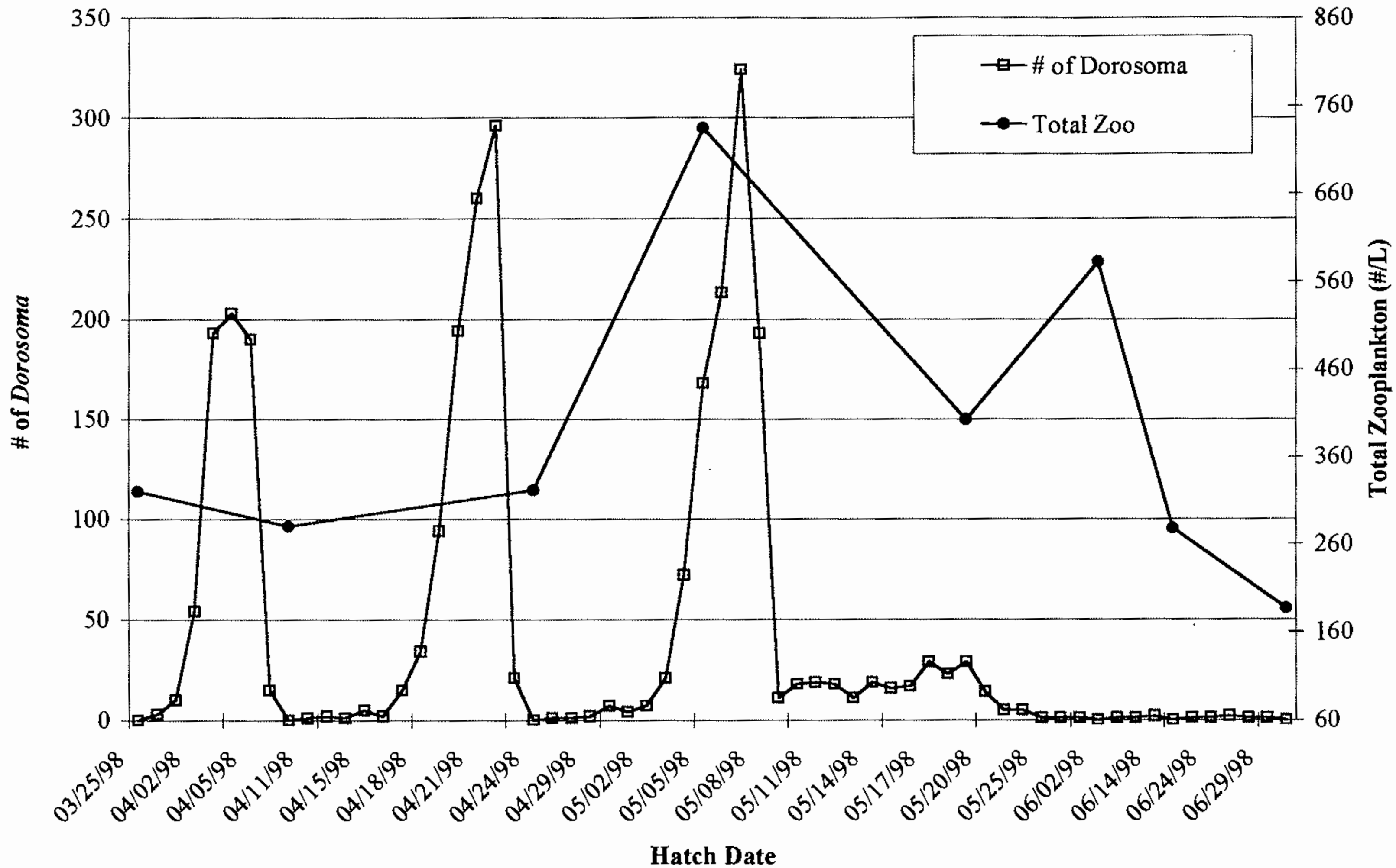

Figure 8.65. Number of *Dorosoma* by hatch date in Newton Lake (all segments combined) in 1998. Total zooplankton (#/L) is from bi-monthly samples in 1998. Hatch dates were calculated by subtracting the age (days) from the collection date.

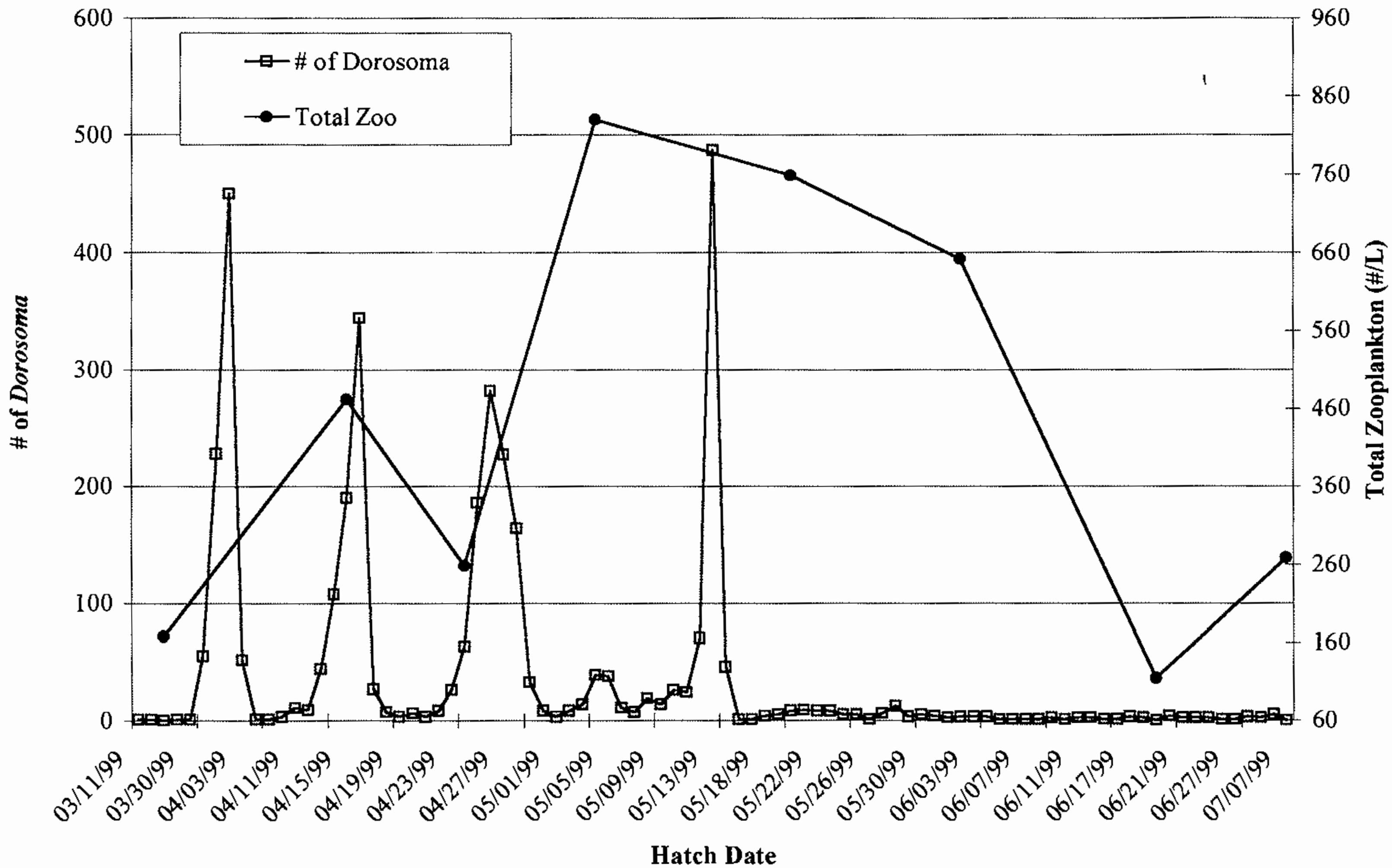

Figure 8.66. Number of *Dorosoma* by hatch date in Newton Lake (all segments combined) in 1999. Total zooplankton (#/L) is from bi-monthly samples in 1999. Hatch dates were calculated by subtracting the age (days) from the collection date.

Chapter 9. Fish Health (Primary responsibility --Melissa Goerlitz)

Introduction:

In 1997, the Newton Power Plant was granted a Variance to increase the thermal loading in Newton Lake. Newton Lake is a power cooling lake designed to take waste heat from the Newton Power Plant and dissipate it into the environment. Power cooling lakes are able to serve as heat sinks and store heat for various lengths of time (Larimore and Tranquilli 1981). Power cooling lakes can store considerable heat due to the high specific heat of water. The amount of heat that can be stored is related to the water volume and other factors.

In some cases, the thermal discharge from the power plant enters the deeper waters of the lake, eliminating temperature gradients and summer stratification (Larimore and Tranquilli 1981). This can increase heat storage, since the coldest waters, waters with the greatest capacity to store heat, are found below the epilimnion during the summer.

Much of the heat absorbed by the lake from the sun and the thermal discharge is dissipated through evaporation, back radiation, and conduction. As temperature and thermal discharge increase, evaporation also increases, thus moderating the thermal loading that occurs in a power cooling lake. Exposure of the lake's surface to wind, general lake morphology, elevation, barometric pressure, and salinity can all also affect evaporation rates. Back radiation is independent of temperature. Conductive heat losses to the air and lake basin occur to a lesser degree than heat losses due to evaporation and back radiation (Larimore and Tranquilli 1981).

Each organism can survive only within some range of temperatures. Each organism grows and survives best over some temperature range. Thermal discharges can cause stress in aquatic organisms, if resulting water temperatures approach their thermal tolerance limits. Low dissolved oxygen can also induce stress in aquatic organisms. The health of a fish can be used as an indicator of the amount of stress it is undergoing over a period of days, weeks, and/or years. Wedemyer et al. (1984) defined a stressor as being an environmental alteration, such as an increase in temperature, and the stress being the fish's response to the stressor. Stress has the potential to load or limit a fish's physiological system, reduce growth, impair reproduction, and reduce the integrity of the immune system, making the fish more susceptible to disease and additional stressors (Adams 1990).

Fish exposed to a stressor undergo a physiological stress response. The stress response primarily occurs through two physiological pathways: a nervous pathway involving the sympathetic branch of the autonomic nervous system and a blood pathway, involving hormonal mechanisms. The nervous pathway mediates changes in cardiac output, ventilation rate, and other processes. It can also stimulate the release of catecholamines from the chromaffin cells into the blood stream. What is commonly referred to as the blood pathway also has a neural component to it. The hypothalamus signals the pituitary to secrete adrenocorticotropic hormone (ACTH). ACTH then travels via the blood to the interrenal cells, stimulating them to release corticosteroids, such as cortisol (Davin et al. 1992; Wedemeyer et al. 1990). The secretion of catecholamines and certain corticosteroids are considered to be the "primary effects of stress". These primary-effect hormones orchestrate physiological adjustments made by the animal during stress.

Corticosteroids and catecholamines act on target tissues producing the "secondary effects of stress". Catecholamines increase blood pressure, blood lactate, and ventilation along with other effects (Davin and Sheehan 1992). Corticosteroids cause catabolism of muscle and liver glycogen, declines in white blood cell counts, immunosuppression and other physiological changes (Davin and Sheehan 1992).

A fish's exposure to a stressor may result in either acute or chronic stress. Acute stress can occur from a single or several short-term exposures to a stressor. Examples of an acute stress include radical changes in temperature or dissolved oxygen (Adams 1990). A stress response can occur immediately or may be prolonged. Sub-lethal or chronic stress has a long-term effect on the health of the fish. Its effects usually will be seen at a suborganismal level first, such as a change in the condition of the liver or a change in plasma osmolality. Exposure to low levels of a stressor over a long period of time or in cycles can provoke a stress response in fish well. These stressors will ultimately affect the reproduction, growth, physiological variables; and the overall future health of the fish (Adams 1990).

Hematological Effects of Stress

Hematological parameters are often used as indicators of sub-lethal stress because of the close relationship that the circulatory system of a fish has with the environment (Casillas and Smith 1977). Elevations in blood sugars can occur in response to the actions of adrenaline and other primary effect stress hormones as a means to provide energy for the "fight-or-flight" response. As glucose concentrations increase, there is a corresponding decrease in glycogen concentrations in the liver, due to glycogenolysis. Therefore, the nutritional status of the fish will affect the magnitude of the response to blood stress hormone concentrations (Davin et al. 1992; Wedemeyer et al. 1990). Casillas and Smith (1977) found that increases in blood glucose concentrations in rainbow trout were correlated with the magnitude of the stressor.

Plasma proteins are largely divided into fibrinogens and albumin (Heath 1995). Fibrinogens play an essential role in the clotting process. Albumin is involved in maintaining normal osmotic pressure, blood pH buffering, serving as an amino acid source, and transporting hormones and exogenous chemicals (Heath 1995). Each of the above can be influenced by factors such as size, sex, state of maturity, and environmental factors such as temperature or food availability (Houston 1997).

Hematocrits measure the packed cell volume of erythrocytes in the blood. McLeay (1973) found decreases in hematocrits in fish exposed to pulp mill effluent. He attributed this to either a decrease in erythrocyte production, an increase in erythrocyte destruction or hemodilution caused by the prolonged exposure to the effluent. Low hematocrits are generally associated with acute stress, while high hematocrits are associated with disease (Goede and Barton 1990).

Differential blood cell counts can aid in detecting stress and disease. This can also aid in verifying hematocrit, leucocrit, and clotting time results. These counts differentiate leukocytes, which include lymphocytes, heterophils, neutrophils, thrombocytes, basophils, esonophils, and monocytes. Lymphocytes are primarily involved in immunoactivity. Heterophils and neutrophils aid in injury repair, e.g. mechanical injury, and bacterial and or parasite infection. Thrombocytes take part in the clotting process. Basophils play a role in inflammatory responses. Esonophils and monocytes are involved with phagocytic activity (Ellis 1977).

Heat shock proteins are biochemical markers of thermal stress. Four universal families of heat shock proteins (hsp90, hsp70, hsp60, and small heat shock proteins) exist in eukaryotes (Kothay and Candido 1982). These families can be classified by their molecular weights on SDS-polyacrylamide gel electrophoresis. Heat shock proteins are typically found in low concentrations in the blood under normal conditions in the absence of a stressor. They serve as protein folders or chaperones that aid in the folding, unfolding, assembly, disassembly and translocation processes (Parcel and Lindquist 1993). Increased concentrations of blood heat shock proteins have been found in trout subjected to a thermal stressor (Vijayan et al. 1997), diptera (Ritossa 1962), and sea urchins (Roccheri et al. 1981) among other eukaryotes.

Effects of Stress on Condition

Coughlan et al. (1996) reported that Ronald Goede first developed a condition assessment procedure in the 1970's to evaluate hatchery raised trout. This necropsy-based condition assessment was developed as a quick, inexpensive procedure to detect a stressed population while corrective actions could still be taken. It was not developed as a diagnostic tool, but rather as a means for following trends in the health and condition of a fish population (Goede and Barton 1990). Adam's et al. (1993) quantified Goede's method (1993) for simplification in statistical analyses.

Several assumptions are made when using this method (Goede and Barton 1990).

(1) An organ or tissue under stress will change in order to maintain homeostasis.

(2) A long-term change in function will result in a gross overall change in structure of an organ or tissue.

(3) If the organ or tissue appears normal, then it probably is normal.

(4) If the organ departs from what is considered normal or the control condition, it is responding to an environmental stressor.

Data acquired from the condition-based assessment can be further supplemented with organosomatic indices and condition factors. The liver-somatic index (LSI) can be used as an indirect indicator of growth (Busacker et al. 1990) and nutritional status (Adams et al. 1982). Heidinger and Crawford (1977) found that as temperatures increased, the liver-somatic index decreased. Adams and McLean (1985) also concluded that the LSI was not only an indicator of food intake, but also an indicator of reproductive and temperature induced demands. Adams and

McLean (1985) also found the LSI to be a better indicator of growth at lower temperatures where a large part of the energy stores were not needed for metabolism.

The visceral-somatic index (VSI) is also an indicator of growth and stress. Adams and McLean (1985) and Adams et al. (1982) found that VSI was lowest during the warmest periods and then decreased again in the winter after a fall increase. Other organosomatic indices used as indicators of growth and stress include: the spleenosomatic index (Payne et al. 1978), the gonadalsomatic index (Adams et al. 1982), relative heart weights, increases in eye lens diameter (Payne et al. 1978), changes in relative weight (Wege and Anderson 1978), and condition factors (Adams and McLean 1985; Busacker et al. 1990; Heidinger and Crawford 1977). These indices along with organ and tissue condition may vary by age, sex, energy demand and season (Heidinger and Crawford 1977; Adams et al. 1982).

Study Objectives

The goal of this study was to determine the health effects of increased thermal loading on the health of fish populations of Newton Lake as compared to those of two other power cooling lakes. The emphasis on fish health is appropriate, since fish are of significant importance, both as a food source and for recreational fishing. The following were the specific objectives of this study:

- to evaluate and detect trends in the health of the fish populations of Newton Lake and two reference power cooling lakes;
- to utilize an necropsy based condition assessment to detect trends in the health of the fish populations in question;
- to compare the short term growth of fishes among the three lakes, within and between species, and between seasons; and

- to compare the long term growth of fishes among the lakes and by species.

Materials and Methods:

Long term population growth and short term stress responses of the fish populations in Newton Lake and two other cooling lakes, Coffeen Lake and Lake of Egypt, was assessed. Coffeen Lake was chosen because it has a thermal regime similar to Newton Lake. Lake of Egypt was chosen as the third power cooling lake because a significantly lower amount of thermal loading occurs in this lake as compared to the other two lakes. Thermal loading in Lake of Egypt results in substantially elevated temperatures only in the immediate vicinity of the thermal discharge. Newton Lake was divided into four segments, with segment one being warmest and four being coolest. Coffeen Lake and Lake of Egypt were both divided into two segments, with one being warmest and two being coolest.

We examined the health of twenty to thirty adult specimens for each of three species, largemouth bass, *Micropterus salmoides*; channel catfish, *Ictaluris punctatus*, and bluegill *Lepomis macrochirus*, from Newton Lake, Coffeen Lake, and Lake of Egypt using procedures outlined and modified from Goede (1993). Hematological effects of secondary stress responses were also determined for a sample of fish representing each species using procedures outlined by Houston (1990). Sampling was conducted in the spring before spawning as well as in the warmest part of the year (July/August) in 1998 and 1999. In the spring, fish were collected throughout each lake, whereas sampling was focused on the warmest areas of each lake in the summer. Fish kills occurred on Newton and Coffeen Lakes in the summer of 1999. The health of moribund largemouth bass from Newton Lake was evaluated at this time. Largemouth bass were also sampled from five non-power cooling lakes in the summer of 1999. This was done to establish the health of largemouth bass in waters with no thermal discharge. The five lakes included East Fork, Sam Dale, Rend, Kinkaid and Cedar Lakes. The necropsy-based health assessment was performed on five largemouth bass from each lake.

Fish Collection

Fish were collected by electrofishing to minimize the stress effects associated with collection time and handling. Clark et al. (1979) stated that previous studies by McCarthy et al. (1973) and Soivio and Oikari (1976) found that the stress of netting and angling caused altered hematological parameters in fish. In our study, there was no more than a 30-minute interval between capture and data collection. This is consistent with previous studies by Casillas and Smith (1977) and Clark et al. (1979). Temperature and dissolved oxygen profiles were also recorded near fish collection sites.

Hematological Tests

Blood samples were drawn from anesthetized fish to determine hematocrit, leucocrit, glucose, osmolality, clotting time, plasma proteins, and heat shock protein levels. Tricaine (MS-222) buffered with $CaCO_3$ was used as the anesthetic. Blood samples were obtained through transection of the caudal peduncle (Houston 1990). Heparinized capillary tubes were used to take blood samples. Three to fourteen hematocrit tubes per fish, depending upon fish size, were filled and immediately sealed with Critoseal™. Samples were centrifuged in a standard microhematocrit centrifuge at 8,000 RPM for 5 minutes. Hematocrits (the relative volumes of the packed red cells as a percentage of the total column height; Houston 1990) were then measured. A leucocrit reading, a volume percentage of leucocytes in the packed column, was also taken. These measurements were taken with a nomograph (Goede 1993).

Glucose concentrations were determined using a Sigma Test Kit 510A™. This test uses an enzymatic colorimetric determination using glucose oxidase and peroxidase (Sigma Technical Bulletin No. 510). A Bausch and Lomb Spectronic 1001™ split-beam spectrophotometer was used to read the samples.

Plasma osmolality was determined by placing an 8μL sample of plasma on to a solute-free paper disc and then analyzing it with a Wescor 1500 vapor pressure osmometer. Measurements were taken as mmol/kg, an indication of the total concentration of dissolved particles. Total plasma proteins(g/100ml) were determined using a standardized refractometer.

Coagulation time was measured in non-heparinized capillary tubes. Each sample was broken at fixed intervals that were determined in the field based on preliminary coagulation time observations for each species. Coagulation time is determined when a clot strand remains suspended between broken segments of the tube as they are pulled apart (Casillas and Smith 1977). Timing began as the caudal peduncle was severed (Casillas and Smith 1976).

Blood smears were made from blood that had been treated with an anti-coagulant. The smears were fixed for five minutes in ethanol and dried. The personnel of the Southern Illinois University School of Medicine Histology Center determined appropriate stains (Wright-Giemsa) and staining times. A differential blood cell count was done on two hundred leucocytes from each specimen (Stoskopf 1993).

Serum samples were also analyzed for the presence of heat shock proteins. This involved taking a 1-2 mL sample of blood from the fish and injecting it into a serum separator tube. The blood was then allowed to coagulate in the tube for up to four hours. The blood was then spun in a centrifuge at 10,000 RPMs for 15 minutes in order to separate the serum from the other blood components. The serum was then removed from the vials and stored in Eppendorf™

microcentrifuge tubes at -80°C. These samples were then sent to Dr. Thomas Eurell at the University of Illinois College of Veterinary Medicine to be analyzed for the presence of heat shock proteins.

Before the serum samples were analyzed for the presence of heat shock proteins, serum proteins were determined. . Sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) was performed in 10% gels using the Laemmli buffering system. Serum samples were diluted (1:4) with sample buffer containing 2-mercaptoethanol and heated for 4 minutes at 100° C Molecular mass markers (BioRad) were rabbit skeletal muscle myosin (200-kDa), *E. coli* β-galactosidase (116- kDa), rabbit muscle phosphorylase B (97.4-kDa), bovine serum albumin (66-kDa), and hen egg white ovalbumin (45-kDa). Duplicate gels were produced using identical samples.

After electrophoresis, gels were stained for total protein, using a BioRad silver stain kit. Images of the gels were captured on a Kodak digital science camera (DC120) and used to create a database of fish serum protein profiles.

For western blot analysis following SDS-PAGE, serum samples were electroblotted onto a PVDF membrane for 30 minutes at 15 V using a BioRad Trans-Blot semidry electrophoretic transfer cell. Before the transfer, the gel was rinsed in double deionized water and equilibrated for 15 min in CAPS buffer containing 5% methanol. The blot was then blocked with 2% non-fat dried milk and rinsed with 10mM PBS and Tween-20 (Sigma). Incubation of the blot was done using either mouse monoclonal antibody (1:200 dilution in PBS/Tween) to catfish vitellogenin (Gift from Auburn University, clone 1D8-A11) or heat shock protein 72/73 (StressGen, lot 611411) at 4°C overnight. After the incubation, the blot was rinsed with PBS/Tween to reduce non-specific protein binding. The membrane was then incubated with goat anti-mouse polyclonal antibody (1:2000 dilution in PBS/Tween) conjugated to an alkaline phosphatase label (Fisher). Several rinses containing only PBS were preformed after the second antibody incubation. Then 5-bromo-4-chloroindoly phosphate/nitroblue tetrazolium (Sigma) was used to develop a colored reaction product from the activity of the alkaline phosphatase label.

Necropsy-Based Condition Assessment and Condition Indices

Goede and Barton (1990) proposed a qualitative necropsy-based health assessment incorporating condition indices and organosomatic indices as overall indicators of fish health. The condition of the eyes, fins, opercales, pseudobranchs, thymus, liver, spleen, bile, fat, hindgut, kidney, and state of maturity were examined using guidelines modified from those originally outlined by Goede and Barton (1990) and Adams et al. (1993) (Appendix 9.1). When Adams et al. (1993) quantified the necropsy-based health assessment procedure, viscera were evaluated as either being normal (0) or abnormal (10 - 60). Modifications were made to this procedure for the current study. In this study, the liver, kidney, and eyes were given possible scores of 0, 30, or 60. This modification allowed viscera exhibiting multiple symptoms to be properly represented in the final fish health assessment index score. Parasite loads in each organ were also assessed on a scale of 0 to 5 with 5 being the heaviest load. Fish with total health scores of 115 or greater are considered to be in poor health (Adams et al. 1990).

This systematic approach was integrated with other condition indices and physiological variables to determine the effects of thermal loading on the fishes of Newton Lake, Coffeen Lake, and Lake of Egypt. Long-term growth indicators that were assessed include weight, length, and gonadalsomatic index (GSI). Only the GSI's of female fish are reported. Liver somatic indices (LSI; Heidinger and Crawford 1977), condition factor (C), relative weight, visceral somatic index (VSI; Adams and McLean 1985), spleenosomatic index (SSI), relative heart weight (HRT), and eye diameter relative to total length (Payne 1978) were assessed as short term indicators of growth. All indices were calculated as the weight of the organ divided by the weight of the fish. The VSI was calculated by dividing the weight of the organs minus the stomach contents by the weight of the fish.

Results:

During the spring and summer of 1998 sampling periods, an attempt was made to collect thirty fish of each species by electrofishing. Gill nets could not be used because this type of sampling would distort the blood parameters. In the spring of 1998, only nineteen bluegill were collected from Newton Lake, and no bluegill, of a suitable size range, were collected from Coffeen Lake. In the summer of 1998, nineteen channel catfish were collected from Lake of Egypt after approximately 360 minutes of electrofishing. Ten channel catfish were collected from Lake of Egypt in the summer of 1999 after 300 minutes of electrofishing. In the summer of 1999, fish kills occurred on both Newton and Coffeen Lakes. Health data was taken on ten moribund largemouth bass from Newton Lake. Normal summer sampling on Newton Lake was conducted during the fish kill as well. Samples were taken on Coffeen Lake in the week directly following the fish kill on this lake. Sampling was concentrated on segment 1 (warm water segment) of each lake until a significant portion of the area was covered. Sampling was then done throughout the lake in the next cooler segment until the desired number of fish was collected. In the summer of 1999, largemouth bass were collected in Newton Lake mainly in segment 4 (cold water segment), the only portion of the lake in which they were found to any great extent. There was period of at least six hours before any areas were electrofished for a second time.

The location, water temperature, and dissolved oxygen concentration at the site of capture was determined for each fish (Tables 9.1-9.4). Surface temperatures in Newton Lake ranged from 49-63°F during fish sampling in the spring of 1998 and 47-71°F in the spring of 1999. Summer temperatures during fish sampling in 1998 for Newton Lake ranged from 90-98°F, while 1999 temperatures ranged from 93-101°F. Sampling temperatures for Coffeen Lake in the summer of 1998 ranged from 90-97°F and 93-96°F in 1999. Sampling temperatures for Lake of Egypt ranged from 87-98°F in both sampling years. Surface temperatures in the five non-power cooling lakes sampled in the summer of 1999 ranged from 80-84°F (Table 9.1).

Statistical analyses in this report are focused on comparisons among lakes with in a season, differences between spring and summer within a given year, and differences among segments within a lake. Percentages were arcsine transformed for statistical analysis. Analysis of variance was used, followed by Tukey's post hoc test when there was a significant difference. Power may have suffered in some comparisons due to low sample sizes.

Hematological testing

Mean hematocrit, leucocrit, plasma proteins, and plasma osmolality along with standard error are reported lake-wide by season and year in Tables 9.5-9.8 and by lake segment in Appendix 9.1-9.9 for each species. Largemouth bass had similar hematological values among the three lakes during each of the seasons. Summer 1999 hematocrit values increased in largemouth bass (Table 9.5) for both Coffeen Lake ($p=0.0001$) and Lake of Egypt ($p=0.001$) as compared to the spring. Comparisons made in the summer of 1999 for largemouth bass (Table 9.6) included the summer samples from the power cooling lakes, the moribund largemouth bass sample from Newton Lake, and samples of five fish from each of th five non-power cooling lakes. Hematological values from fish sampled from the five non-power cooling lakes were pooled.

Overall, little variation in the means occurred among these samples. Variables for the five non-power cooling lakes are broken down by lake in Appendix 9.10.

Summer 1998 hematocrit values (Table 9.7) for channel catfish in Newton Lake were significantly lower than Coffeen Lake (p=0.0002). In the summer of 1999, channel catfish in both Newton and Coffeen Lakes had lower hematocrit values than Lake of Egypt (p=0.0110).

Bluegill in Newton Lake (summer of 1999) had hematocrit values (Table 9.8) lower than bluegill in Lake of Egypt (p=0.0007). Leucocrit values for bluegill in Newton Lake during the summer of 1999 were higher than for bluegill from both Coffeen Lake and Lake of Egypt (p=0.0001). No differences were detected across the segments for most of the hematological measures for any of the species reported in Appendix 9.1-9.9.

Lymphocyte percentages were significantly lower in the spring of 1998 as compared to summer 1998 percentages for Newton Lake (p=0.0432) largemouth bass (Table 9.9). Conversely, lymphocyte percentages were higher for largemouth bass in the spring of 1999 than in the summer for Newton Lake (p=0.0367). Thrombocyte percentages were lower in the spring than in the summer of 1999 for largemouth bass in Newton Lake (p=0.0128). Moribund largemouth bass from Newton Lake had significantly lower lymphocyte percentages (Table 9.10) than the other samples taken in the summer of 1999 (p=0.0001). Heterophil percentages were higher for the moribund largemouth bass than the other samples (p=0.0025). Neutrophil percentages were higher in the power cooling lake samples and the moribund sample than the pooled non-power cooling lake sample (p=0.0048). The thrombocyte percentages in the pooled non-power cooling lake sample was lower than those of the rest of the samples taken in the summer of 1999 (p=0.0021). Differential blood cell counts by lake, including the five non-power cooling lakes are reported in Appendix 9.11.

Channel catfish in Lake of Egypt had lower lymphocyte percentages (p=0.0058) and higher thrombocyte percentage (p=0.0448) in the spring of 1998 than channel catfish in Newton Lake (Table 9.11). Seasonal differences occurred in thrombocyte percentages for channel catfish in both Coffeen Lake (p=0.0453) and Lake of Egypt (p=0.0152) in 1998.

Mean blood glucose concentrations (mg/dL) and standard errors are reported lake-wide by season and year in Tables 9.13-9.15 and by lake segment in Appendix 9.12-9.14 for each species. In general, glucose concentrations tended to be higher in the summer than in the spring except in Coffeen Lake. Largemouth bass in Coffeen Lake had significantly higher blood glucose concentrations in the spring of 1998 (p=0.0001) and 1999 (p=0.0001) than the other two cooling lakes (Table 9.13). Bluegill blood glucose concentrations in Coffeen Lake were higher than Lake of Egypt bluegill (p=0.0352) in the spring of 1999 (Table 9.15).

Blood clotting times were highly variable within all lakes (Tables 9.16-9.18, Appendix 9.15-9.17). Clotting times were generally substantially longer, however, in the spring than in the summer in general for largemouth bass and channel catfish. For example, 48% of the largemouth bass sampled had clotting times of 4 minutes or greater in the spring of 1998. In the summer, average clotting times for largemouth bass were about 1/3 shorter than in the spring of 1998. Clotting times were longer for largemouth bass from Coffeen Lake in the spring (p=0.0122) of 1998 than those of largemouth bass in Newton Lake (Table 9.16). Channel catfish in both Coffeen Lake and Lake of Egypt had significantly longer clotting times than those fish in Newton Lake the spring of both years (Table 9.17). Clotting times for channel catfish ranged from approximately 2 minutes to 30 minutes in the spring of both years. Fifty percent of the channel catfish sampled in the spring of 1998 had a clotting time of 4 minutes or greater. The median clotting time in Coffeen Lake for the spring of 1998 was 11 minutes for channel catfish. In the spring of 1999, channel catfish from Coffeen Lake and Lake of Egypt had significantly higher clotting times than those of Newton Lake ($p=0.0001$). Overall, clotting times decreased significantly for largemouth bass and channel catfish in the summer. Spring and summer clotting times were found to be similar for bluegill. Heat shock proteins were not detected in significant amounts in samples ran from 1998 or 1999.

Necropsy-based condition assessment and condition indices

A mean fish health assessment index (FHAI) score is reported along with standard deviation and coefficient of variation for each fish collected (Tables 9.19-9.25). Higher FHAI scores indicate poorer health. The criteria used to evaluate the fish are found in Appendix 9.23 "Normal" ranges of hematocrits, leucocrits, and plasma proteins were determined from the mean values for these variables found in Lake of Egypt. In the summer of 1999, these ranges were established for largemouth bass using the data collected on the five non-power cooling lakes. It is our belief that the effects of thermal loading were minimal in this lake as compared to the other two lakes. The area between the warm water discharge and the cold water intake in Lake of Egypt is significantly smaller than that of Newton and Coffeen Lakes. It is assumed from this that the area affected by thermal discharge is greater in Newton and Coffeen Lakes.

The mean health assessment index scores were lower for each species in the three lakes for the summer than for the spring of 1998 (Tables 9.19-9.25). FHAI scores dropped by 43% for largemouth bass in Newton Lake from the spring to the summer of 1998 (Table 9.19). Lake-wide, largemouth bass in Newton Lake FHAI scores dropped by 23% from the spring to the summer of 1999 (Table 9.20). Largemouth bass in Lake of Egypt showed a decrease in FHAI scores of 45% from the spring to the summer of 1998. FHAI scores were generally lower in the spring of 1999 than those in the spring of 1998, but higher than the summer FHAI scores. No differences were found among the lakes within a season for largemouth bass during 1998 and 1999. Table 9.21 reports mean FHAI scores for largemouth bass sampled in the summer of 1999 from the power cooling lakes, Newton moribund fish, and a pooled sample of the 5 non-power cooling lakes. The Newton Lake moribund fish had the highest mean FHAI score, however, no statistical differences were found between the health of the moribund fish and the other largemouth bass sampled in the summer of 1999.

Newton Lake channel catfish were in the poorest health in the spring of 1998 as compared to those from Coffeen Lake and Lake of Egypt (p=0.0002), according to the FHAI reported in Table 9.22. Channel catfish FHAI scores were otherwise similar among the lakes across seasons with the exception of spring 1998 scores. Similar to largemouth bass, spring 1998 FHAI scores (Table 9.22) were higher than the summer FHAI scores in each of the lakes (Newton Lake p=0.0001, Coffeen Lake p=0.0002, and Lake of Egypt p=0.0104). Spring 1999 scores (Table 9.23) decreased by 36% from spring 1998 scores.

Coffeen Lake bluegill had the highest FHAI scores (p=0.0001) for this species in the summer of 1998 (Table 9.24). Mean FHAI scores increased from the spring to the summer for bluegill from both Newton Lake (p=0.0001) and Lake of Egypt (p=0.0001). In the summer of 1999, lake-wide FHAI scores (Table 9.25) for bluegill in Newton Lake showed almost a two-fold increase from the spring.

Parasite loads were generally found to be extremely heavy in bluegill in the three power cooling lakes, with Newton and Coffeen Lake bluegills showing the most severe infestations. Largemouth bass also had heavy parasite loads in each of the three lakes. Observations indicated that in the summer of 1999 moribund largemouth bass had lower parasite loads than fish in the normal summer sample from Newton Lake. The organs most heavily infested with parasites in both largemouth bass and bluegill were the kidneys and the liver.

Condition indices are reported by size range (Tables 9.26-9.34). Lake of Egypt largemouth bass 9.8-15.7 inches in length had a significantly larger eye diameter to length ratio in the spring of both years (p=0.0005, 0.0011) as reported in Table 9.27. Largemouth bass (9.8-15.7 in) from Coffeen Lake had the lowest spleenosomatic index (SSI) values among the lakes in all of the seasons. Seasonal differences in spleenosomatic index and liver somatic (LSI) values occurred in largemouth bass (9.8-15.7 in) in all lakes except for Coffeen Lake 1998 (SSI) and Newton Lake 1998 (LSI). Visceral somatic index values for largemouth bass (9.8-15.7 in) were higher in Newton and Coffeen Lakes as compared to Lake of Egypt during the summer of 1998 (p=0.0001). VSI values for largemouth bass (9.8-15.7 in) in Newton Lake were highest in the summer of 1999 (p=0.0001). SSI values for largemouth bass, 15.8-21.7 in, also tended to be lowest for Coffeen Lake. Seasonal differences occurred in all lakes for both the LSI and SSI for largemouth bass in this size range.

Channel catfish (7.9-13.8 in), similar to largemouth bass, showed seasonal differences in all lakes for both the LSI and the SSI (Table 9.29). VSI values for channel catfish (7.9-13.8 in.) were significantly lower in Newton Lake than Coffeen Lake in the spring of 1999 (p=0.0001). Channel catfish (13.9-19.7 in) had significantly higher LSI's in the summer than in the spring of 1999 (p=0.0001). Bluegill (5.6-7.1 in) LSI values (Table 9.33) for the summer of 1999 were significantly different in each of the three lakes(p=0.0001).

Condition factors and relative weights generally did not vary among lakes within a season for largemouth bass (Tables 9.35-9.37). Condition factors for moribund largemouth bass fell into a range in the middle of the five non-power cooling lakes and the three cooling lakes. Relative weights for channel catfish generally were higher in Lake of Egypt throughout the seasons (Table 9.39). Bluegill, similar to largemouth bass, did not vary among the lakes within a season (Tables 9.41-43).

Discussion:

Hematological testing

The results suggest that season and lake segment in which fish were collected did not substantially influence many of the physiological measures monitored. Physiological stress appeared to be minimal in fish populations during the summer and spring of 1998 in all three lakes based on most measures, with the exception of clotting time. Clotting times were high in largemouth bass and channel catfish in each of the three lakes during the spring. This may be attributable to water temperature and photoperiod, although similar findings have not been reported in the literature to our knowledge. Fish naturally undergo physiological changes with the seasons; however, in power cooling lakes water temperatures warm up faster than they would in a non-power cooling lake. In the case of the high clotting times in the spring, catch and release could be lethal if a fish was injured upon capture.

Differential blood cell counts for channel catfish in Coffeen Lake and Lake of Egypt were not consistent with expectations based on clotting times. Thrombocytes, an essential part of the clotting process, were present in higher numbers in the spring than in the summer. As the stress response is initiated, thrombocyte counts should increase (Mazeaud et al. 1977) leading to a decrease in clotting time. The reverse of this was found in both Coffeen Lake and Lake of Egypt. Channel catfish from Coffeen Lake and Lake of Egypt could also be lacking an essential component in the clotting process. As the stress response is initiated, lymphocyte counts should be declining, as was seen in all channel catfish sampled in the spring of both year.

Differential blood cell counts supported clotting time results for largemouth bass in the summer of 1999. Again, as expected in the stress response, lymphocyte counts should decline and thrombocyte counts should increase. Moribund largemouth bass taken during the fish kill in Newton Lake exhibited these signs, indicating physiological stress, in the summer of 1999.

Blood glucose concentrations were lower in the spring than in the summer for both largemouth bass and channel catfish in each of the lakes. High glucose concentrations in the summer may be attributed to short-term stress and or greater metabolism demands. An increase in blood glucose concentrations is consistent with stress response intiation.

Fish health assessment index and condition indices

According to the fish health assessment index, largemouth bass and channel catfish were in poorer health in the spring than in the summer. This may be attributable to the increased physiological demands placed on fish in the spring. We sampled each lake prior to the spawning periods for the three species we examined, a time when energy is diverted to reproduction. The poorer condition of fish in the spring may also have been due to reduced food consumption coupled with harsh conditions during the winter. Both largemouth bass and channel catfish health improved from the spring to the summer in both years. The lower FHAI summer scores may be attributable to the fish repairing their tissues during the summer.

The mean FHAI score for moribund fish from Newton Lake, although approaching levels considered to be in poor health (FHAI scores of 115 or greater), did not statistically differ from other samples taken in the summer of 1999. The majority of the abnormalities in the moribund largemouth bass occurred in the livers, kidneys, and eyes. These abnormalities do not likely develop quickly (i.e. in the time period in which the extreme heat event took place on Newton Lake in the summer of 1999) suggesting that the moribund fish may have already been unhealthy.

Differential blood cell counts for the moribund largemouth bass indicated some kind of stress response was occurring as compared to the other samples taken in the summer of 1999. Condition factors of largemouth bass sampled in Newton and Coffeen Lakes, during normal summer sampling, were highest among all samples in the summer of 1999. As measured by condition factor, largemouth bass in power cooling lakes did not appear to be adversely affected by warm summer temperatures.

While, fish in the summer where in better condition overall, slight decreases in condition indices such as the VSI and LSI were found. These findings concur with those of Bulow (1981) and Adams and McLean (1985). They believed that greater metabolism demands at warmer temperatures allow fewer nutrients to be stored in organs such as the liver.

Relative weight data suggested that largemouth bass in Newton and Coffeen Lakes were in better condition than in Lake of Egypt. This may be attributable to the extended growing period occurring in the former two lakes, due to warmer annual temperatures. Relative weights for channel catfish and bluegill (Tables 9.16-9.17) were slightly low. This may be caused by an imbalance between predator and prey.

Parasite infestations in the kidneys and livers of largemouth bass and bluegill contributed to the most obvious pathological changes in the organs. It is not known to what extent these parasite infestations affect the health of fish in the three lakes. The majority of the parasites observed appear to be Trematoda.

In conclusion, the FHAI did not appear to be a good indicator of thermal stress events. It should also be noted that dissolved oxygen concentrations were relatively low in Newton and Coffeen Lakes during the fish kill, indicating that the FHAI did not appear to be sensitive to this stressor or the combined stressor of high temperatures and low dissolved oxygen. This index was developed to detect trends and abnormalities in the health of a fish population while corrective actions could still be taken. Water temperatures in Newton and Coffeen Lakes reached or approached the chronic thermal maxima, 99°F, (acclimated at 89.6°F with 1°C change/day) for northern largemouth bass (Fields et al. 1987) and the upper incipient lethal temperature, 93°F, (Hart 1952) for largemouth bass, yet most variables measured in this study did not adequately indicate stress occurring in largemouth bass during the summer of 1999. Previous studies (see Coutant 1975 for a review) have shown that largemouth bass generally grow, swim, and feed well at high temperatures approaching their lethal limit, perhaps making it hard to detect changes in health before death resulting from exposure to temperatures outside of their tolerance range. Overall, the results indicate that the fish in the three cooling lakes are in similar health. It is our feeling that fluctuations in condition and physiological variables (with the exception of clotting time) seen in the fishes of Newton Lake, Lake of Egypt, and Coffeen Lake can be primarily attributed to season, forage base, reproductive demands, and size.

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Table 9.1. Mean lake surface temperatures (°F), dissolved oxygen concentrations (mg/L), and ranges for 1998 and 1999 fish health sampling periods. Sampling took place within the time periods listed.

Year	Season	Sampling Dates	Lake	Mean Surface Temperature (F)	Range	Dissolved Oxygen (mg/L)	Range
1998	Spring	3/13-3/30	Newton	55	49-63	11.98	9.70-18.30
		3/31-4/1	Coffeen	67	62-78	9.37	8.65-11.30
		3/23-3/27	Egypt	54	50-57	10.81	10.05-11.70
	Summer	8/17-8/18	Newton	92	90-98	8.33	6.75-10.67
		8/12-8/13	Coffeen	91	90-97	8.83	6.40-13.90
		8/10-8/27	Egypt	92	88-98	5.52	1.66-9.10
1999	Spring	3/16-3/17	Newton	55	47-71	11.59	9.60-12.90
		3/11-3/12	Coffeen	62	56-69	9.62	8.78-10.35
		3/19,3/26	Egypt	53	50-56	12.17	9.45-13.20
	Summer	7/29-7/30	Newton	96	93-101	8.34	7.60-9.60
		7/31-8/1	Coffeen	94	93-96	6.64	4.80-9.44
		8/5-8/6	Egypt	90	87-98	5.55	2.11-7.27
		8/19	Sam Dale	80	--	652	5.80-7.30
		8/19	East Fork	82	82-84	9.64	8.20-11.80
		8/18	Rend	80	80-81	6.46	5.70-7.50
		8/16	Kinkaid	83	83-84	6.92	6.20-7.50
		8/16	Cedar	80	80-81	7.38	7.30-7.50

Table 9.2. Mean surface temperatures (°F), dissolved oxygen concentrations (mg/L), and ranges by segment for Newton Lake in 1998 and 1999.

Year	Lake	Season	Segment	Mean Surface Temperature (F)	Range	Dissolved Oxygen (mg/L)	Range
1998	Newton	Spring	1	59	49-52	11.56	9.70-18.30
			2	51	49-52	10.79	10.30-12.10
			3	50	49-51	13.12	11.63-13.50
			4	58	49-61	13.25	12.10-14.43
		Summer	1	96	--	7.32	--
			2	93	91-98	7.90	6.75-9.25
			3	92	--	7.41	--
			4	90	--	10.11	9.60-10.67
1999	Newton	Spring	1	66	54-71	10.32	9.60-11.88
			2	54	54-55	11.83	11.46-12.11
			3	51	48-52	12.02	11.56-12.83
			4	48	47-50	12.13	11.55-12.90
		Summer	1	99	--	8.60	--
			2	100	98-101	9.03	8.50-9.60
			3	--	--	--	--
			4	94	93-95	8.10	7.60-8.30

Table 9.3. Mean surface temperatures (°F), dissolved oxygen concentrations (mg/L), and ranges by segment for Coffeen Lake in 1998 and 1999.

Year	Season	Segment	Mean Surface Temperature (F)	Range	Dissolved Oxygen (mg/L)	Range
1998	Spring	1	72	65-78	9.48	9.20-9.80
		2	63	62-63	9.25	8.65-11.30
	Summer	1	91	91-97	7.54	6.40-10.60
		2	90	90-93	10.90	7-13.90
1999	Spring	1	68	67-69	9.02	8.78-9.50
		2	58	56-62	10.02	9.45-10.35
	Summer	1	--	--	--	--
		2	94	93-96	6.64	4.80-9.44

Table 9.4. Mean surface temperatures (°F), dissolved oxygen concentrations (mg/L), and ranges by segment for Lake of Egypt in 1998 and 1999.

Year	Season	Segment	Mean Surface Temperature (F)	Range	Dissolved Oxygen (mg/L)	Range
1998	Spring	1	55	50-57	10.57	10.05-11.62
		2	53	51-55	11.2	10.74-11.70
	Summer	1	92	88-98	5.17	1.66-9.10
		2	91	--	7.94	6.42-8.14
1999	Spring	1	55	52-56	11.86	11.30-13.00
		2	51	50-53	12.48	9.45-13.20
	Summer	1	91	87-98	4.67	2.11-6.71
		2	87	87-88	7.17	7.04-7.27

Table 9.5. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality and standard errors for largemouth bass in the spring and summer of 1998 and 1999. Values with different superscripts indicate differences within a season among the lakes for individual variables at the α=0.05 level. Asterisks indicate seasonal differences for individual variables occurring within a lake during a year at the α=0.05 level.

Year	Season	Lake	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	Newton	34	37^{a}	0.96	36*	0.56^{a}	0.09	30*	$6.66^{a,b}$	0.19	34	346^{a}	13.71
		Coffeen	30	$36^{a,b}$	0.72	30	0.09^{b}	0.04	22*	6.97^{a}	0.20	28	322^{a}	2.38
		Egypt	31*	33^{b}	0.64	31*	0.92^{a}	0.17	26	6.07^{b}	0.20	23*	313^{a}	1.93
	Summer	Newton	20	39^{a}	0.93	20	0.00^{a}	0.00	16	5.37^{a}	0.23	19	323^{a}	3.56
		Coffeen	20	39^{a}	1.05	20	0.00^{a}	0.00	18	5.44^{a}	0.16	19	321^{a}	2.92
		Egypt	28	37^{a}	0.58	28	0.00^{a}	0.00	23	5.69^{a}	0.15	24	324^{a}	1.89
1999	Spring	Newton	25	37^{a}	1.21	25*	0.37^{a}	0.07	21*	6.79^{a}	0.20	21	315^{a}	1.94
		Coffeen	20*	31^{b}	0.89	20*	0.19^{a}	0.08	19	6.54^{a}	0.19	19	327^{b}	1.56
		Egypt	23*	29^{b}	0.67	23*	0.17^{a}	0.05	19	5.68^{b}	0.13	22	316^{a}	2.49
	Summer	Newton	17	$42^{a,b}$	1.2	17	0.00^{a}	0.00	11	$5.69^{a,b}$	0.28	17	318^{a}	5.58
		Coffeen	27	43^{a}	0.81	27	0.00^{a}	0.00	25	6.53^{a}	0.13	25	323^{a}	4.2
		Egypt	22	37^{b}	0.93	22	0.02^{a}	0.01	22	5.73^{b}	0.14	23	318^{a}	5.35

Table 9.6. Largemouth bass mean hematocrit, leucocrit, and plasma proteins for Newton Lake, Coffeen Lake, Lake of Egypt, and a pooled sample from five non-power cooling lakes in the summer of 1999. Values with different superscripts indicate differences among the lakes for an individual variable at the α=0.05 level.

Lake	N	Hematocrit (%)	N	Leucocrit (%)	N	Plasma Proteins (g/100ml)
Newton	17	$42^{b,c,d}$	17	0.00^{a}	11	5.69^{a}
Coffeen	27	$43^{c,d}$	27	$0.00^{a,b}$	25	6.53^{c}
Egypt	22	37^{a}	22	$0.02^{a,b}$	22	$5.73^{a,b}$
Newton Moribund	10	$41^{a,b,c}$	10	0.92^{c}	6	$6.78^{a,b,c}$
Pooled 5 Lakes	25	$38^{a,b}$	25	0.47^{c}	25	$6.03^{a,b,c}$

Table 9.7. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for channel catfish in the spring and summer of 1998 and 1999. Values with different superscripts indicate differences within a season among the lakes for individual variables at the $\propto$=0.05 level. Asterisks indicate seasonal differences for individual variables occurring within a lake during a year at the $\propto$=0.05 level.

Year	Season	Lake	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	Newton	31*	25^{a}	1.05	31	0.86^{a}	0.19	9	3.19^{a}	0.18	23	285^{a}	10.99
		Coffeen	30*	33^{b}	1.28	30	0.60^{b}	0.13	25	4.38^{b}	0.19	27	278^{a}	2.79
		Egypt	20	31^{b}	1.53	20*	1.02^{a}	0.12	17	5.99^{c}	0.42	11	277^{a}	2.66
	Summer	Newton	20	30^{a}	1.60	20	0.50^{a}	0.08	14	4.20^{a}	0.18	15	287^{a}	3.13
		Coffeen	20	39^{b}	1.39	20	0.48^{a}	0.06	12	4.40^{a}	0.14	17	276^{b}	1.99
		Egypt	18	$34^{a,b}$	0.97	18	0.56^{a}	0.00	13	4.47^{a}	0.18	14	$282^{a,b}$	2.47
1999	Spring	Newton	26	28^{a}	1.00	26	0.81^{a}	0.11	17	4.09^{a}	0.16	21	268^{a}	2.16
		Coffeen	19	28^{a}	1.55	20	0.80^{a}	0.09	17	3.54^{a}	0.19	19	270^{a}	2.81
		Egypt	21*	30^{a}	1.89	21*	0.57^{a}	0.07	18	5.27^{b}	0.24	19	276^{a}	3.85
	Summer	Newton	17	30^{a}	0.94	17	$0.71^{a,b}$	0.09	5	4.62^{a}	0.43	17	281^{a}	3.82
		Coffeen	21	31^{a}	1.18	21	0.57^{a}	0.06	20	6.06^{b}	0.25	20	286^{a}	3.52
		Egypt	10	36^{b}	2.48	10	1.07^{b}	0.04	10	4.62^{a}	0.36	10	287^{a}	4.23

Table 9.8. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for bluegill in the spring and summer of 1998 and 1999. Values with different superscripts indicate differences within a season among the lakes for individual variables at the $\alpha=0.05$ level. Asterisks indicate seasonal differences for individual variables occurring within a lake during a year at the $\alpha=0.05$ level.

Year	Season	Lake	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	Newton	5	36[a]	2.23	5*	0.90[a]	0.40		--	--	5	280[a]	6.92
		Coffeen		--	--		--	--		--	--		--	--
		Egypt	13*	31[a]	1.77	13*	0.80[a]	0.12	3	5.35	0.55	10	297[b]	4.14
	Summer	Newton	10	33[a]	1.62	10	0.00[a]	0.00	2	5.75[a]	0.65	6	291[a]	5.17
		Coffeen	9	40[b]	2.24	9	0.00[a]	0.00	6	4.58[a]	0.37	8	301[a]	4.77
		Egypt	10	38[a,b]	1.74	10	0.00[a]	0.00	9	5.24[a]	0.28	10	291[a]	5.94
1999	Spring	Newton	15	31[a]	1.57	15*	0.10[a]	0.05	6	5.33[a]	0.25	13	288[a]	3.32
		Coffeen	16	34[a]	1.18	16	0.23[a]	0.08	5*	4.14[b]	0.21	15	272[a]	19.3
		Egypt	10*	29[a]	1.7	10	0.15[a]	0.07	7	5.47[a]	0.17	11*	285[a]	7.6
	Summer	Newton	14	32[a]	0.87	14	0.64[a]	0.09		--	--	14	297[a]	5.13
		Coffeen	4	34[a,b]	2.18	4	0.13[b]	0.13	1	5.60[a]	--	4	301[a]	12.3
		Egypt	22	37[b]	0.92	22	0.08[b]	0.04	8	4.88[a]	0.48	16	302[a]	3.84

Table 9.9. Mean differential blood cell counts and standard errors for largemouth bass in the spring and summer of 1998 and 1999. Values with different superscripts indicate differences among the lakes within a season, for each blood cell type, at the ∝=0.05 level. Asterisks indicate seasonal differences within a lake in a given year at the ∝=0.05 level. LYM=lymphocytes, HET = heterophils, NEUT = neutrophils, THROM = thrombocytes, BASO = basophils, ESO = esonophils, MONO = monocytes, Unknown = unidentifiable white blood cell types.

Year	Season	Lake	N	%LYM	S.E.	%HET	S.E.	%NEUT	S.E.	%THROM	S.E.	%BASO	S.E.	%ESO	S.E.	%MONO	S.E.	Unknown	S.E.
1998	Spring	Newton	22	*51.80^{a}	3.44	0.32^{a}	0.23	3.66^{a}	1.46	38.41^{a}	3.95	0.02^{a}	0.02	0.09^{a}	0.07	1.30^{a}	0.41	4.41^{a}	0.96
		Coffeen	23	49.46^{a}	3.36	0.24^{a}	0.20	3.50^{a}	1.44	39.17^{a}	3.47	0.15^{a}	0.10	0.02^{a}	0.02	0.63^{a}	0.29	6.83^{a}	1.63
		Egypt	23	56.24^{a}	3.41	0.57^{a}	0.25	1.89^{a}	0.55	33.65^{a}	3.22	*0.20^{a}	0.09	*0.22^{a}	0.08	*1.80^{a}	0.51	*5.43^{a}	1.26
1998	Summer	Newton	15	61.83^{a}	2.63	0.33^{a}	0.17	1.30^{a,b}	0.35	32.37^{a}	2.52	0.03^{a}	0.03	0.03^{a}	0.03	1.00^{a}	0.41	3.10^{a,b}	0.64
		Coffeen	18	45.56^{b}	3.32	0.44^{a}	0.17	2.53^{a}	0.73	45.39^{a}	3.63	0.06^{a}	0.06	0.17^{a}	0.14	1.08^{a}	0.40	4.78^{a}	1.14
		Egypt	20	57.48^{a}	4.18	0.18^{a}	0.11	1.03^{b}	0.47	39.35^{a}	4.09	0.00^{a}	0.00	0.00^{a}	0.00	0.00^{b}	0.00	1.98^{b}	0.61
1999	Spring	Newton	25	*62.40^{a}	2.57	1.30^{a}	0.33	2.46^{a}	0.74	*29.82^{a}	2.75	0.06^{a}	0.06	0.00^{a}	0.00	0.00^{a}	0.00	3.96^{a}	0.76
		Coffeen	25	63.36^{a}	3.37	*0.53^{b}	0.47	2.83^{a}	1.35	30.61^{a}	3.79	0.08^{a}	0.06	0.00^{a}	0.00	0.00^{a}	0.00	2.58^{a,b}	0.70
		Egypt	20	*65.34^{a}	2.87	0.55^{a,b}	0.19	2.89^{a}	0.47	*29.42^{a}	2.81	0.00^{a}	0.00	0.00^{a}	0.00	0.05^{a}	0.05	*1.74^{b}	0.66
1999	Summer	Newton	16	54.09^{a}	2.69	0.53^{a}	0.19	2.56^{a}	0.47	40.84^{a}	2.64	0.00^{a}	0.00	0.00^{a}	0.00	0.00^{a}	0.00	1.97^{a}	0.55
		Coffeen	25	54.32^{a}	3.54	2.06^{a}	0.89	4.66^{a}	1.63	35.28^{a}	2.80	0.02^{a}	0.02	0.00^{a}	0.00	0.02^{a}	0.02	3.64^{a}	1.10
		Egypt	20	48.00^{a}	3.81	0.55^{a}	0.29	4.00^{a}	1.00	40.58^{a}	2.85	0.05^{a}	0.05	0.00^{a}	0.00	0.63^{a}	0.63	6.20^{a}	1.10

Table 9.10. Mean differential blood cell counts and standard errors for largemouth bass in (summer of 1999) Newton Lake, Coffeen Lake, Lake of Egypt, and a pooled sample of five non-power cooling lakes . Values with different superscripts indicate differences among the lakes within the summer of 1999, for each blood cell type, at the α=0.05 level. LYM=lymphocytes, HET = heterophils, NEUT = neutrophils, THROM = thrombocytes, BASO = basophils, ESO = esonophils, MONO = monocytes, Unknown = unidentifiable white blood cell types.

Lake	N	%LYM	S.E.	%HET	S.E.	%NEUT	S.E.	%THROM	S.E.	%BASO	S.E.	%ESO	S.E.	%MONO	S.E.	Unknown
Newton	16	54.09^{a}	2.69	0.53^{a}	0.19	2.56^{a}	0.47	40.84^{a,b}	2.64	0.00^{a}	0.00	0.00^{a}	0.00	0.00^{a}	0.00	1.97^{a}
Coffeen	25	54.32^{a}	3.54	2.06^{a,b,c,d}	0.89	4.66^{a}	1.63	35.28^{a}	2.80	0.02^{a}	0.02	0.00^{a}	0.00	0.02^{a}	0.02	3.64^{a,b}
Egypt	20	48.00^{a}	3.81	0.55^{a,b}	0.29	4.00^{a}	1.00	40.58^{a,b}	2.85	0.05^{a}	0.05	0.00^{a}	0.00	0.63^{a}	0.63	6.20^{b,c,d}
Newton Moribund	9.00	19.94^{b}	2.96	5.89^{d}	3.22	13.11^{b}	2.89	52.00^{b}	3.39	0.00^{a}	0.00	0.00^{a}	0.00	0.06^{a}	0.06	9.00^{c,d}
Pooled 5 Lakes	20	54.73^{a}	2.93	0.98^{a,b,c}	0.38	6.98^{a,b}	2.28	32.20^{a}	2.80	0.00^{a}	0.00	0.00^{a}	0.00	0.10^{a}	0.07	5.03^{a,b,c}

Table 9.11. Mean differential blood cell counts and standard errors for channel catfish in the spring and summer of 1998 and 1999. Values with different superscripts indicate differences among the lakes within a season, for each blood cell type, at the α=0.05 level. Asterisks indicate seasonal differences within a lake in a given year at the α=0.05 level. LYM=lymphocytes, HET = heterophils, THROM = thrombocytes, BASO = basophils, ESO = esonophils, MONO = monocytes, Unknown = unidentifiable white blood cell types.

Year	Season	Lake	N	%LYM	S.E.	%HET	S.E.	%THROM	S.E.	%BASO	S.E.	%ESO	S.E.	%MONO	S.E.	Unknown	S.E.
1998	Spring	Newton	14	*71.29^{a}	4.07	1.14^{a}	0.30	25.82^{a}	4.11	0.00^{a}	0.00	0.00^{a}	0.00	0.04^{a}	0.04	1.71^{a}	0.49
		Coffeen	24	*66.02^{a,b}	2.48	*2.56^{b}	0.50	*28.54^{a,b}	2.59	0.00^{a}	0.00	0.00^{a}	0.00	0.15^{a}	0.08	2.73^{a}	0.70
		Egypt	17	*56.32^{b}	2.81	2.38^{a,b}	0.65	*37.59^{b}	3.19	0.03^{a}	0.03	0.00^{a}	0.00	0.00^{a}	0.00	3.68^{a}	1.42
1998	Summer	Newton	9	76.39^{a}	3.56	1.28^{a}	0.62	17.56^{a}	4.13	0.00^{a}	0.00	0.00^{a}	0.00	0.06^{a}	0.06	4.72^{a}	2.04
		Coffeen	13	76.77^{a}	3.53	1.27^{a}	0.51	19.96^{a}	3.41	0.00^{a}	0.00	0.00^{a}	0.00	0.00^{a}	0.00	2.00^{a}	0.83
		Egypt	13	70.62^{a}	3.13	3.23^{a}	2.00	24.35^{a}	3.71	0.00^{a}	0.00	0.00^{a}	0.00	0.08^{a}	0.05	1.73^{a}	0.87
1999	Spring	Newton	24	*65.98^{a}	2.15	2.56^{a}	0.51	23.67^{a}	1.96	0.02^{a}	0.02	0.21^{a}	0.21	0.02^{a}	0.02	*7.54^{a}	1.82
		Coffeen	8	*65.00^{a,b}	3.60	*0.88^{a}	0.25	31.88^{a,b}	3.20	0.00^{a}	0.00	0.00^{a}	0.00	0.00^{a}	0.00	2.25^{a}	1.33
		Egypt	18	*55.14^{b}	3.17	*1.97^{a}	0.38	*36.31^{b}	3.01	0.69^{a}	0.69	0.00^{a}	0.00	0.08^{a}	0.08	5.81^{a}	0.93
1999	Summer	Newton	13	74.42^{a}	2.24	4.50^{a}	0.84	18.73^{a}	2.19	0.00^{a}	0.00	0.00^{a}	0.00	0.00^{a}	0.00	2.35^{a}	1.90
		Coffeen	17	66.18^{a}	2.55	5.74^{a}	0.94	23.68^{a}	2.80	0.15^{a}	0.15	0.00^{a}	0.00	0.12^{a}	0.09	4.15^{a}	0.99
		Egypt	9	64.33^{a}	4.72	9.39^{a}	2.34	22.72^{a}	4.45	0.00^{a}	0.00	0.00^{a}	0.00	0.11^{a}	0.11	3.44^{a}	0.96

Table 9.12. Mean differential blood cell counts and standard errors for bluegill in the spring and summer of 1998 and 1999. Values with different superscripts indicate differences among the lakes within a season, for each blood cell type, at the ∝=0.05 level. Asterisks indicate seasonal differences within a lake in a given year at the ∝=0.05 level. LYM=lymphocytes, HET = heterophils, NEUT = neutrophils, THROM = thrombocytes, BASO = basophils, ESO = esonophils, MONO = monocytes, Unknown = unidentifiable white blood cell types.

Year	Season	Lake	N	%LYM	S.E.	%HET	S.E.	%NEUT	S.E.	%THROM	S.E.	%BASO	S.E.	%ESO	S.E.	%MONO	S.E.	Unknown	S.E.
1998	Spring	Newton	1	45.50	--	0.00	--	*2.00	--	52.50	--	0.00	--	0.00	--	0.00	--	0.00	--
		Coffeen		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Egypt	9	52.78	6.69	0.00	0.00	0.39	0.18	*41.06	7.39	0.39	0.26	0.00^{a}	0.00	0.22	0.12	5.17	1.71
1998	Summer	Newton	6	60.50^{a}	7.46	0.00	0.00	0.00^{a}	0.00	33.83^{a,b}	7.79	0.00^{a}	0.00	0.00^{a}	0.00	0.67^{a}	0.67	5.00^{a}	2.22
		Coffeen	7	45.14^{a}	5.58	0.00	0.00	10.29^{a}	4.28	40.36^{a}	3.17	0.00^{a}	0.00	0.00^{a}	0.00	0.64^{a}	0.64	3.57^{a}	1.12
		Egypt	13	65.65^{a}	4.53	0.04	0.04	5.31^{a}	2.84	23.85^{b}	2.97	0.12^{a}	0.12	0.42^{a}	0.42	0.65^{a}	0.30	4.96^{a}	2.06
1999	Spring	Newton	10	61.15^{a}	6.67	0.25	0.15	*1.90^{a}	1.25	27.80^{a}	6.27	0.00^{a}	0.00	0.00^{a}	0.00	0.00^{a}	0.00	*8.90^{a}	2.29
		Coffeen	12	67.42^{a}	4.82	1.38	0.67	*0.79^{a}	0.36	21.29^{a}	4.30	0.00^{a}	0.00	0.29^{a}	0.22	0.04^{a}	0.04	8.79^{a}	3.58
		Egypt	9	63.89^{a}	2.32	*1.89	0.89	2.11^{a}	0.59	24.17^{a}	3.17	0.00^{a}	0.00	0.00^{a}	0.00	0.11^{a}	0.11	*7.83^{a}	1.88
1999	Summer	Newton	11	64.14^{a}	2.96	0.36^{a}	0.19	3.82^{a}	0.90	28.73^{a}	2.70	0.00^{a}	0.00	0.00^{a}	0.00	0.00^{a}	0.00	2.95^{a}	0.71
		Coffeen	1	59.50	--	0.00	--	5.00^{a}	--	33.00^{a}	--	0.00^{a}	--	0.00^{a}	--	0.00^{a}	--	2.50^{a}	--
		Egypt	16	69.69^{a}	3.06	0.00^{b}	0.00	2.00^{a}	1.35	24.78^{a}	2.58	0.00^{a}	0.00	0.00^{a}	0.00	0.00^{a}	0.00	3.53^{a}	1.00

Table 9.13. Mean blood glucose concentrations (mg/dL) and standard errors for largemouth bass in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the $\propto$=0.05 level. Asterisks indicate differences between seasons for individual lakes within a year at the $\propto$=0.05 level.

Year	Season	Lake	N	Glucose Concentration (mg/dL)	S.E.
1998	Spring	Newton	32*	83^{a}	7.10
		Coffeen	29	217^{b}	14.73
		Egypt	23*	97^{a}	6.85
	Summer	Newton	16	$174^{a,b}$	18.05
		Coffeen	15	213^{a}	24.47
		Egypt	13	137^{b}	14.02
1999	Spring	Newton	23*	75^{a}	5.61
		Coffeen	20	114^{b}	7.59
		Egypt	22*	61^{a}	4.79
	Summer	Newton	12	226^{a}	31.94
		Coffeen	17	102^{b}	10.25
		Egypt	21	105^{b}	9.73
		Newton Moribund	8	$156^{a,b}$	62-250

Table 9.14. Mean blood glucose concentrations (mg/dL) and standard errors for channel catfish in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons for individual lakes within a year at the α=0.05 level.

Year	Season	Lake	N	Glucose Concentration (mg/dL)	S.E.
1998	Spring	Newton	23*	36^{a}	5.06
		Coffeen	25	87^{b}	6.40
		Egypt	10	60^{a}	11.53
	Summer	Newton	9	112^{a}	17.79
		Coffeen	18	80^{a}	6.86
		Egypt	17	80^{a}	5.49
1999	Spring	Newton	20*	38^{a}	3.27
		Coffeen	17*	36^{a}	3.78
		Egypt	20*	29^{a}	3.63
	Summer	Newton	16	71^{a}	4.91
		Coffeen	13	68^{a}	4.25
		Egypt	9	54^{a}	4.69

Table 9.15. Mean blood glucose concentrations (mg/dL) and standard errors for bluegill in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons for individual lakes within a year at the α=0.05 level.

Year	Season	Lake	N	Glucose Concentration (mg/dL)	S.E.
1998	Spring	Newton	1	130^{a}	--
		Coffeen		--	--
		Egypt	7*	59^{b}	2.19
	Summer	Newton	6	108^{a}	13.15
		Coffeen	3	89^{a}	25.92
		Egypt	2	201^{b}	29.5
1999	Spring	Newton	8	95^{a}	22.40
		Coffeen	7	150^{b}	36.46
		Egypt	9*	59^{a}	7.38
	Summer	Newton	8	108^{a}	5.85
		Coffeen	2	128^{a}	17.38
		Egypt	10	91^{a}	8.76

Table 9.16. Mean clotting times (minutes) and standard errors for largemouth bass in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons for individual lakes at the α=0.05 level.

Year	Season	Lake	N	Clotting Time (minutes)	S.E.
1998	Spring	Newton	36*	3.72[a]	0.31
		Coffeen	30*	6.01[b]	0.73
		Egypt	31*	4.49[a,b]	0.56
	Summer	Newton	31	1.08[a]	0.10
		Coffeen	20	1.58[a,b]	0.20
		Egypt	27	1.74[b]	0.18
1999	Spring	Newton	25*	2.97[a]	0.22
		Coffeen	20*	5.33[b]	0.50
		Egypt	23*	3.70[a]	0.42
	Summer	Newton	17	1.39[a]	0.22
		Coffeen	26	1.55[a]	0.18
		Egypt	24	0.98[a]	0.15

Table 9.17. Mean clotting times (minutes) and standard errors for channel catfish in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons for individual lakes at the α=0.05 level.

Year	Season	Lake	N	Clotting Time (minutes)	S.E.
1998	Spring	Newton	34	2.07^{a}	0.17
		Coffeen	30*	11.12^{b}	1.05
		Egypt	20*	5.48^{b}	0.94
	Summer	Newton	19	2.00^{a}	0.24
		Coffeen	20	2.26^{a}	0.6
		Egypt	19	2.27^{a}	0.28
1999	Spring	Newton	29*	3.21^{a}	0.27
		Coffeen	19*	7.05^{b}	0.26
		Egypt	20*	9.90^{b}	2.03
	Summer	Newton	21	1.73^{a}	0.19
		Coffeen	21	1.45^{a}	0.10
		Egypt	10	1.74^{a}	0.27

Table 9.18. Mean clotting times (minutes) and standard errors for bluegill in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons for individual lakes at the ∝=0.05 level.

Year	Season	Lake	N	Clotting Time (min)	S.E.
1998	Spring	Newton	36*	3.72[a]	0.31
		Coffeen	30*	6.01[b]	0.73
		Egypt	31*	4.49[a,b]	0.56
	Summer	Newton	31	1.08[a]	0.10
		Coffeen	20	1.58[a,b]	0.20
		Egypt	27	1.74[b]	0.18
1999	Spring	Newton	25*	2.97[a]	0.22
		Coffeen	20*	5.33[b]	0.50
		Egypt	23*	3.70[a]	0.42
	Summer	Newton	17	1.39[a,b]	0.22
		Coffeen	26	1.55[a,b]	0.18
		Egypt	24	0.98[a]	0.15
		Newton Moribund	10	1.46[a,b]	0.42
		Pooled 5 Lakes	25	1.71[b]	0.13

Table 9.19. Mean fish health assessment index (FHAI) values, standard deviations, and coefficient of variations for largemouth bass ranging from 3.9-21.7 inches in the spring and summer of 1998. No differences in FHAI scores occurred among the lakes in the spring or the summer of 1998. Asterisks indicate differences among the lakes between the seasons for individual lakes at the ∝=0.05 level.

Lake	Season	Size Range (in.)	N	FHAI	S.D.	C.V.	Season	Size Range (in.)	N	FHAI	S.D.	C.V.
Newton	Spring	Lake	36*	103	30.74	29.97	Summer	Lake	26	59	31.38	53.48
		3.9-9.7	2	119	8.02	6.74		3.9-9.7		--	--	--
		9.8-15.7	8	109	39.79	36.50		9.8-15.7	19	72	25.75	35.54
		15.8-21.7	28	104	32.50	31.21		15.8-21.7	7	84	20.76	24.84
Coffeen	Spring	Lake	30*	100	31.73	31.85	Summer	Lake	30	71	24.00	33.75
		3.9-9.7		--	--	--		3.9-9.7		--	--	--
		9.8-15.7	12	78	26.89	34.62		9.8-15.7	15	67	21.05	31.48
		15.8-21.7	22	96	28.59	29.71		15.8-21.7	10	67	21.36	32.12
Egypt	Spring	Lake	31*	97	26.66	27.39	Summer	Lake	30	53	30.96	57.97
		3.9-9.7		--	--	--		3.9-9.7		--	--	--
		9.8-15.7	16	99	32.78	33.01		9.8-15.7	25	51	29.71	57.88
		15.8-21.7	14	96	19.71	20.62		15.8-21.7	5	64	38.63	60.52

Table 9.20. Mean fish health assessment index (FHAI) values, standard deviations, and coefficient of variations for largemouth bass ranging from 3.9-21.7 inches in the spring and summer of 1999. No differences in FHAI scores occurred among the lakes within a season and no seasonal differences within a lake occurred.

Lake	Season	Size Range (in.)	N	FHAI	S.D.	C.V.	Season	Size Range (in.)	N	FHAI	S.D.	C.V.
Newton	Spring	Lake	32	91	48.95	53.63	Summer	Lake	17	70	26.87	38.56
		3.9-9.7		--	--	--		3.9-9.7		--	--	--
		9.8-15.7	11	80	56.07	69.80		9.8-15.7	14	62	22.80	36.56
		15.8-21.7	21	97	45.18	46.58		15.8-21.7	3	104	16.42	15.81
Coffeen	Spring	Lake	30	90	33.10	36.86	Summer	Lake	31	76	36.18	47.85
		3.9-9.7		--	--	--		3.9-9.7		--	--	--
		9.8-15.7	12	78	26.89	34.62		9.8-15.7	15	67	21.05	31.48
		15.8-21.7	17	101	33.20	32.83		15.8-21.7	13	75	37.70	50.47
Egypt	Spring	Lake	31	81	32.91	40.69	Summer	Lake	28	74	41.89	56.34
		3.9-9.7		--	--	--		3.9-9.7		--	--	--
		9.8-15.7	8	88	22.01	25.00		9.8-15.7	21	63	31.08	49.01
		15.8-21.7	23	78	36.02	45.95		15.8-21.7	7	107	54.79	51.13

Table 9.21. Mean fish health assessment index value, standard deviations and coefficient of variation for Newton Lake, Coffeen Lake, Lake of Egypt, and a pooled sample of five non-power cooling lakes. No differences in FHAI scores occurred among the lakes in the summer of 1999.

Lake	N	FHAI	S.D.	C.V.
Newton	17	70	26.87	38.56
Coffeen	31	76	36.18	47.85
Egypt	28	74	41.89	56.34
Newton Moribund	10	102	23.06	22.54
5 Lakes	23	71	27.17	38.04

Table 9.22. Mean fish health assessment index (FHAI) values, standard deviations, and coefficient of variations for channel catfish ranging from 7.9-25.6 inches in the spring and summer of 1998. Values with different superscripts indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons for individual lakes at the ∝=0.05 level.

Lake	Season	Size Range (in.)	N	FHAI	S.D.	C.V.	Season	Size Range (in.)	N	FHAI	S.D.	C.V.
Newton	Spring	Lake	35*	104[a]	68.01	65.34	Summer	Lake	27	27[a]	13.14	49.20
		7.9-13.8	34	104	69.04	66.37		7.9-13.8	22	24	12.46	51.23
		13.9-19.7		--	--	--		13.9-19.7	4	35	11.62	33.64
		19.8-25.6		--	--	--		19.8-25.6		--	--	--
Coffeen	Spring	Lake	30*	58[b]	28.70	49.76	Summer	Lake	25	29[a]	21.86	74.66
		7.9-13.8	9	55	30.12	55.07		7.9-13.8	8	24	20.52	85.08
		13.9-19.7	21	59	28.74	48.74		13.9-19.7	16	33	22.71	68.78
		19.8-25.6		--	--	--		19.8-25.6		--	--	--
Egypt	Spring	Lake	20*	57[b]	27.98	48.78	Summer	Lake	18	36[a]	19.69	54.83
		7.9-13.8		--	--	--		7.9-13.8		--	--	--
		13.9-19.7	9	55	15.78	28.75		13.9-19.7	13	35	18.44	53.32
		19.8-25.6	10	60	37.48	61.95		19.8-25.6	4	43	27.23	64.08

Table 9.23. Mean fish health assessment index (FHAI) values, standard deviations, and coefficient of variations for channel catfish ranging from 7.9-25.6 inches in the spring and summer of 1999. No differences in FHAI scores occurred among the lakes within a season and no seasonal differences within a lake occurred.

Lake	Season	Size Range (in.)	N	FHAI	S.D.	C.V.	Season	Size Range (in.)	N	FHAI	S.D.	C.V.
Newton	Spring	Lake	35	61	29.52	48.69	Summer	Lake	23	48	24.52	51.28
		7.9-13.8	28	61	29.54	48.78		7.9-13.8	13	48	23.47	48.64
		13.9-19.7	5	73	20.19	27.65		13.9-19.7	8	38	18.84	49.06
		19.8-25.6		--	--	--		19.8-25.6	1	105	--	--
Coffeen	Spring	Lake	30	60	30.10	49.95	Summer	Lake	21	64	32.75	50.83
		7.9-13.8	18	63	31.01	48.93		7.9-13.8	6	61	21.54	35.50
		13.9-19.7	11	56	30.71	54.72		13.9-19.7	14	64	36.97	58.22
		19.8-25.6		--	--	--		19.8-25.6	1	100	--	--
Egypt	Spring	Lake	25	64	26.20	40.86	Summer	Lake	10	48	33.85	70.51
		7.9-13.8		--	--	--		7.9-13.8		--	--	--
		13.9-19.7	10	54	21.00	38.62		13.9-19.7	2	60	56.57	94.28
		19.8-25.6	13	70	24.27	34.58		19.8-25.6	7	47	32.90	69.78

Table 9.24. Mean fish health assessment index (FHAI) values, standard deviations, and coefficient of variations for bluegill ranging from 3.9-8.7 inches in the spring and summer of 1998. Values with different superscripts indicate differences among the lakes within a season at the ∝=0.05 level. No differences in FHAI scores between the seasons occurred in 1998.

Lake	Season	Size Range (in.)	N	FHAI	S.D.	C.V.	Season	Size Range (in.)	N	FHAI	S.D.	C.V.
Newton	Spring	Lake	6	66^a	34.80	52.44	Summer	Lake	30	66^a	32.31	49.30
		3.9-5.5	2	77	12.02	15.71		3.9-5.5	17	51	18.88	37.06
		5.6-7.1	3	46	38.12	82.33		5.6-7.1	11	82	22.86	27.75
		7.2-8.7	--	--	--			7.2-8.7		--	--	--
Coffeen	Spring	Lake		--	--	--	Summer	Lake	31	103^b	20.20	19.61
		3.9-5.5		--	--	--		3.9-5.5	16	103	19.25	18.62
		5.6-7.1		--	--	--		5.6-7.1	11	102	23.02	22.50
		7.2-8.7		--	--	--		7.2-8.7		--	--	--
Egypt	Spring	Lake	13	82^a	44.02	53.84	Summer	Lake	27	61^a	30.15	49.74
		3.9-5.5		--	--	--		3.9-5.5	--	--	--	
		5.6-7.1	7	89	44.19	49.42		5.6-7.1	12	55	33.81	61.00
		7.2-8.7	6	73	46.16	63.37		7.2-8.7	13	66	26.12	39.62

Table 9.25. Mean fish health assessment index (FHAI) values, standard deviations, and coefficient of variations for bluegill ranging from 3.9-8.7 inches in the spring and summer of 1999. Values with different superscripts indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons for individual lakes at the ∝=0.05 level.

Lake	Season	Size Range (in.)	N	FHAI	S.D.	C.V.	Season	Size Range (in.)	N	FHAI	S.D.	C.V.
Newton	Spring	Lake	34*	46[a]	27.67	60.69	Summer	Lake	25	89[a]	28.77	32.22
		3.9-5.5	12	45	28.17	61.97		3.9-5.5	12	84	29.17	34.65
		5.6-7.1	21	46	28.75	63.15		5.6-7.1	8	83	31.43	37.91
		7.2-8.7	1	106	--	--		7.2-8.7		--	--	--
Coffeen	Spring	Lake	19	68[b]	29.92	43.98	Summer	Lake	7	63[a,b]	15.15	23.88
		3.9-5.5	11	67	34.97	52.12		3.9-5.5	5	57	13.65	23.77
		5.6-7.1	8	69	23.50	33.89		5.6-7.1	2	78	0.00	0.00
		7.2-8.7		--	--	--		7.2-8.7		--	--	--
Egypt	Spring	Lake	32*	33[a]	17.44	52.39	Summer	Lake	31	58[b]	24.72	42.61
		3.9-5.5	1	24	--	--		3.9-5.5	9	51	24.34	47.34
		5.6-7.1	16	36	19.96	55.66		5.6-7.1	8	52	18.93	36.26
		7.2-8.7	12	34	15.53	45.86		7.2-8.7	8	76	30.24	40.03

Table 9.26. Mean eye diameter (eye diameter in./total length of fish in.), spleenosomatic index (SSI, wt of spleen/wt of fish), liver somatic index (LSI, wt of liver/wt of fish), visceral somatic index (VSI, wt of the viscera-stomach contents/wt of the fish), and relative heart weight (HRT, wt of the heart/wt of the fish) for largemouth bass ranging from 3.9-9.7 inches in length.

Year	Season	Size Range (inches)	Lake	N	Eye Diameter (inches)	S.E.	N	SSI	S.E.	N	LSI	S.E.	N	VSI	S.E.	N	HRT	S.E.
1998	Spring	3.9-9.7	Newton	2	0.046	0.002	2	0.08	0.00	2	1.05	0.07	2	5.07	0.05	2	0.13	0.02
			Coffeen		---	--		---	--		---	--		---	--		---	--
			Egypt		---	--		---	--		---	--		---	--		---	--

Table 9.27. Mean eye diameter (eye diameter in./total length of fish in.), spleenosomatic index (SSI, wt of spleen/wt of fish), liver somatic index (LSI, wt of liver/wt of fish), visceral somatic index (VSI, wt of the viscera-stomach contents/wt of the fish), and relative heart weight (HRT, wt of the heart/wt of the fish) for largemouth bass ranging from 9.8-15.7 inches in length. Values with different superscripts indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons for individual lakes at the ∝=0.05 level.

Year	Season	Size Range (inches)	Lake	N	Eye Diameter (inches)	S.E.	N	SSI	S.E.	N	LSI	S.E.	N	VSI	S.E.	N	HRT	S.E.
1998	Spring	9.8-15.7	Newton	6	0.037^{a}	0.001	6*	$0.13^{a,b}$	0.02	6	1.03^{a}	0.15	6	6.25^{a}	0.67	6	0.13^{a}	0.02
			Coffeen	6	0.037^{a}	0.001	6	0.09^{b}	0.01	6*	1.24^{a}	0.16	6*	7.84^{a}	1.10	6	0.13^{a}	0.02
			Egypt	16	0.046^{b}	0.001	16*	0.16^{a}	0.01	16*	1.15^{a}	0.12	16*	7.66^{a}	0.67	16*	0.14^{a}	0.01
1998	Summer	9.8-15.7	Newton	20	0.038^{a}	0.001	20	0.08^{a}	0.01	20	$0.79^{a,b}$	0.06	20	5.86^{a}	0.21	20	0.13^{a}	0.01
			Coffeen	19	0.038^{a}	0.001	19	0.11^{b}	0.01	19	0.89^{a}	0.03	19	5.66^{a}	0.25	19	0.14^{a}	0.01
			Egypt	24	0.040^{a}	0.000	24	0.07^{a}	0.00	24	0.57^{b}	0.03	24	4.09^{b}	0.11	24	0.12^{a}	0.01
1999	Spring	9.8-15.7	Newton	8	0.036^{a}	0.001	8*	0.16^{a}	0.02	8*	$1.21^{a,b}$	0.10	8*	$8.08^{a,b}$	0.84	8	0.20^{a}	0.10
			Coffeen	12	0.037^{a}	0.001	12*	0.09^{b}	0.01	12*	1.35^{a}	0.07	12	10.27^{a}	1.14	12	0.12^{a}	0.01
			Egypt	8	0.042^{b}	0.002	8*	$0.13^{a,b}$	0.02	8*	0.98^{b}	0.19	8*	6.08^{b}	0.68	8	0.12^{a}	0.01
1999	Summer	9.8-15.7	Newton	14	0.041^{a}	0.001	14	0.08^{a}	0.01	14	0.90^{b}	0.06	14	5.83^{a}	0.18	14	0.09^{b}	0.01
			Coffeen	15	0.040^{a}	0.000	15	0.06^{a}	0.01	15	0.67^{a}	0.04		--	--	15	0.13^{a}	0.01
			Egypt	22	0.040^{a}	0.08	22	0.08^{a}	0.000	22	0.63^{a}	0.03	22	4.53^{b}	0.14	22	0.13^{a}	0.01

Table 9.28. Mean eye diameter (eye diameter in./total length of fish in.), spleenosomatic index (SSI, wt of spleen/wt of fish), liver somatic index (LSI, wt of liver/wt of fish), visceral somatic index (VSI, wt of the viscera-stomach contents/wt of the fish), and relative heart weight (HRT, wt of the heart/wt of the fish) for largemouth bass ranging from 15.8-21.7 inches in length. Values with different superscripts indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons for individual lakes at the ∝=0.05 level.

Year	Season	Size Range (inches)	Lake	N	Eye Diameter (inches)	S.E.	N	SSI	S.E.	N	LSI	S.E.	N	VSI	S.E.	N	HRT	S.E.
1998	Spring	15.8-21.7	Newton	27	0.036^{a}	0.001	27	0.16^{a}	0.01	27*	1.11^{a}	0.05	27*	8.72^{a}	0.70	27	0.11^{a}	0.01
			Coffeen	20	0.036^{a}	0.001	21	0.09^{b}	0.00	21*	1.37^{b}	0.07	21*	8.90^{a}	0.89	21	0.14^{b}	0.01
			Egypt	14	0.035^{a}	0.001	14*	0.15^{a}	0.02	14*	1.07^{a}	0.12	14*	8.97^{a}	0.96	14	0.14^{b}	0.01
	Summer	15.8-21.7	Newton	8	0.036^{a}	0.000	8	0.17^{a}	0.02	8	0.74^{a}	0.04	8	4.97^{a}	0.28	8	0.11^{a}	0.01
			Coffeen	9	0.036^{a}	0.000	9	0.08^{b}	0.01	9	0.81^{a}	0.05	9	5.53^{a}	0.24	9	0.16^{a}	0.02
			Egypt	5	0.037^{a}	0.000	5	0.08^{b}	0.02	5	0.61^{a}	0.11	5	5.14^{a}	0.29	5	0.14^{a}	0.01
1999	Spring	15.8-21.7	Newton	16	0.036^{a}	0.000	16	0.21^{a}	0.02	16*	1.17^{a}	0.08	16	8.21^{a}	0.79	16	0.11^{a}	0.01
			Coffeen	16	0.036^{a}	0.000	16*	0.10^{b}	0.01	16*	1.38^{a}	0.11	17	10.04^{a}	1.17	16	0.14^{b}	0.01
			Egypt	22	0.038^{b}	0.001	23*	0.15^{c}	0.02	23*	1.09^{a}	0.06	23*	8.68^{a}	0.53	23	0.11^{a}	0.01
	Summer	15.8-21.7	Newton	3	0.035^{a}	0.001	3	0.12^{a}	0.03	3	0.72^{a}	0.06	3	5.74^{a}	0.30	3	0.11^{a}	0.01
			Coffeen	12	0.038^{a}	0.001	12	0.07^{a}	0.01	12	0.71^{a}	0.09		--		12	0.15^{a}	0.01
			Egypt	8	0.040^{a}	0.001	8	0.08^{a}	0.01	8	0.51^{a}	0.04	8	4.32^{a}	0.45	8	0.13^{a}	0.01

Table 9.29. Mean eye diameter (eye diameter in./total length of fish in.), spleenosomatic index (SSI, wt of spleen/wt of fish), liver somatic index (LSI, wt of liver/wt of fish), visceral somatic index (VSI, wt of the viscera-stomach contents/wt of the fish), and relative heart weight (HRT, wt of the heart/wt of the fish) for channel catfish ranging from 7.9-13.8 inches in length. Values with different superscripts indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons for individual lakes at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	Eye Diameter (inches)	S.E.	N	SSI	S.E.	N	LSI	S.E.	N	VSI	S.E.	N	HRT	S.E.
1998	Spring	7.9-13.8	Newton	32	0.041^{a}	0.001	32*	0.16^{a}	0.02	32*	1.16^{a}	0.06	32	9.19^{a}	0.44	32	0.10^{a}	0.00
			Coffeen	7	0.035^{b}	0.001	7	0.14^{a}	0.02	7*	1.38^{a}	0.14	8	10.75^{a}	2.35	8	0.11^{a}	0.02
			Egypt		--	--		--	--		--	--		--	--		--	--
1998	Summer	7.9-13.8	Newton	24	0.038^{a}	0.000	24	0.07^{a}	0.00	24	0.89^{a}	0.06	23	9.21^{a}	3.56	24	0.10^{a}	0.01
			Coffeen	9	0.036^{a}	0.002	9	0.10^{b}	0.02	9	0.88^{a}	0.06	9	7.38^{a}	0.86	9	0.09^{a}	0.01
			Egypt	1	0.039^{a}	--		--	--	1	0.66^{a}	--		--	--	1	0.13^{a}	--
1999	Spring	7.9-13.8	Newton	30	0.035^{a}	0.001	30*	0.15^{a}	0.01	30	1.21^{a}	0.06	30*	10.7^{a}	0.52	30	0.11^{a}	0.00
			Coffeen	18	0.036^{a}	0.001	18*	0.13^{a}	0.01	18*	0.77^{b}	0.06	18	5.83^{b}	0.67	18	0.10^{a}	0.01
			Egypt		--	--		--	--		--	--		--	--		--	--
1999	Summer	7.9-13.8	Newton	12	0.034^{a}	0.000	11	0.08^{a}	0.01	12	1.19^{a}	0.10	12	5.38	0.31	12	0.10^{a}	0.01
			Coffeen	6	0.033^{a}	0.001	6	0.08^{a}	0.01	6	2.12^{b}	0.26		--	--	6	0.10^{a}	0.00
			Egypt		--	--		--	--		--	--		--	--		--	--

Table 9.30. Mean eye diameter (eye diameter in./total length of fish in.), spleenosomatic index (SSI, wt of spleen/wt of fish), liver somatic index (LSI, wt of liver/wt of fish), visceral somatic index (VSI, wt of the viscera-stomach contents/wt of the fish), and relative heart weight (HRT, wt of the heart/wt of the fish) for channel catfish ranging from 13.9-19.7 inches in length. Values with different superscripts indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons for individual lakes at the ∝=0.05 level.

Year	Season	Size Range (inches)	Lake	N	Eye Diameter (inches)	S.E.	N	SSI	S.E.	N	LSI	S.E.	N	VSI	S.E.	N	HRT	S.E.
1998	Spring	13.9-19.7	Newton		--	--		--	--		--	--		--	--		--	--
			Coffeen	20	0.032^{a}	0.000	20*	0.15^{a}	0.01	20*	1.31^{a}	0.07	19	9.07^{a}	0.51	18	0.11^{a}	0.01
			Egypt	7	0.028^{a}	0.000	8*	0.19^{a}	0.03	8*	1.34^{a}	0.16	7*	11.25^{a}	1.56	8	0.09^{a}	0.01
1998	Summer	13.9-19.7	Newton	4	0.030^{a,b}	0.26	4	0.08^{a}	0.01	4	1.02^{a}	0.06	4	7.51^{a}	0.96	4	0.10^{a,b}	0.01
			Coffeen	18	0.031^{a}	0.001	18	0.11^{a}	0.01	18	1.03^{a}	0.11	18	8.08^{a}	0.53	18	0.10^{a}	0.01
			Egypt	13	0.027^{b}	0.000	13	0.11^{a}	0.01	13	0.78^{a}	0.09	13	7.79^{a}	0.51	13	0.08^{b}	0.00
1999	Spring	13.9-19.7	Newton	5	0.030^{a}	0.001	5	0.13^{a}	0.01	5	1.04^{a}	0.12	5*	8.99^{a}	1.43	5	0.10^{a}	0.00
			Coffeen	11	0.031^{a}	0.001	11*	0.17^{a}	0.02	11*	1.24^{a}	0.09	11	10.20^{a}	0.57	11	0.10^{a}	0.01
			Egypt	9	0.028^{a}	0.002	9	0.19^{a}	0.02	9	1.48^{a}	0.11	9	11.49^{a}	1.62	8	0.08^{a}	0.01
1999	Summer	13.9-19.7	Newton	8	0.028^{a}	0.001	8	0.11^{a,b}	0.01	8	1.33^{a}	0.31	8	5.79^{a}	0.51	8	0.11^{a}	0.01
			Coffeen	10	0.029^{a}	0.001	10	0.08^{b}	0.01	10	3.26^{b}	0.13		--	--	10	0.12^{a}	0.01
			Egypt	2	0.028^{a}	0.001	2	0.17^{a}	0.05	1	0.85^{a}	--	2	8.18^{a}	0.13	2	0.10^{a}	0.00

Table 9.31. Mean eye diameter (eye diameter in./total length of fish in.), spleenosomatic index (SSI, wt of spleen/wt of fish), liver somatic index (LSI, wt of liver/wt of fish), visceral somatic index (VSI, wt of the viscera-stomach contents/wt of the fish), and relative heart weight (HRT, wt of the heart/wt of the fish) for channel catfish ranging from 19.8-25.6 inches in length. Values with different superscripts indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons for individual lakes at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	Eye Diameter (inches)	S.E.	N	SSI	S.E.	N	LSI	S.E.	N	VSI	S.E.	N	HRT	S.E.
1998	Spring	19.8-25.6	Newton		--	--		--	--		--	--		--	--		--	--
			Coffeen		--	--		--	--		--	--		--	--		--	--
			Egypt	9	0.027	0.001	9	0.15	0.01	10	1.11	0.15	9	8.95	1.92	9	0.10	0.01
1998	Summer	19.8-25.6	Newton		--	--		--	--		--	--		--	--		--	--
			Coffeen	1	0.021^{a}	--	1	0.17^{a}	--	1	0.93^{a}	--	1	9.74^{a}	--	1	0.13^{a}	--
			Egypt	4	0.025^{b}	0.000	4*	0.11^{b}	0.01	4	0.98^{a}	0.06	4	7.82^{a}	0.37	4	0.12^{a}	0.02
1999	Spring	19.8-25.6	Newton		--	--	--	--		--	--		--	--		--	--	
			Coffeen		--	--	--	--		--	--		--	--		--	--	
			Egypt	9	0.027	0.001	9*	0.15	0.02	10*	1.11	0.11	9*	8.95	1.08	9	0.10	0.01
1999	Summer	19.8-25.6	Newton	1	0.024^{a}	--	1	0.07^{a}	--	1	$1.28^{a,b}$	--	1	6.55^{a}	--	1	0.10^{a}	--
			Coffeen	1	0.028^{a}	--	1	0.09^{a}	--	1	2.13^{a}	--		--	--	1	0.08^{a}	--
			Egypt	7	0.026^{a}	0.001	7	0.13^{a}	0.01	7	0.95^{b}	0.08	7	6.49^{a}	0.64	7	0.10^{a}	0.01

Table 9.32. Mean eye diameter (eye diameter in./total length of fish in.), spleenosomatic index (SSI, wt of spleen/wt of fish), liver somatic index (LSI, wt of liver/wt of fish), visceral somatic index (VSI, wt of the viscera-stomach contents/wt of the fish), and relative heart weight (HRT, wt of the heart/wt of the fish) for bluegill ranging from 3.9-5.5 inches in length. Values with different superscripts indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons for individual lakes at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	Eye Diameter (inches)	S.E.	N	SSI	S.E.	N	LSI	S.E.	N	VSI	S.E.	N	HRT	S.E.
1998	Spring	3.9-5.5	Newton	3	0.072	0.002	3*	0.04	0.01	3*	7.20	6.79	3	3.95	0.63	3	0.11	0.02
			Coffeen		--	--		--	--		--	--		--	--		--	--
			Egypt		--	--		--	--		--	--		--	--		--	--
1998	Summer	3.9-5.5	Newton	16	0.077^{a}	0.002	14	0.01^{a}	0.00	16	0.80^{a}	0.06	16	5.41^{a}	0.44	13	0.20^{a}	0.04
			Coffeen	16	0.077^{a}	0.001	16	0.04^{b}	0.01	16	0.87^{a}	0.10	16	4.47^{a}	0.27	16	0.25^{a}	0.04
			Egypt		--	--		--	--		--	--		--	--		--	--
1999	Spring	3.9-5.5	Newton	9	0.075^{a}	0.001	8*	0.07^{a}	0.02	8	0.55^{a}	0.10	8*	3.64^{a}	0.31	10	0.15^{a}	0.02
			Coffeen	11	0.075^{a}	0.001	7*	0.05^{a}	0.01	11*	0.95^{b}	0.11	11*	4.75^{a}	0.49	11	0.16^{a}	0.02
			Egypt	1	0.078^{a}		1	0.07^{a}		1	$0.65^{a,b}$		1	4.80^{a}		1	0.09^{a}	
1999	Summer	3.9-5.5	Newton	10	0.074^{a}	0.002	12	0.01^{a}	0.01	12	0.74^{a}	0.07	12	6.50^{a}	0.59	12	0.15^{a}	0.02
			Coffeen	5	0.078^{a}	0.002	5	0.02^{a}	0.01	5	1.68^{b}	0.29	5	7.54^{a}	0.58	5	0.20^{a}	0.04
			Egypt	8	0.070^{a}	0.001	8	0.03^{a}	0.01	8	0.44^{c}	0.05	7	5.05^{a}	0.45	8	0.08^{b}	0.01

Table 9.33. Mean eye diameter (eye diameter in./total length of fish in.), spleenosomatic index (SSI, wt of spleen/wt of fish), liver somatic index (LSI, wt of liver/wt of fish), visceral somatic index (VSI, wt of the viscera-stomach contents/wt of the fish), and relative heart weight (HRT, wt of the heart/wt of the fish) for bluegill ranging from 5.6-7.1 inches in length. Values with different superscripts indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons for individual lakes at the ∝=0.05 level.

Year	Season	Size Range (inches)	Lake	N	Eye Diameter (inches)	S.E.	N	SSI	S.E.	N	LSI	S.E.	N	VSI	S.E.	N	HRT	S.E.
1998	Spring	5.6-7.1	Newton	5	0.069[a]	0.001	5	0.03[a]	0.02	5	0.48[a]	0.13	3	3.19[a]	0.10	5*	0.06[a]	0.03
			Coffeen		--	--		--	--		--	--		--	--		--	--
			Egypt	14	0.070[a]	0.002	13	0.09[a]	0.02	13	0.55[a]	0.06	13	4.09[b]	0.19	13	0.11[b]	0.01
1998	Summer	5.6-7.1	Newton	9	0.071[a]	0.001	8	0.02[a]	0.01	9	0.64[a,b]	0.06	12	3.14[a]	0.44	9	0.17[a]	0.02
			Coffeen	11	0.072[a]	0.002	11	0.03[a]	0.01	11	0.81[a]	0.07	11	4.87[b]	0.50	11	0.20[a]	0.03
			Egypt	15	0.068[a]	0.001	15	0.06[a]	0.01	14	0.51[b]	0.07	14	4.11[a,b]	0.42	14	0.09[b]	0.01
1999	Spring	5.6-7.1	Newton	21	0.068[a]	0.001	20	0.08[a]	0.01	20	0.60[a]	0.05	21*	3.67[a]	0.23	21	0.11[a]	0.01
			Coffeen	8	0.070[a]	0.001	8*	0.07[a]	0.01	8*	0.67[a]	0.10	8*	4.14[a,b]	0.53	8	0.13[a]	0.01
			Egypt	16	0.067[a]	0.001	15*	0.09[a]	0.01	16	0.54[a]	0.03	16	4.85[b]	0.15	16*	0.10[a]	0.00
1999	Summer	5.6-7.1	Newton	8	0.070[a]	0.002	8	0.03[a]	0.01	8	0.70[a]	0.04	8	4.88[a]	0.49	8	0.14[a,b]	0.03
			Coffeen	2	0.069[a]	0.000	2	0.03[a]	0.00	2	2.64[b]	0.09	2	7.61[a]	0.75	2	0.21[a]	0.04
			Egypt	7	0.067[a]	0.001	7	0.05[a]	0.01	7	0.44[c]	0.09	8	4.27[a]	0.71	7	0.08[b]	0.01

Table 9.34. Mean eye diameter (eye diameter in./total length of fish in.), spleenosomatic index (SSI, wt of spleen/wt of fish), liver somatic index (LSI, wt of liver/wt of fish), visceral somatic index (VSI, wt of the viscera-stomach contents/wt of the fish), and relative heart weight (HRT, wt of the heart/wt of the fish) for bluegill ranging from 7.2-8.7 inches in length. Values with different superscripts indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons for individual lakes at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	Eye Diameter (inches)	S.E.	N	SSI	S.E.	N	LSI	S.E.	N	VSI	S.E.	N	HRT	S.E.
1998	Spring	7.2-8.7	Newton		--	--		--	--		--	--		--	--		--	--
			Coffeen		--	--		--	--		--	--		--	--		--	--
			Egypt	9	0.059	0.001	11*	0.15	0.02	11	0.48	0.06	11	3.79	0.23	11	0.10	0.01
1998	Summer	7.2-8.7	Newton		--	--		--	--		--	--		--	--		--	--
			Coffeen		--	--		--	--		--	--		--	--		--	--
			Egypt	14	0.062	0.001	14	0.06	0.01	14	0.54	0.05	14	3.23	0.17	14	0.09	0.00
1999	Spring	7.2-8.7	Newton		--	--		--	--		--	--		--	--		--	--
			Coffeen		--	--		--	--		--	--		--	--		--	--
			Egypt	12	0.061	0.001	11*	0.13	0.02	12	0.42	0.03	12	3.51	0.16	12*	0.08	0.01
1999	Summer	7.2-8.7	Newton	1	0.061	--	1	0.06	--	1	0.56	--	1	3.48	--	1	0.05	--
			Coffeen		--	--		--	--		--	--		--	--		--	--
			Egypt	8	0.061	0.001	7	0.06	0.01	8	0.46	0.03	8	4.22	0.56	8	0.11	0.01

Table 9.35. Mean condition factor (C) and relative weight for largemouth bass ranging from 3.9-9.7 inches in the spring of 1998. Fish of this size were not collected at any other time.

Year	Season	Size Range (inches)	Lake	N	C	S.E.	N	RW	S.E.
1998	Spring	3.9-9.7	Newton	2	4.73	0.16	2	97	2.30
			Coffeen		---	--		---	--
			Egypt		---	--		---	--

Table 9.36. Mean condition factor (C) and relative weight for largemouth bass ranging from 9.8-15.7 inches in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons within a lake for an individual variable at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	C	S.E.	N	RW	S.E.
1998	Spring	9.8-15.7	Newton	6	5.07[a]	0.18	6	96[a]	2.5
			Coffeen	8	5.48[a]	0.20	8	101[a]	3.63
			Egypt	16*	4.86[a]	0.17	16*	90[a]	3.12
1998	Summer	9.8-15.7	Newton	20	4.93[a]	0.18	20	95[a]	3.55
			Coffeen	19	5.17[a]	0.09	19	97[a]	1.57
			Egypt	25	4.35[b]	0.10	25	82[a]	1.85
1999	Spring	9.8-15.7	Newton	11	5.68[a]	0.15	11	106[a]	2.82
			Coffeen	12	5.45[a]	0.18	12	102[a]	3.03
			Egypt	8	5.34[a]	1.02	8	101[a]	20.92
1999	Summer	9.8-15.7	Newton	14	5.53[a]	0.19	14	105[a]	3.56
			Coffeen	15	5.26[a]	0.10	15	98[a]	1.89
			Egypt	22	4.41[b]	0.08	22	83[b]	1.58

Table 9.37. Mean condition factor (C) and relative weight for largemouth bass ranging from 15.8-21.7 inches in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons within a lake for an individual variable at the ∝=0.05 level.

Year	Season	Size Range (inches)	Lake	N	C	S.E.	N	RW	S.E.
1998	Spring	15.8-21.7	Newton	28*	6.13[a]	0.09	28*	109[a]	1.49
			Coffeen	22*	5.81[a]	0.11	22*	104[a]	2.01
			Egypt	14	4.91[b]	0.25	14	88[b]	4.31
1998	Summer	15.8-21.7	Newton	8	5.57[a]	0.09	8	99[a]	1.49
			Coffeen	9	4.95[b]	0.17	9	89[b]	2.96
			Egypt	5	4.74[b]	0.19	5	85[b]	3.2
1999	Spring	15.8-21.7	Newton	21	6.13a	0.13	21	109[a]	2.22
			Coffeen	17*	6.32[a]	0.14	17*	113[a]	2.46
			Egypt	23*	5.45[b]	0.18	23*	97[b]	3.11
1999	Summer	15.8-21.7	Newton	3	5.70[a]	0.10	3	101[a]	2.34
			Coffeen	13	5.09[a]	0.07	13	92[a]	1.37
			Egypt	8	4.24[b]	0.25	8	76[b]	4.54

Table 9.38. Mean condition factor (C) and relative weight for channel catfish ranging from 7.9-13.8 inches in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons within a lake for an individual variable at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	C	S.E.	N	RW	S.E.
1998	Spring	7.9-13.8	Newton	35	2.67[a]	0.24	35	92[a]	8.68
			Coffeen	9	2.84[a]	0.13	9	90[a]	4.06
			Egypt		--	--		--	--
1998	Summer	7.9-13.8	Newton	24	2.67[a]	0.16	24	93[a]	5.16
			Coffeen	10	3.83[a]	0.85	10	129[a]	31.61
			Egypt	1	2.78[a]	--	1	99[a]	--
1999	Spring	7.9-13.8	Newton	30	2.52[a]	0.04	30	83[a]	1.40
			Coffeen	18*	2.45[a]	0.09	18*	81[a]	3.40
			Egypt		--	--		--	--
1999	Summer	7.9-13.8	Newton	13	2.52[a]	0.04	13	82[a]	1.81
			Coffeen	6	3.17[a]	0.19	6	102[b]	6.78
			Egypt		--	--		--	--

Table 9.39. Mean condition factor (C) and relative weight for channel catfish ranging from 13.9-19.7 inches in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons within a lake for an individual variable at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	C	S.E.	N	RW	S.E.
1998	Spring	13.9-19.7	Newton		--	--		--	--
			Coffeen	21	2.92[a]	0.08	21	87[a]	2.35
			Egypt	9	3.35[b]	0.11	9	95[b]	3.36
1998	Summer	13.9-19.7	Newton	4	2.63[a]	0.26	4	80[a]	7.33
			Coffeen	18	2.73[a]	0.09	18	82[a]	2.78
			Egypt	13	3.33[b]	0.09	13	96[b]	2.69
1999	Spring	13.9-19.7	Newton	5	2.89[a]	0.19	5	87[a]	5.49
			Coffeen	11*	2.54[a]	0.09	11*	77[a]	2.5
			Egypt	10	4.23[a]	0.81	10	122[a]	25.33
1999	Summer	13.9-19.7	Newton	8	2.61[b]	0.08	8	78[a]	2.17
			Coffeen	14	3.15[a]	0.10	14	94[b]	3.15
			Egypt	2	3.40[a]	0.30	2	98[a,b]	6.66

Table 9.40. Mean condition factor (C) and relative weight for channel catfish ranging from 19.8-25.6 inches in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons within a lake for an individual variable at the ∝=0.05 level.

Year	Season	Size Range (inches)	Lake	N	C	S.E.	N	RW	S.E.
1998	Spring	19.8-25.6	Newton		--	--		--	--
			Coffeen		--	--		--	--
			Egypt	10	3.9	0.24	10	106	6.2
1998	Summer	19.8-25.6	Newton		--	--		--	--
			Coffeen	1	1.31[a]	--		--	--
			Egypt	4	3.13[b]	0.14	4	86	3.62
1999	Spring	19.8-25.6	Newton		--	--		--	--
			Coffeen		--	--		--	--
			Egypt	10	3.9	0.14	13	97	3.69
1999	Summer	19.8-25.6	Newton	1	3.70[a]	--	1	101[a]	--
			Coffeen	1	3.45[a]	--	1	95[a]	--
			Egypt	7	3.46[a]	0.20	7	94[a]	5.45

Table 9.41. Mean condition factor (C) and relative weight for bluegill ranging from 3.9-5.5 inches in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons within a lake for an individual variable at the ∝=0.05 level.

Year	Season	Size Range (inches)	Lake	N	C	S.E.	N	RW	S.E.
1998	Spring	3.9-5.5	Newton	7	6.06	0.22	7	84	3.06
			Coffeen		--	--		--	--
			Egypt		--	--		--	--
1998	Summer	3.9-5.5	Newton	17	6.12[a]	0.17	17	87[a]	2.40
			Coffeen	17	6.32[a]	0.15	17	89[a]	2.30
			Egypt		--	--		--	--
1999	Spring	3.9-5.5	Newton	12*	5.55[a]	0.16	12*	78[a]	2.33
			Coffeen	11	5.65[a]	0.18	11*	79[a]	2.72
			Egypt	1	6.32[a]	--	1	87[a]	--
1999	Summer	3.9-5.5	Newton	12	6.42[a]	0.16	12	91[a]	2.04
			Coffeen	5	6.41[a]	0.37	5	91[a]	5.31
			Egypt	9	6.01[a]	0.16	9	85[a]	2.64

Table 9.42. Mean condition factor (C) and relative weight for bluegill ranging from 5.6-7.1 inches in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level. Asterisks indicate differences between seasons within a lake for an individual variable at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	C	S.E.	N	RW	S.E.
1998	Spring	5.6-7.1	Newton	11	6.17[a]	0.10	11	83[a]	1.26
			Coffeen		--	--		--	--
			Egypt	17	6.04[a]	0.19	17*	79[a]	2.38
1998	Summer	5.6-7.1	Newton	12	5.99[a]	0.23	12	80[a]	3.2
			Coffeen	11	6.40[a]	0.26	11	86[a]	3.61
			Egypt	15	6.42[a]	0.15	15	86[a]	1.91
1999	Spring	5.6-7.1	Newton	21	5.79[a]	0.14	21*	77[a]	1.78
			Coffeen	8*	5.81[a]	0.19	8*	78[a]	2.53
			Egypt	16	6.15[a]	0.11	16	80[a]	1.28
1999	Summer	5.6-7.1	Newton	8	6.33[a]	0.26	8	84[a]	3.27
			Coffeen	2	7.19[a]	0.01	2	96[a]	0.93
			Egypt	8	6.21[a]	0.08	8	82[a]	0.9

Table 9.43. Mean condition factor (C) and relative weight for bluegill ranging from 7.2-8.7 inches in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the ∝=0.05 level. Asterisks indicate differences between seasons within a lake for an individual variable at the ∝=0.05 level.

Year	Season	Size Range (inches)	Lake	N	C	S.E.	N	RW	S.E.
1998	Spring	7.2-8.7	Newton		--	--		--	--
			Coffeen		--	--		--	--
			Egypt	12	7.17	0.22	12	89	2.79
1998	Summer	7.2-8.7	Newton		--	--		--	--
			Coffeen		--	--		--	--
			Egypt	14	6.52	0.23	12	89	2.79
1999	Spring	7.2-8.7	Newton		--	--		--	--
			Coffeen		--	--		--	--
			Egypt	12	6.84	0.18	12*	89	2.79
1999	Summer	7.2-8.7	Newton	1	7.28	--	1	91	--
			Coffeen		--	--		--	--
			Egypt	8	6.13	0.28	8	76	3.31

Chapter 9. Appendix: Supplemental Data Tables.

Appendix 9.1. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for largemouth bass in the spring and summer of 1998 and 1999, by segment, in Newton Lake. Values with different superscripts indicate differences among segments within a season for individual variables at the α=0.05 level.

Season	Segment	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
Spring	1	10	36^{a}	1.43	12	0.90^{a}	0.17	8	6.83^{a}	0.49	12	361^{a}	34.30
	2	8	35^{a}	1.82	8	0.28^{a,b}	0.07	6	6.26^{a}	0.22	6	344^{a}	22.68
	3	8	40^{a}	2.45	8	0.25^{b}	0.11	8	7.08^{a}	0.40	8	353^{a}	23.42
	4	8	36^{a}	1.87	8	0.63^{a,b}	0.17	8	6.36^{a}	0.32	8	319^{a}	2.18
Summer	1		--	--		--	--		--	--		--	--
	2	2	37^{a}	1.75	2	0.00^{a}	0.00	2	5.25^{a}	0.05	2	324^{a}	11.25
	3	5	40^{a}	1.87	5	0.00^{a}	0.00	2	5.45^{a}	0.75	4	315^{a}	12.64
	4	13	38^{a}	1.24	13	0.00^{a}	0.00	12	5.38^{a}	0.29	13	325^{a}	3.40
Spring	1	7	40^{a}	3.04	7	0.10^{a}	0.07	6	6.90^{a}	0.45	7	317^{a}	2.37
	2	6	35^{a}	2.02	6	0.43^{a}	0.12	6	6.35^{a}	0.34	5	314^{a}	2.53
	3	6	39^{a}	1.56	6	0.42^{a}	0.20	4	6.61^{a}	0.39	4	317^{a}	7.44
	4	6	35^{a}	2.5	6	0.58^{a}	0.14	5	7.34^{a}	0.33	5	313	4.95
Summer	1		--	--		--	--		--	--		--	--
	2		--	--		--	--		--	--		--	--
	3		--	--		--	--		--	--		--	--
	4	17	42	1.2	17	0.00	0.00	11	5.69	0.28	17	318	5.58

Appendix 9.2. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for largemouth bass in the spring and summer of 1998 and 1999, by segment, in Coffeen Lake. Values with different superscripts indicate differences among segments within a season for individual variables at the α=0.05 level.

Year	Season	Segment	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	1	15	37[a]	1.00	15	0.02[a]	0.02	12	7.02[a]	0.3	14	325[a]	4.12
		2	15	35[a]	1.03	15	0.17[b]	0.07	10	6.91[a]	0.28	14	320[a]	2.36
	Summer	1	15	38[a]	1.18	15	0.00[a]	0.00	14	5.43[a]	0.15	14	317[a]	3.23
		2	5	43[a]	1.6	5	0.00[a]	0.00	4	5.48[a]	0.58	5	332[b]	3.41
1999	Spring	1	10	32[a]	1.34	10	0.35[a]	0.15	10	6.81[a]	0.28	10	326[a]	1.79
		2	10	31[a]	1.22	10	0.03[b]	0.02	9	6.25[a]	0.25	9	329[a]	2.68
	Summer	1		--	--		--	--		--	--		--	--
		2	27	43	0.81	27	0.00	0.00	25	6.53	0.13	25	323	4.2

Appendix 9.3. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for largemouth bass in the spring and summer of 1998 and 1999, by segment, in Lake of Egypt. Values with different superscripts indicate differences among segments within a season for individual variables at the α=0.05 level.

Year	Season	Segment	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	1	15	33^a	0.96	15	1.30^a	0.31	13	6.09^a	0.31	15	314^a	2.54
		2	16	33^a	0.87	16	0.56^a	0.11	13	6.05^a	0.25	8	311^a	2.92
	Summer	1	25	37^a	0.61	25	0.00^a	0.00	21	5.63^a	0.16	22	324^a	1.93
		2	3	38^a	2.01	3	0.00^a	0.00	2	6.25^a	0.45	2	325^a	11.25
1999	Spring	1	11	30^a	0.45	11	0.20^a	0.07	11	5.89^a	0.09	11	315^a	2.87
		2	12	29^a	1.19	12	0.14^a	0.07	8	5.39^a	0.25	11	317^a	4.18
	Summer	1	15	37^a	1.33	15	0.02^a	0.02	15	5.76^a	0.19	15	325^a	5.62
		2	7	38^a	0.66	7	0.00^a	0.00	7	5.66^a	0.17	8	305^a	10.16

Appendix 9.4. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for channel catfish in the spring and summer of 1998 and 1999, by segment, in Newton Lake. Values with different superscripts indicate differences among segments within a season for individual variables at the α=0.05 level.

Season	Segment	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
Spring	1	9	21^{a}	2.32	9	1.67^{a}	0.50	1	3.40^{a}	--	5	277^{a}	6.67
	2	11	28^{a}	1.48	11	$0.77^{a,b}$	0.15	5	3.29^{a}	0.18	7	313^{a}	35.05
	3	10	25^{a}	1.4	10	0.28^{b}	0.16	3	2.95^{a}	0.49	10	272^{a}	2.55
	4	1	27^{a}	--	1	$0.30^{a,b}$	--		--	--	1	266^{a}	--
Summer	1		--	--		--	--		--	--		--	--
	2	20	30	1.6	20	0.50	0.08	14	4.20	0.18	15	287	3.13
	3		--	--		--	--		--	--		--	--
	4		--	--		--	--		--	--		--	--
Spring	1	7	29^{a}	1.68	7	1.24^{a}	0.10	7	4.27^{a}	0.36	6	273^{a}	5.25
	2	6	27^{a}	1.15	6	$0.56^{a,b}$	0.17	3	3.85^{a}	0.37	7	267^{a}	4.04
	3	7	29^{a}	1.28	7	0.43^{b}	0.21	3	3.85^{a}	0.25	6	263^{a}	3.86
	4	6	24^{a}	3.23	6	$1.00^{a,b}$	0.25	4	4.13^{a}	0.11	6	269^{a}	4.05
Summer	1	1	35^{a}	--	1	0.33	--		--	--	1	284^{a}	--
	2	11	30^{a}	1.32	11	0.58^{a}	0.08	2	4.58	0.98	10	277^{a}	5.44
	3		--	--		--	--		--	--		--	--
	4	5	29^{a}	1.06	5	1.07^{b}	0.15	3	4.65	0.53	5	290^{a}	3.28

Appendix 9.5. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for channel catfish in the spring and summer of 1998 and 1999, by segment, in Coffeen Lake. Values with different superscripts indicate differences among segments within a season for individual variables at the α=0.05 level.

Year	Season	Segment	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	1	15	34[a]	2.26	15	0.02[a]	0.02	15	4.41[a]	0.26	14	280[a]	2.93
		2	15	32[a]	1.18	15	1.18[b]	0.15	10	4.32[a]	0.27	13	275[a]	4.91
	Summer	1	20	39	1.39	20	0.48	0.06	12	4.40	0.14	17	276	1.99
		2		--	--		--	--		--	--		--	--
1999	Spring	1	9	25[a]	2.53	10	0.94[a]	0.14	8	3.31[a]	0.38	9	278[a]	3.70
		2	10	30[a]	1.58	10	0.67[a]	0.11	9	3.74[a]	0.13	10	262[b]	2.42
	Summer	1		--	--		--	--		--	--		--	--
		2	21	31	1.18	21	0.57	0.06	20	6.06	0.25	20	286	3.52

Appendix 9.6. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for channel catfish in the spring and summer of 1998 and 1999, by segment, in Lake of Egypt. Values with different superscripts indicate differences among segments within a season for individual variables at the α=0.05 level.

Year	Season	Segment	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	1	20	31	1.53	20	1.02	0.05	17	5.99	0.42	11	277	2.66
		2		--	--		--	--					--	--
	Summer	1	18	34	0.97	18	0.56	0.10	13	4.47	0.18	14	282	2.47
		2		--	--		--	--					--	--
1999	Spring	1	11	32[a]	2.86	11	0.42[a]	0.10	9	5.53[a]	0.18	10	271[a]	3.90
		2	10	28[a]	2.35	10	0.73[a]	0.12	9	5.01[a]	0.45	9	281[a]	6.70
	Summer	1	10	36	2.48	10	1.07	0.15	10	4.62	0.36	10	287	4.23
		2		--	--		--	--		--	--		--	--

Appendix 9.7. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for bluegill in the spring and summer of 1998 and 1999, by segment, in Newton Lake. Values with different superscripts indicate differences among segments within a season for individual variables at the α=0.05 level.

Year	Season	Segment	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	1	3	36^{a}	3.93	3	0.67^{a}	0.67		--	--	3	289^{a}	6.37
		2		--	--		--	--		--	--		--	--
		3		--	--		--	--		--	--		--	--
		4	2	38^{a}	1.17	2	1.32^{a}	0.02		--	--	2	267^{a}	9.25
	Summer	1	7	33^{a}	2.36	7	0.00^{a}	--		--		4	290^{a}	4.71
		2	3	34^{a}	0.56	3	0.00^{a}	--	2	5.75	0.65	2	292^{a}	16.25
		3		--	--		--	--		--	--		--	--
		4		--	--		--	--		--	--		--	--
1999	Spring	1	3	33^{a}	0.51	3	0.17^{a}	0.17	2	5.75^{a}	0.45	2	284^{a}	6.5
		2	5	32^{a}	2.23	5	0.20^{a}	0.10		--	--	5	295^{a}	3.57
		3	3	32^{a}	3.86	3	0.00^{a}	0.00	2	5.60^{a}	0.20	2	297^{a}	7.25
		4	4	29^{a}	4.86	4	0.00^{a}	0.00	2	4.65^{a}	0.05	4	277^{a}	5.52
	Summer	1		--	--		--	--		--	--		--	--
		2		--	--		--	--		--	--		--	--
		3		--	--		--	--		--	--		--	--
		4	14	32	0.87	14	0.64	0.09		--		14	297	5.13

Appendix 9.8. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for bluegill in the spring and summer of 1998 and 1999, by segment, in Coffeen Lake. Values with different superscripts indicate differences among segments within a season for individual variables at the α=0.05 level.

Year	Season	Segment	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	1		--	--		--	--		--	--		--	--
		2		--	--		--	--		--	--		--	--
	Summer	1		--	--		--	--		--	--		--	--
		2	9	40	2.24	9	0.00	0.00	6	4.58	0.92	8	301	4.77
1999	Spring	1		--	--		--	--		--	--		--	--
		2	16	34	1.18	16	0.23	0.08	5	4.14	0.47	15	272	19.3
	Summer	1		--	--		--	--		--	--		--	--
		2	4	34	2.18	4	0.25	0.13	1	5.6	--	4	301	12.3

Appendix 9.9. Mean hematocrit, leucocrit, plasma proteins, plasma osmolality, and standard errors for bluegill in the spring and summer of 1998 and 1999, by segment, in Lake of Egypt. Values with different superscripts indicate differences among segments within a season for individual variables at the α=0.05 level.

Year	Season	Segment	N	Hematocrit (%)	S.E.	N	Leucocrit (%)	S.E.	N	Plasma Proteins (g/100ml)	S.E.	N	Osmolality (mmol/kg)	S.E.
1998	Spring	1	7	28^{a}	1.92	7	0.78^{a}	0.21	1	5.95^{a}	--	7	300^{a}	2.58
		2	6	33^{a}	2.85	6	0.75^{a}	0.11	2	5.05^{a}	0.8	3	290^{a}	13.36
	Summer	1	10	38	1.74	10	0.00	0.00	9	5.24	0.28	10	291	5.94
		2		--	--		--	--		--	--		--	--
1999	Spring	1	5	25^{a}	2.11	5	0.30^{a}	0.10	5	5.34^{a}	0.11	5	301^{a}	8.86
		2	5	32^{b}	1.51	5	0.00^{b}	0.00	2	5.80^{a}	0.60	5	266^{b}	6.4
	Summer	1	17	38^{a}	1.12	17	0.10^{a}	0.05	5	4.91^{a}	0.77	13	303^{a}	4.59
		2	5	36^{a}	1.25	5	0.00^{a}	0.00	3	4.83^{a}	0.34	3	295^{a}	3.77

Appendix 9.10. Mean hematocrit, leucocrit, and plasma proteins for Newton Lake, Coffeen Lake, Lake of Egypt, and five non-power cooling lakes in the summer of 1999.

Lake	N	Hematocrit (%)	N	Leucocrit (%)	N	Plasma Proteins (g/100ml)
Newton	17	42	17	0.00	11	5.69
Coffeen	27	43	27	0.00	25	6.53
Egypt	22	37	22	0.02	22	5.73
Newton Moribound	10	41	10	0.92	6	6.78
Sam Dale	5	41	5	0.20	5	6.31
East Fork	5	37	5	0.93	5	6.07
Rend	5	42	5	0.07	5	6.39
Kinkaid	5	38	5	0.00	4	5.68
Cedar	5	34	5	1.13	4	5.53

Appendix 9.11. Mean differential blood cell counts and standard errors for largemouth bass (summer 1999) in Newton Lake, Coffeen Lake, Lake of Egypt, and five non-power cooling lakes. LYM =lymphocytes, HET = heterophils, NEUT = neutrophils, THROM = thrombocytes, BASO = basophils, ESO = esonophils, MONO = monocytes, Unkown = unidentifiable white blood cell types.

Year	Season	Lake	N	%LYM	S.E.	%HET	S.E.	%NEUT	S.E.	%THROM	S.E.	%BASO	S.E.	%ESO	S.E.	%MONO	S.E.	Unknown	S.E.
1999	Summer	Newton	16	54.09	2.69	0.53	0.19	2.56	0.47	40.84	2.64	0.00	0.00	0.00	0.00	0.00	0.00	1.97	0.55
		Coffeen	25	54.32	3.54	2.06	0.89	4.66	1.63	35.28	2.80	0.02	0.02	0.00	0.00	0.02	0.02	3.64	1.10
		Egypt	20	48.00	3.81	0.55	0.29	4.00	1.00	40.58	2.85	0.05	0.05	0.00	0.00	0.63	0.63	6.20	1.10
		Newton Moribund	9.00	19.94	2.96	5.89	3.22	13.11	2.89	52.00	3.39	0.00	0.00	0.00	0.00	0.06	0.06	9.00	1.93
		Sam Dale	4.00	54.75	3.27	1.00	0.29	5.38	1.20	32.50	4.68	0.00	0.00	0.00	0.00	0.00	0.00	6.38	3.16
		East Fork	5.00	61.10	2.83	0.40	0.19	2.40	0.86	30.60	4.58	0.00	0.00	0.00	0.00	0.00	0.00	5.50	2.25
		Rend	5.00	48.30	6.24	2.40	1.37	18.30	7.19	25.40	3.57	0.00	0.00	0.00	0.00	0.20	0.20	5.40	2.00
		Kinkaid	3.00	44.17	12.66	0.17	0.17	3.67	1.76	47.17	12.37	0.00	0.00	0.00	0.00	0.33	0.33	4.50	1.26
		Cedar	3.00	65.33	5.09	0.33	0.33	1.17	0.67	30.83	5.83	0.00	0.00	0.00	0.00	0.00	0.00	2.33	1.33

Appendix 9.12. Mean blood glucose concentrations (mg/dL) and standard errors by segment for largemouth bass in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among segments within a lake and season at the α=0.05 level.

Year	Lake	Season	Segment	N	Glucose Concentration (mg/dL)	S.E.	Season	Segment	N	Glucose Concentration (mg/dL)	S.E.
1998	Newton	Spring	1	9	120^{a}	15.14	Summer	1		--	--
			2	8	$61^{b,c}$	7.89		2	2	110^{a}	14.75
			3	7	64^{c}	9.17		3	2	181^{a}	26.5
			4	8	$80^{a,b,c}$	11.87		4	12	184^{a}	22.51
1999	Newton	Spring	1	7	102^{a}	9.65	Summer	1		--	--
			2	6	$72^{a,b,c}$	6.13		2		--	--
			3	6	$63^{b,c}$	7.43		3		--	--
			4	4	49^{c}	7.61		4	12	226	31.94
1998	Coffeen	Spring	1	15	253^{a}	16.97	Summer	1	12	201^{a}	27.96
			2	14	178^{b}	20.21		2	3	263^{a}	47.2
1999	Coffeen	Spring	1	10	101^{a}	7.78	Summer	1		--	--
			2	10	128^{a}	11.93		2	17	102	10.25
1998	Egypt	Spring	1	11	86^{a}	11.17	Summer	1	12	135^{a}	15.12
			2	12	108^{a}	7.38		2	1	158^{a}	--
1999	Egypt	Spring	1	11	54^{a}	5.76	Summer	1	15	112^{a}	11.83
			2	11	68^{a}	7.26		2	6	89^{a}	16.55

Appendix 9.13. Mean blood glucose concentrations (mg/dL) and standard errors by segment for channel catfish in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among segments within a lake and season at the α=0.05 level.

Lake	Season	Segment	N	Glucose Concentration (mg/dL)	S.E.	Season	Segment	N	Glucose Concentration (mg/dL)	S.E.
Newton	Spring	1	7	$40^{a,b}$	6.99	Summer	1		--	--
		2	8	48^{b}	10.23		2	9	112	17.79
		3	7	16^{a}	3.00		3		--	--
		4	1	$60^{a,b}$	--		4		--	--
Newton	Spring	1	6	37^{a}	4.25	Summer	1	1	47^{a}	--
		2	4	32^{a}	5.54		2	10	74^{a}	4.58
		3	4	58^{b}	5.92		3		--	--
		4	6	29^{a}	4.29		4	5	68^{a}	12.61
Coffeen	Spring	1	12	87^{a}	10.33	Summer	1	18	80	6.86
		2	13	87^{a}	8.21		2		--	--
Coffeen	Spring	1	7	43^{a}	4.59	Summer	1	13	68	4.25
		2	10	31^{a}	5.18		2		--	--
Egypt	Spring	1	10	60	11.53	Summer	1	17	80	5.49
		2		--	--		2		--	--
Egypt	Spring	1	10	27^{a}	3.79	Summer	1	9	54	4.69
		2	10	31^{a}	6.37		2		--	--

Appendix 9.14. Mean blood glucose concentrations (mg/dL) and standard errors by segment for bluegill in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among segments within a lake and season at the ∝=0.05 level.

Year	Lake	Season	Segment	N	Glucose Concentration (mg/dL)	S.E.	Season	Segment	N	Glucose Concentration (mg/dL)	S.E.
1998	Newton	Spring	1	1	130	--	Summer	1	5	113[a]	14.53
			2		--	--		2	1	79[a]	--
			3		--	--		3		--	--
			4		--	--		4		--	--
1999	Newton	Spring	1	3	161[a]	26.3	Summer	1		--	--
			2	2	75[a]	24.66		2		--	--
			3	2	42[a]	5.18		3		--	--
			4	1	40[a]	--		4	8	108	5.85
1998	Coffeen	Spring	1		--	--	Summer	1		--	--
			2		--	--		2	3	89	25.92
1999	Coffeen	Spring	1		--	--	Summer	1		--	--
			2	7	150	36.46		2	2	128	17.38
1998	Egypt	Spring	1	7	59	2.19	Summer	1	2	201	29.50
			2		--	--		2		--	--
1999	Egypt	Spring	1	5	49[a]	8.07	Summer	1	7	92[a]	11.77
			2	4	72[a]	10.84		2	3	89[a]	13.38

Appendix 9.15. Mean blood clotting times (minutes) and standard errors by segment for largemouth bass in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among segments within a lake and season at the ∝=0.05 level.

Year	Lake	Season	Segment	N	Clotting Time (minutes)	S.E.	Season	Segment	N	Clotting Time (minutes)	S.E.
1998	Newton	Spring	1	12	4.26[a]	0.66	Summer	1		--	--
			2	8	4.61[a]	0.61		2	2	0.84[a]	0.09
			3	8	2.31[a]	0.42		3	5	0.83[a]	0.12
			4	8	3.44[a]	0.34		4	14	1.20[a]	0.14
1999	Newton	Spring	1	7	3.73[a]	0.55	Summer	1		--	--
			2	6	2.59[a]	0.32		2		--	--
			3	6	2.86[a]	0.26		3		--	--
			4	6	2.56[a]	0.39		4	17	1.39	0.22
1998	Coffeen	Spring	1	15	5.10[a]	1.15	Summer	1	15	1.48[a]	0.21
			2	15	6.91[a]	0.90		2	5	1.87[a]	0.51
1999	Coffeen	Spring	1	10	4.92[a]	0.76	Summer	1		--	--
			2	10	5.73[a]	0.65		2	26	1.55	0.18
1998	Egypt	Spring	1	15	6.63[a]	0.74	Summer	1	23	1.78[a]	0.20
			2	16	2.49[b]	0.44		2	4	1.50[a]	0.40
1999	Egypt	Spring	1	11	4.09[a]	0.51	Summer	1	16	0.67[a]	0.13
			2	12	3.35[a]	0.66		2	8	1.59[b]	0.24

Appendix 9.16. Mean blood clotting times (minutes) and standard errors by segment for channel catfish in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among segments within a lake and season at the ∝=0.05 level.

Lake	Season	Segment	N	Clotting Time (minutes)	S.E.	Season	Segment	N	Clotting Time (minutes)	S.E.
Newton	Spring	1	8	3.02^{a}	0.43	Summer	1		--	--
		2	12	$2.08^{a,b}$	0.26		2	19	2.00	0.24
		3	13	1.50^{b}	0.08		3		--	--
		4	1	$1.75^{a,b}$	0.00		4		--	--
Newton	Spring	1	8	4.14^{a}	0.56	Summer	1	1	1.33^{a}	0.00
		2	6	4.58^{a}	0.38		2	12	1.93^{a}	0.28
		3	9	2.34^{b}	0.18		3		--	--
		4	6	1.91^{b}	0.17		4	8	1.47^{a}	0.24
Coffeen	Spring	1	15	12.84^{a}	1.67	Summer	1	20	2.26	0.26
		2	15	9.39^{a}	1.17		2		--	--
Coffeen	Spring	1	9	7.32^{a}	1.13	Summer	1		--	--
		2	10	6.80^{a}	0.59		2	21	1.45	0.10
Egypt	Spring	1	20	5.48	0.94	Summer	1	19	0.28	1.68-2.87
		2		--	--		2		--	--
Egypt	Spring	1	10	6.62^{a}	0.53	Summer	1	10	0.27	1.12-2.36
		2	10	13.18^{a}	3.84		2		--	--

Appendix 9.17. Mean blood clotting times (minutes) and standard errors by segment for bluegill in the spring and summer of 1998 and 1999. Superscripts with different letters indicate differences among segments within a lake and season at the ∝=0.05 level.

Year	Lake	Season	Segment	N	Clotting Time (minutes)	S.E.	Season	Segment	N	Clotting Time (minutes)	S.E.
1998	Newton	Spring	1	4	1.67[a]	0.14	Summer	1	7	1.14[a]	0.11
			2		--	--		2	3	1.29[a]	0.20
			3		--	--		3		--	--
			4	2	1.00[b]	0.00		4		--	--
1999	Newton	Spring	1	3	1.19[a]	0.08	Summer	1		--	--
			2	5	1.64[a]	0.19		2	1	0.53[a]	0.00
			3	3	1.27[a]	0.06		3		--	--
			4	5	1.60[a]	0.07		4	14	0.72[a]	0.05
1998	Coffeen	Spring	1		--	--	Summer	1		--	--
			2					2	10	0.98	0.12
1999	Coffeen	Spring	1		--	--	Summer	1		--	--
			2	16	1.64	0.18		2	6	0.69	0.33
1998	Egypt	Spring	1	7	2.20[a]	0.28	Summer	1	10	0.88	0.07
			2	6	0.94[b]	0.08		2		--	--
1999	Egypt	Spring	1	5	3.00[a]	0.40	Summer	1	16	0.49[a]	0.09
			2	5	1.43[b]	0.11		2	5	0.50[a]	0.12

Appendix 9.18. Mean fish health assessment index (FHAI) values for largemouth bass (summer of 1999) in Newton Lake, Coffeen Lake, Lake of Egypt, and five non-power cooling lakes.

Lake	N	FHAI	S.D.	C.V.
Newton	17	70	26.87	38.56
Coffeen	31	76	36.18	47.85
Egypt	28	74	41.89	56.34
Newton Moribund	10	102	23.06	22.54
Sam Dale	4	60	29.15	48.59
East Fork	5	60	30.21	50.35
Rend	4	96	14.93	15.51
Kinkaid	5	67	19.24	28.71
Cedar	5	77	31.7	41.44

Appendix 9.19. Mean condition factor (C) and standard errors for largemouth bass from Newton Lake, Coffeen Lake, Lake of Egypt, a moribund sample from Newton Lake, and a pooled sample of five non-power cooling lakes in the summer of 1999.

Lake	N	C	S.E.
Newton	17	5.56	0.16
Coffeen	31	5.20	0.06
Egypt	30	4.36	0.09
Newton Moribund	10	4.81	0.20
5 Lakes	25	4.94	0.12

Appendix 9.20. Mean gonadal somatic index (GSI, wt of the gonads/wt of the fish) for female largemouth bass ranging from 3.9-21.7 inches for the spring of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	GSI	S.E.
1998	Spring	3.9-9.7	Newton	2.00	0.65	0.05
			Coffeen		--	--
			Egypt		--	--
1998	Spring	9.8-15.7	Newton	3	2.27[a]	0.93302
			Coffeen	4	4.82[a]	0.10701
			Egypt	8	2.39[a]	0.82183
1999	Spring	9.8-15.7	Newton	4	4.98[a]	0.79262
			Coffeen	9	6.99[a]	0.8625
			Egypt	2	4.53[a]	0.6728
1998	Spring	15.8-21.7	Newton	16	4.16[a,b]	0.80
			Coffeen	11	6.68[a]	0.90
			Egypt	11	3.09[b]	0.61
1999	Spring	15.8-21.7	Newton	8	6.08[a]	0.60
			Coffeen	11	7.59[a]	0.62
			Egypt	17	3.96[b]	0.34

Appendix 9.21. Mean gonadal somatic index (GSI, wt of the gonads/wt of the fish) for female channel catfish ranging from 7.9-25.6 inches for the spring of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the α=0.05 level.

Year	Season	Size Range (inches)	Lake	N	GSI	S.E.
1998	Spring	7.9-13.8	Newton	4	0.24[a]	0.04
			Coffeen	5	3.61[a]	2.21
			Egypt		--	--
1999	Spring	7.9-13.8	Newton	15	0.98[a]	0.27
			Coffeen	10	0.47[a]	0.08
			Egypt		--	--
1998	Spring	13.9-19.7	Newton		--	--
			Coffeen	10	2.47[a]	0.80
			Egypt	5	3.91[a]	2.28
1998	Spring	13.9-19.7	Newton	2	1.04[a]	0.39
			Coffeen	10	2.17[a]	0.58
			Egypt	4	6.88[b]	1.61
1998	Spring	19.8-25.6	Newton		--	--
			Coffeen		--	--
			Egypt	4	8.06	3.06
1999	Spring	19.8-25.6	Newton		--	--
			Coffeen		--	--
			Egypt	7	4.18	1.72

Appendix 9.22. Mean gonadal somatic index (GSI, wt of the gonads/wt of the fish) for female bluegill ranging from 3.9-8.7 inches for the spring of 1998 and 1999. Superscripts with different letters indicate differences among the lakes within a season at the ∝=0.05 level.

Year	Season	Size Range (inches)	Lake	N	GSI	S.E.
1998	Spring	3.9-5.5	Newton		--	--
			Coffeen		--	--
			Egypt		--	--
1999	Spring	3.9-5.5	Newton	6	1.01	0.04
			Coffeen		--	--
			Egypt	1	0.59	--
1998	Spring	5.6-7.1	Newton		--	--
			Coffeen		--	--
			Egypt	4	0.68	0.19
1999	Spring	5.6-7.1	Newton	5	1.09[a]	0.14
			Coffeen		--	--
			Egypt	7	0.80[a]	0.03
1998	Spring	7.2-8.7	Newton		--	--
			Coffeen		--	--
			Egypt	2	0.10	0.01
1999	Spring	7.2-8.7	Newton		--	--
			Coffeen		--	--
			Egypt	2	0.86	0.03

Appendix 9.23. Variables used in the health assessment index. Variables are modified from Goede (1993) and Adams (1993)

Variable	Description	Designation	Value
Eyes:	Normal	N	0
	Exopthalmia- swollen, protruding eye	E1/E2	30
	Hemorrhagic - bleeding	H1/H2	30
	Blind - opaque eyes	B1/B2	30
	Missing	M1/M2	30
	Other	OT	30
Gills:	Normal	N	0
	Frayed - ragged appearing gills	F	30
	Clubbed - swelling of tips of gill lamellae	C	30
	Marginate - gill with a light discolored margin along the distal ends or tips of the lamellae or filaments	M	30
	Pale - very light color	P	30
	Other	OT	30
Pseudobranchs:	Normal	N	0
	Swollen - convex	S	30
	Lithic - Mineral deposits in pseudobranchs - white amorphous spots or foci	L	30
	Swollen and Lithic	SL	30
	Inflamed - redness	I	30
	Other	OT	30
Fins:	No active erosion	0	0
	Mild active erosion	1	20
	Severe active erosion	2	30
	Fins involved will be noted.		
Opercales:	Normal opercale - no shortening, gills completely covered	0	
	Slight shortening - very small portion of the gill exposed	1	
	Severe shortening - considerable portion of gills exposed	2	
Thymus:	No Hemorrhage	0	0
	Mild Hemorrhage	1	10
	Severe Hemorrhage	2	30

Visceral Fat Percentage-Channel Catfish

0 - no fat surrounding the viscera	0	
1 - less than 50% of viscera covered in fat	1	
2 - 50% fat	2	
3 - more than 50% fat	3	
4 - viscera completely covered in fat	4	

Largemouth Bass/Bluegill:

0 - no fat around pyloric ceca	0	
1 - slight, less than 50%	1	
2 - 50% of cecum covered with fat	2	
3 - more than 50%	3	
4 - completely covered by large amount of fat	4	

Gonads: note any abnormalities

Spleen: Black - very dark red color, considered normal	B	0
Red - red coloration, considered normal	R	0
Granular - granular or rough	G	0
Nodular - nodules, cysts	D	30
Enlarged	E	30
Other	OT	30
Hindgut: No inflammation	0	0
Slight inflammation	1	10
Moderate inflammation	2	20
Severe inflammation	3	30
Kidney: Normal-good firm dark red color	N	0
Swollen- enlarged or swollen wholly or in part	S	30
Mottled - gray discoloration, patchy in appearance- scattered patches of gray to total gray discoloration.	M	30
Granular	G	30
Urolithiasis - deposition of white or "cream-colored " amorphous mineral material in tubules	U	30
Other	OT	30

Appendix 9.23. continued

Liver:	Normal, good, solid red color	A	0
	Lighter or less vivid red color than in A - normal	B	0
	"Fatty" liver , coffee with cream color	C	30
	Nodules	D	30
	Focal discoloration	E	30
	General discoloration	G	30
	Other	OT	30
Bile: considers fullness and degree of green of the gall bladder			
	Yellow or straw color; bladder empty or only partially full	0	
	Yellow or straw color; bladder full, distended	1	
	Light green to grass green	2	
	Dark green, dark blue-green	3	
Hemolysis in bile:			
	No hemolysis	0	
	Slight hemolysis	1	
	Moderate hemolysis	2	
	Extreme hemolysis	3	
Parasites:	No observed parasites	0	0
	Few observed parasites	1	10
	Moderated parasite infestation	2	20
	Numerous parasites	3	30
Hematocrit-Largemouth bass (Spring 1998):			
	Normal range:	29-37%	0
	Above normal range:	37-41%	15
	High above normal range	41-44%	30
	Below normal range:	26-28	15
	High below normal range	21.84	30
Hematocrit-Largemouth bass (Summer 1998):			
	Normal range:	33-41%	0
	Above normal range:	42-44%	15
	High above normal range	45-48%	30
	Below normal range:	30-33%	15
	High below normal range	26-29%	30

Appendix 9.23. continued

Hematocrit-Largemouth bass (Spring 1999):

Normal range:	26-33%	0
Above normal range:	33-36%	15
High above normal range	36-39%	30
Below normal range:	23-25%	15
High below normal range	19-23%	30

Hematocrit-Largemouth bass (Summer 1999):

Normal range:	32-43%	0
Above normal range:	44-49%	15
High above normal range	49-54%	30
Below normal range:	27-33%	15
High below normal range	21-27%	30

Hematocrit-Channel Catfish (Spring 1998):

Normal range:	24-37%	0
Above normal range:	38-44%	15
High above normal range	44-51%	30
Below normal range:	18-24%	15
High below normal range	11-17%	30

Hematocrit-Channel Catfish (Summer 1998):

Normal range:	30-38%	0
Above normal range:	38-43%	15
High above normal range	43-47%	30
Below normal range:	25-30%	15
High below normal range	21-25%	30

Hematocrit-Channel Catfish (Spring 1999):

Normal range:	21-39%	0
Above normal range:	39-47%	15
High above normal range	47-56%	30
Below normal range:	13-20%	15
High below normal range	4-12%	30

Hematocrit-Channel Catfish (Summer 1999):

Normal range:	29-44%	0
Above normal range:	45-52%	15
High above normal range	52-59%	30
Below normal range:	21-28%	15
High below normal range	14-20%	30

Appendix 9.23. continued

Hematocrit-Bluegill (Spring 1998)		
Normal range:	24-36%	0
Above normal range:	19-23%	15
High above normal range	13-18%	30
Below normal range:	37-42%	15
High below normal range	43-48%	30
Hematocrit-Bluegill (Summer 1998)		
Normal range:	33-44%	0
Above normal range:	45-50%	15
High above normal range	51-56%	30
Below normal range:	27-32%	15
High below normal range	21-28%	30
Hematocrit-Bluegill (Spring 1999)		
Normal range:	23-34%	0
Above normal range:	35-40%	15
High above normal range	41-45%	30
Below normal range:	18-22%	15
High below normal range	12-17%	30
Hematocrit-Bluegill (Spring 1999)		
Normal range:	23-34%	0
Above normal range:	35-40%	15
High above normal range	41-45%	30
Below normal range:	18-22%	15
High below normal range	12-17%	30
Leucocrit-Largemouth Bass (Spring 1998)		
Normal range:	0-2%	0
Above normal range:	2.1-3.1%	15
High above normal range	3.2-4.2%	30
Below normal range:	--	15
High below normal range	--	30
Leucocrit-Largemouth Bass (Summer 1998)		
Normal range:	0%	0
Above normal range:	--	15
High above normal range	--	30
Below normal range:	--	15
High below normal range	--	30

Appendix 9.23. continued

Leucocrit-Largemouth Bass (Spring 1999)		
Normal range:	0-0.42%	0
Above normal range:	0.43-0.67%	15
High above normal range	0.68-0.92%	30
Below normal range:	--	15
High below normal range	--	30
Leucocrit-Largemouth Bass (Summer 1999)		
Normal range:	0-1.1%	0
Above normal range:	1.2-1.8%	15
High above normal range	1.9-2.6%	30
Below normal range:	--	15
High below normal range	--	30
Leucocrit-Channel Catfish (Spring 1998)		
Normal range:	0.7-1.34%	0
Above normal range:	1.35-1.66%	15
High above normal range	1.67-1.98%	30
Below normal range:	0.38-0.69%	15
High below normal range	0.06-0.37%	30
Leucocrit-Channel Catfish (Summer 1998)		
Normal range:	0.08-1.06%	0
Above normal range:	1.07-1.55%	15
High above normal range	1.56-2.04%	30
Below normal range:	0-0.07%	15
High below normal range	--	30
Leucocrit-Channel Catfish (Spring 1999)		
Normal range:	0.17-0.97%	0
Above normal range:	0.98-1.38%	15
High above normal range	1.39-1.77%	30
Below normal range:	0-0.16%	15
High below normal range	--	30
Leucocrit-Channel Catfish (Summer 1999)		
Normal range:	0.54-1.6%	0
Above normal range:	1.7-2.1%	15
High above normal range	2.2-2.6%	30
Below normal range:	0.01-0.53%	15
High below normal range	---	30

Appendix 9.23. continued

Leucocrit-Bluegill (Spring 1998)		
Normal range:	0.2-1.3%	0
Above normal range:	1.3-1.9%	15
High above normal range	2-2.4%	30
Below normal range:	0-0.1%	15
High below normal range	---	30
Leucocrit-Bluegill (Summer 1998)		
Normal range:	0%	0
Above normal range:	--	15
High above normal range	--	30
Below normal range:	--	15
High below normal range	--	30
Leucocrit-Bluegill (Spring 1999)		
Normal range:	0-0.3%	0
Above normal range:	0.4-0.5%	15
High above normal range	0.6-0.8%	30
Below normal range:	0.9-1.1%	15
High below normal range	1.2-1.4%	30
Leucocrit-Bluegill (Summer 1999)		
Normal range:	0-0.3%	0
Above normal range:	0.4-0.6%	15
High above normal range	0.7-0.8%	30
Below normal range:	--	15
High below normal range	--	30
Plasma Proteins-Largemouth Bass (Spring 1998)		
Normal range:	5.02-7.06%	0
Above normal range:	7.06-8.08%	15
High above normal range	8.09-9.10%	30
Below normal range:	4.00-5.03%	15
High below normal range	2.98-3.99%	30
Plasma Proteins-Largemouth Bass (Summer 1998)		
Normal range:	4.90-6.36%	0
Above normal range:	6.37-7.09%	15
High above normal range	7.10-7.82%	30
Below normal range:	4.17-4.89%	15
High below normal range	3.44-4.16%	30

Appendix 9.23. continued

Plasma Proteins-Largemouth Bass (Spring 1999)		
Normal range:	5.06-6.18%	0
Above normal range:	6.19-6.74%	15
High above normal range	6.75-7.30%	30
Below normal range:	4.5-5.05%	15
High below normal range	3.94-4.49%	30
Plasma Proteins-Largemouth Bass (Summer 1999)		
Normal range:	5.3-6.7%	0
Above normal range:	6.71-7.4%	15
High above normal range	7.41-8.1%	30
Below normal range:	4.6-5.29%	15
High below normal range	3.9-4.59%	30
Plasma Proteins-Channel Catfish (Spring 1998)		
Normal range:	4.27-7.69%	0
Above normal range:	7.70-9.40%	15
High above normal range	9.41-11.11%	30
Below normal range:	2.56-4.29%	15
High below normal range	0.85-2.55%	30
Plasma Proteins-Channel Catfish (Summer 1998)		
Normal range:	3.75-4.99%	0
Above normal range:	5.00-5.61%	15
High above normal range	5.62-6.23%	30
Below normal range:	3.13-3.76%	15
High below normal range	2.51-3.12%	30
Plasma Proteins-Channel Catfish (Spring 1999)		
Normal range:	4.2-6.36%	0
Above normal range:	6.37-7.44%	15
High above normal range	7.45-8.52%	30
Below normal range:	3.12-4.19%	15
High below normal range	2.04-3.11%	30
Plasma Proteins-Channel Catfish (Summer 1999)		
Normal range:	3.63-5.77%	0
Above normal range:	5.78-6.84%	15
High above normal range	6.85-7.91%	30
Below normal range:	2.56-3.64%	15
High below normal range	1.49-2.55%	30

Appendix 9.23. continued

Plasma Proteins-Bluegill (Spring 1998)		
Normal range:	4.55-6.15%	0
Above normal range:	6.16-6.95%	15
High above normal range	6.96-7.75%	30
Below normal range:	3.75-4.54%	15
High below normal range	2.95-3.74%	30
Plasma Proteins-Bluegill (Summer 1998)		
Normal range:	4.34-5.88%	0
Above normal range:	5.89-6.65%	15
High above normal range	6.66-7.42%	30
Below normal range:	3.57-4.33%	15
High below normal range	2.8-3.56%	30
Plasma Proteins-Bluegill (Spring 1999)		
Normal range:	5.18-6.24%	0
Above normal range:	6.35-6.77%	15
High above normal range	6.77-7.30%	30
Below normal range:	4.65-5.17%	15
High below normal range	4.12-4.64%	30
Plasma Proteins-Bluegill (Summer 1999)		
Normal range:	3.9-6.46%	0
Above normal range:	6.45-7.74%	15
High above normal range	7.75-9.02%	30
Below normal range:	2.62-3.89%	15
High below normal range	1.34-2.61%	30

Chapter 10. Food Habits

Introduction and Methods:

In Newton Lake, food habits were determined for largemouth bass, channel catfish, and bluegill. Where possible, stomach contents were sampled from 20 specimens of each species collected by electrofishing once a month from September 1997 through December 1999 from each of the four lake segments of Newton Lake (a total of nine crew days for each segment, except segment 1 that required 11 crew days for collection). In order to draw comparisons, 14 sampling trips for food habits data were conducted on Coffeen, and 8 on the Lake of Egypt during this period.

Plastic (acrylic) tubes were inserted through the esophagus and into the stomach of larger piscivorous fishes such as largemouth bass (Van Den Avyle and Roussel 1980). The vacuum produced when an appropriate sized tube is withdrawn removes greater than 80% of the prey (Cailteux et al. 1991). A stomach gastric lavage that flushes the gut content out was used on the smaller fish and bluegill (Giles 1980). A subsample of fish were brought back to the lab to assess the efficiency of the gastric lavage technique. Stomach contents of all fishes that were sacrificed in Chapter 11 (Age and Growth) were included in the food habits study. Stomach contents were also used from the fish sacrificed for Chapter 9 (Fish Health). Stomach contents from each fish were initially fixed in 7% formalin and then transferred to 70% ethyl alcohol. Each sample jar contained an appropriate label specifying date, location, and species from which the sample was obtained. Contents of stomach samples were identified to the lowest taxon possible and wet weights determined. Data are also presented in higher taxon groups that more closely align to those of Chapter 5 (Benthos) and Chapter 6 (Phytomacrobenthos). Stomach contents are also grouped more coarsely as fish, zooplankton, other invertebrates, and miscellaneous items for ease of interpretation. Particular attention is also paid to the percentage of empty stomachs.

Results and Discussion:

During the three study years largemouth bass in Newton Lake had a mean of 60.2% empty stomachs (Table 10.1), while a mean of 51.0% of channel catfishes' stomachs were empty. The percentage of empty stomachs was higher in largemouth bass during 1999 than either 1997 or 1998 in all three lakes. Channel catfish in Newton Lake and Coffeen Lake had a higher percentage of empty stomachs during 1999 than the prior years, but, this was not the case for channel catfish from Lake of Egypt.

Over all, the number of empty stomachs in largemouth bass from month to month was higher during 1999 than 1997 or 1998 in Newton Lake (Figure 10.1). Most bluegill in Newton Lake had something in their stomach throughout the spring and summer months (Figure 10.1). The trend in empty stomachs in largemouth bass captured from Coffeen Lake was consistent from year to year (Figure 10.2). However, channel catfish from Coffeen Lake had far more empty stomachs during the spring and summer months of 1999 than during 1998. The trends in empty stomachs for both largemouth bass and channel catfish were consistent from year to year in Lake of Egypt (Figure 10.3).

It was not surprising to see that a major proportion of largemouth bass in all three lakes were feeding on fishes, and that this was the largest component of their diet, based on percent wet weight (Figures 10.4 - 10.6). Gizzard shad were of particular importance in the diet of largemouth bass in Coffeen and Newton Lakes, (See dietary breakdowns in this Chapter 10: Supplemental Figures and Data Tables). Whereas, *Lepomis* spp. (bluegill in particular) and

Pomoxis spp. were the dominant fish consumed by largemouth bass in the Lake of Egypt. For most of the sampling period gizzard shad were an important component of the diet of largemouth bass in Newton Lake (Supplemental Figures and Data Tables in this chapter); however, during late summer of 1999 and fall of 1998 and 1999, the importance of bluegill increased and surpassed gizzard shad.

Channel catfish were more omnivorous than largemouth bass, particularly in Newton Lake. Their diet during the sample period consisted of over 45 distinguishable food items during the 1998 season versus fewer than 10 in the other two lakes. Fish were important component by percentage weight of the channel catfish's diet in all three lakes (Figures 10.7 - 10.9). However, in both Newton Lake and Coffeen Lake only a very small percentage if individuals were found to have fish in their stomachs. It is this lack of fish in the diet of the majority of channel catfish sampled from Newton Lake and Coffeen Lake that could explain the slow growth they are exhibiting in these lakes (see Chapter 11: Age, Growth, and Mortality Rates). For some reason the channel catfish in these two lake are not making the switch from a primarily invertebrate diet to a primarily fish diet. This phenomenon does not appear to be a function of size since the channel catfish in Newton Lake and Coffeen Lake that are preying on fish are well distributed within the length frequency of channel catfish sampled from these lakes during 1998 and 1999 (Figure 10.10). In the Lake of Egypt a large percentage of channel catfish are on a fish diet and this is reflected in the higher growth rates seen.

Bluegill from Newton Lake had by far the greatest diversity in their diet consisting of at least 54 distinguishable food items. During 1997 the most prevalent food item by percent weight in the diet of bluegill Newton Lake were the cladocerans, particularly the non-native *Daphnia* *lumholtzi* (See Chapter 10: Supplemental Figures and Data Tables). Although *D. lumholtzi* was present in the bluegill's diet during 1998 and 1999, it was not as important an item by weight. In fact, based on percentage of weight, combined zooplankton comprised only a minor proportion of Newton Lake bluegills' diet after the fall of 1997 (Figure 10.11). The dietary profile of bluegill in Newton Lake over time is most probably driven by the availability of any given prey item in its environment. For example during the spring spawning season when eggs are plentiful, a relatively high number of fish are found with eggs in their diet. Eggs were also present in the diet of channel catfish during the spring months.

Literature Cited:

Cailteux, R.L., W.F. Porak, and S. Crawford. 1991. Reevaluating the use of acrylic tubes for collection of largemouth bass stomach contents. Proceedings of the Annual Conference of the Southwestern Association of Fish and Wildlife Agencies 44(1990):126-132.

Giles, N. 1980. A stomach sampler for use on live fish. Journal of Fish Biology 16:441-444.

Van Den Avyle, M.J., and J.E. Roussel. 1980. Evaluation of a simple method for removing food items from live black bass. The Progressive Fish-Culturist 42:222-223.

Table 10.1. Mean percentage of largemouth bass, and channel catfish with empty stomachs from the three Illinois power-cooling reservoirs (Newton Lake, Coffeen Lake, and Lake of Egypt) during 1997, 1998, and 1999.

		Newton Lake		Coffeen Lake		Lake of Egypt	
Species	Year	% Empty	Months[a]	% Empty	Months[a]	% Empty	Months[a]
Largemouth	1997	49.9	4	33.6	2	36.4	1
Bass	1998	51.7	9	29.4	5	30.4	4
	1999	70.0	12	54.6	5	55.4	2
	Mean	60.2		40.6		38.4	
Channel	1997	30.6	4	46.3	2	25.0	1
Catfish	1998	48.6	9	43.1	6	39.4	4
	1999	59.2	10	87.5	3	28.6	2
	Mean	51.0		55.8		34.3	

[a/] Number of months that samples were taken.

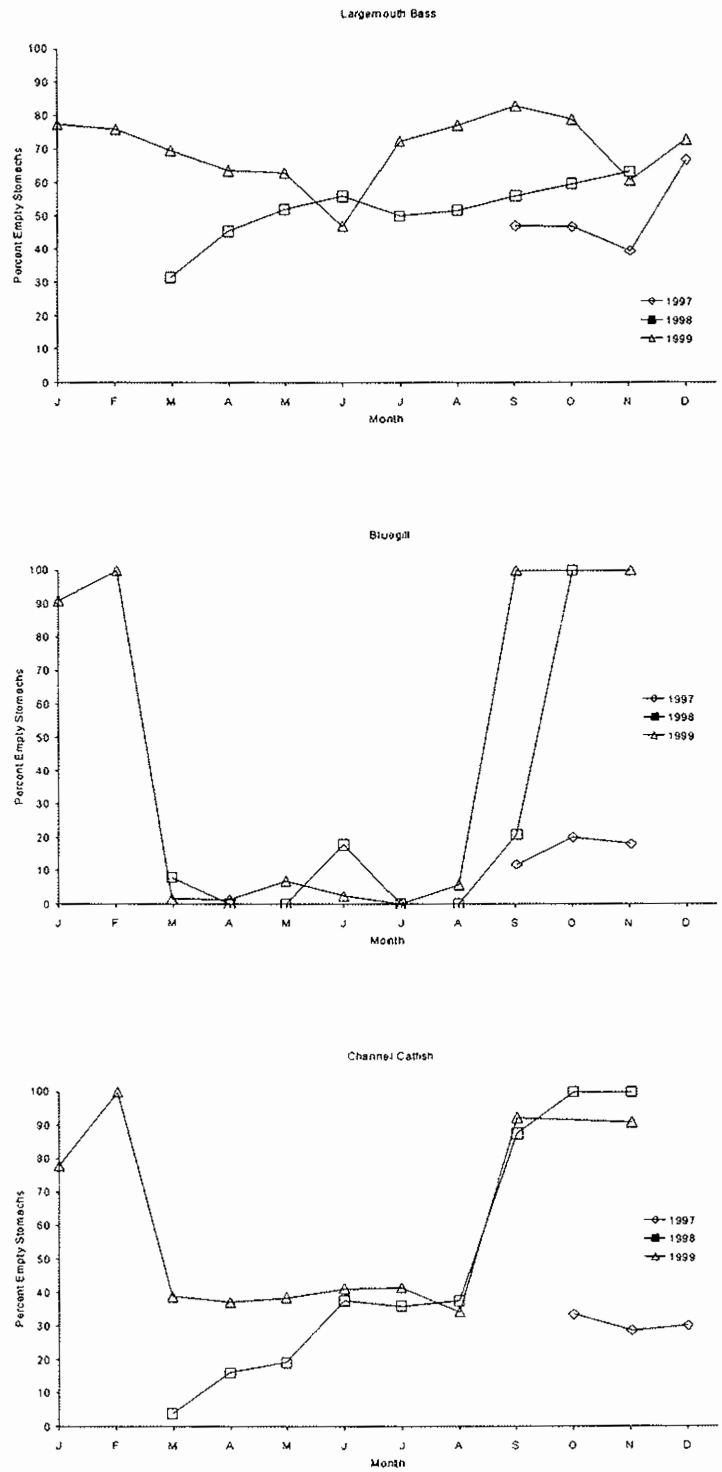


Figure 10.1. Monthly percentage of largemouth bass, bluegill, and channel catfish captured from Newton Lake during 1997, 1998, and 1999 with nothing in their stomachs.

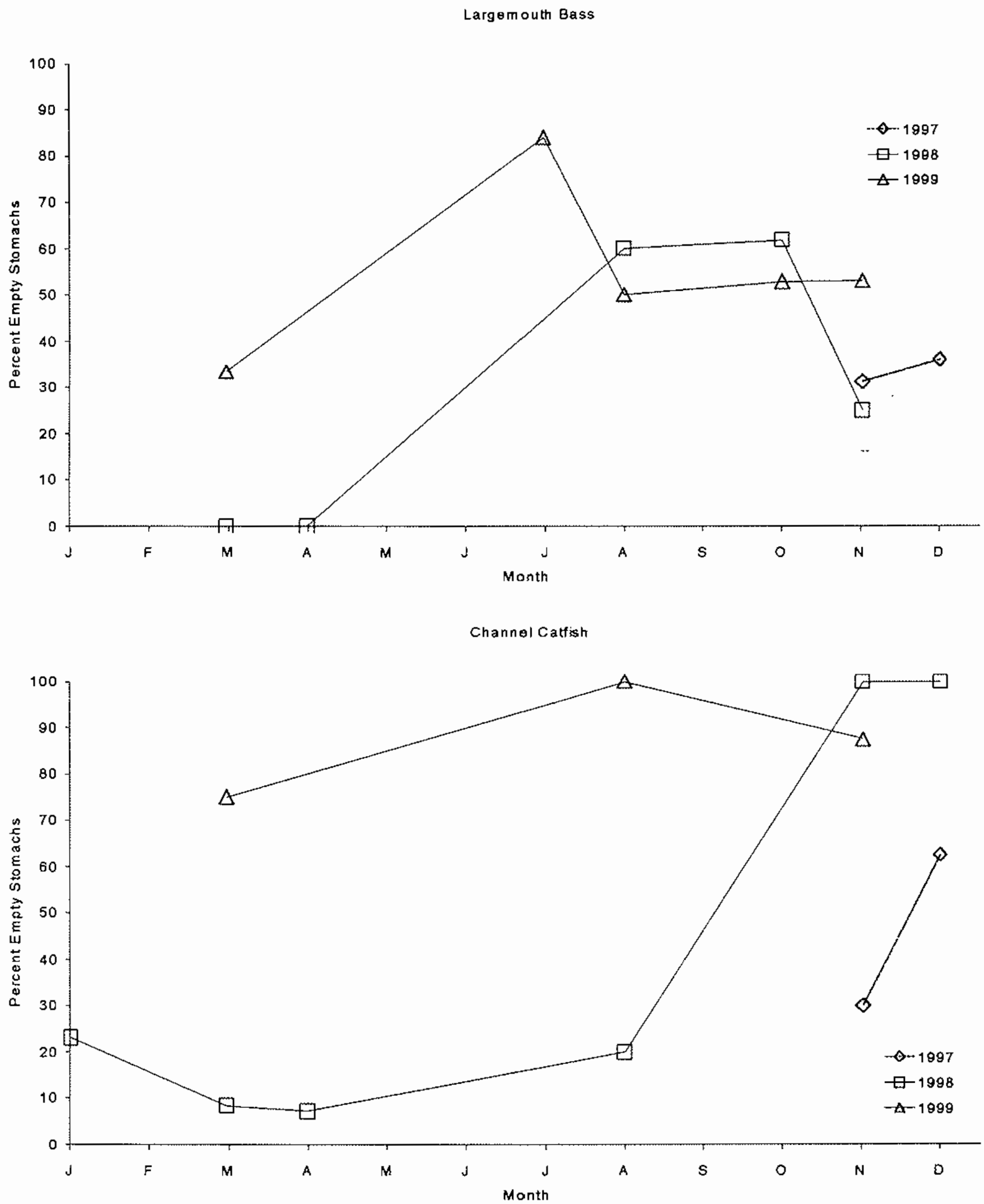


Figure 10.2. Monthly percentage of largemouth bass, and channel catfish captured from Coffeen Lake during 1997, 1998, and 1999 with nothing in their stomachs.

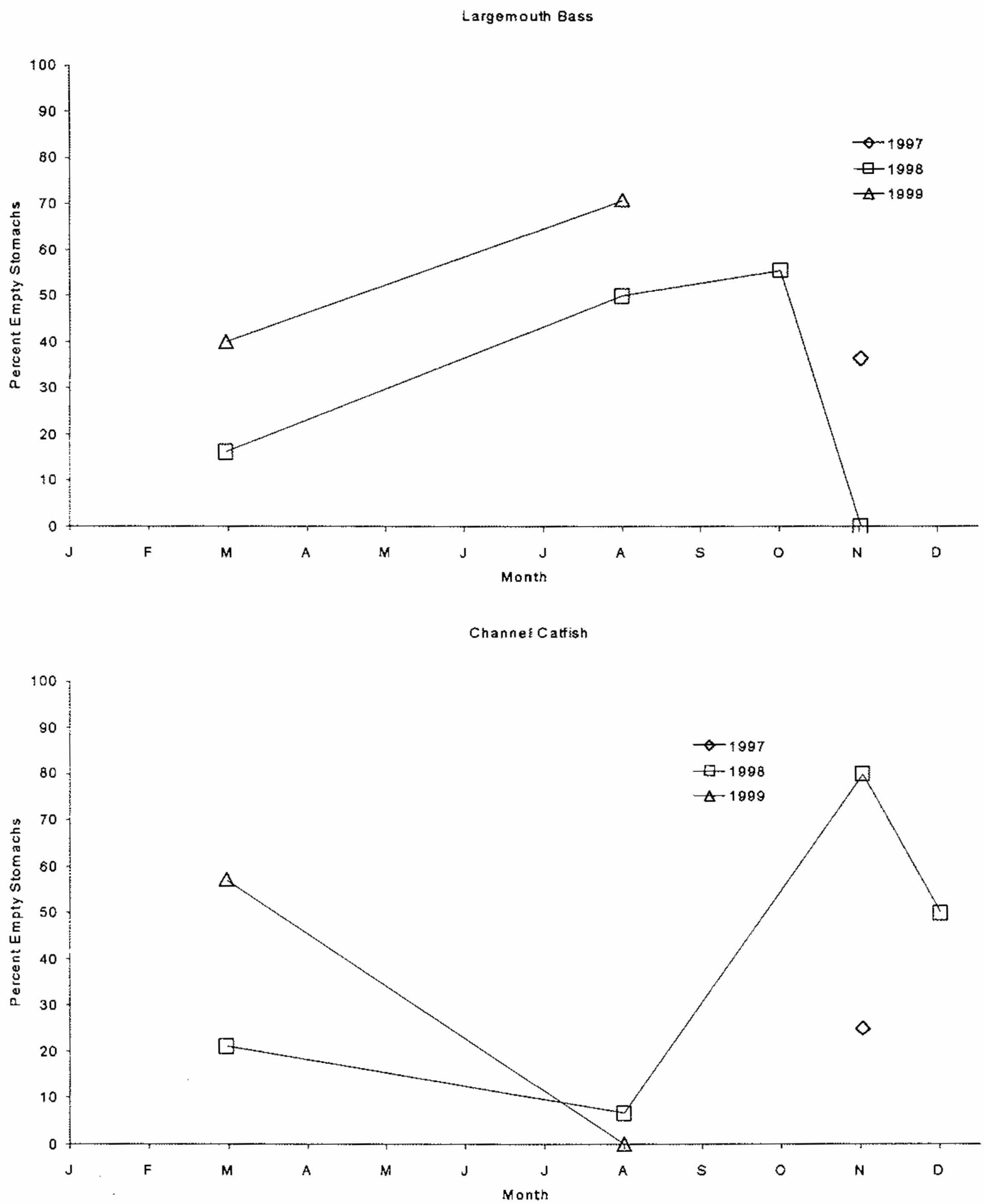


Figure 10.3. Monthly percentage of largemouth bass, and channel catfish captured from the Lake of Egypt during 1997, 1998, and 1999 with nothing in their stomachs.

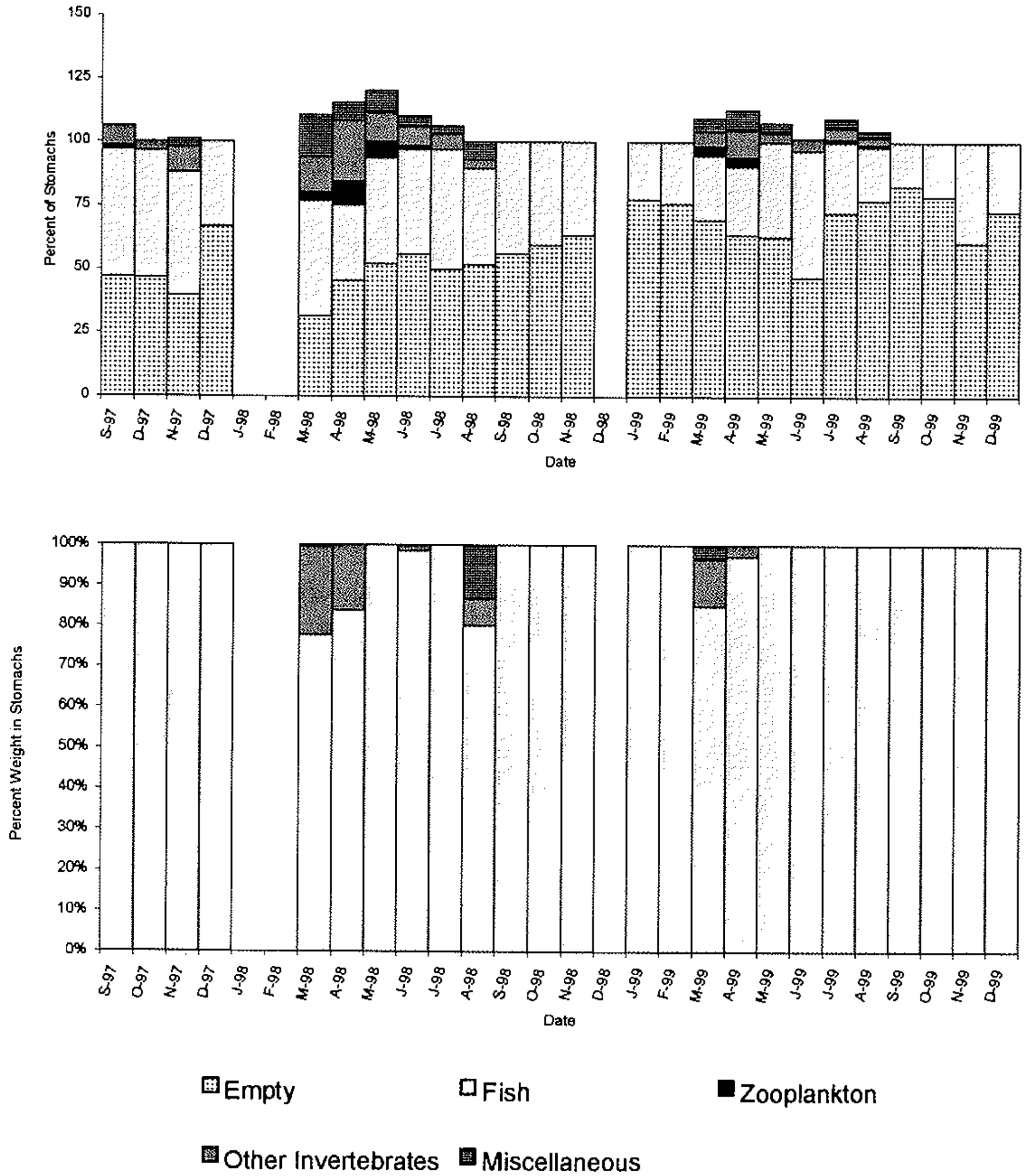


Figure 10.4. Monthly percentage of stomachs containing each food type (top), and percentage total weight of each food type in stomachs (bottom) for largemouth bass captured from Newton Lake during September 1997 through December 1999.

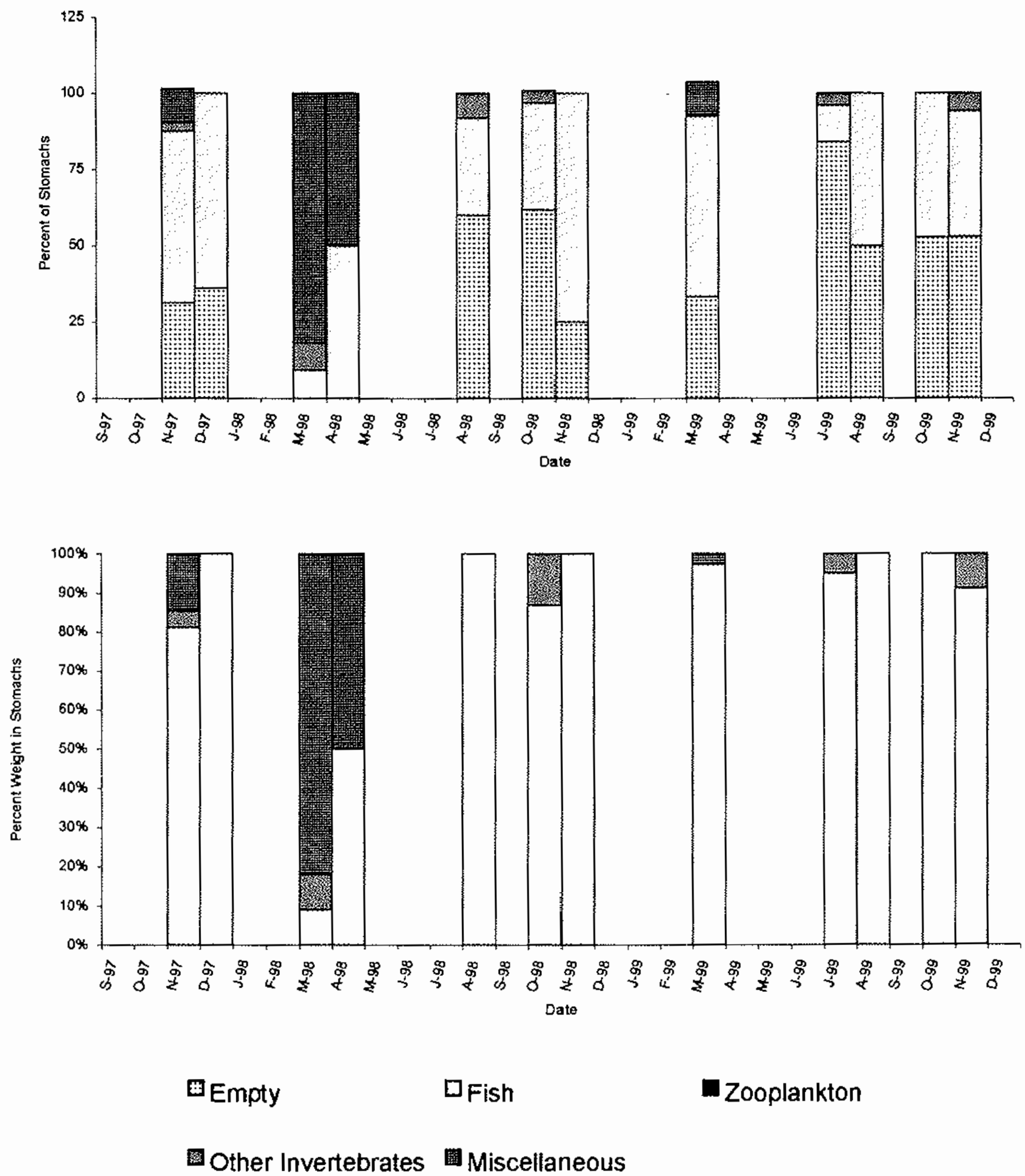


Figure 10.5. Monthly percentage of stomachs containing each food type (top), and percentage total weight of each food type in stomachs (bottom) for largemouth bass captured from Coffeen Lake during September 1997 through December 1999.

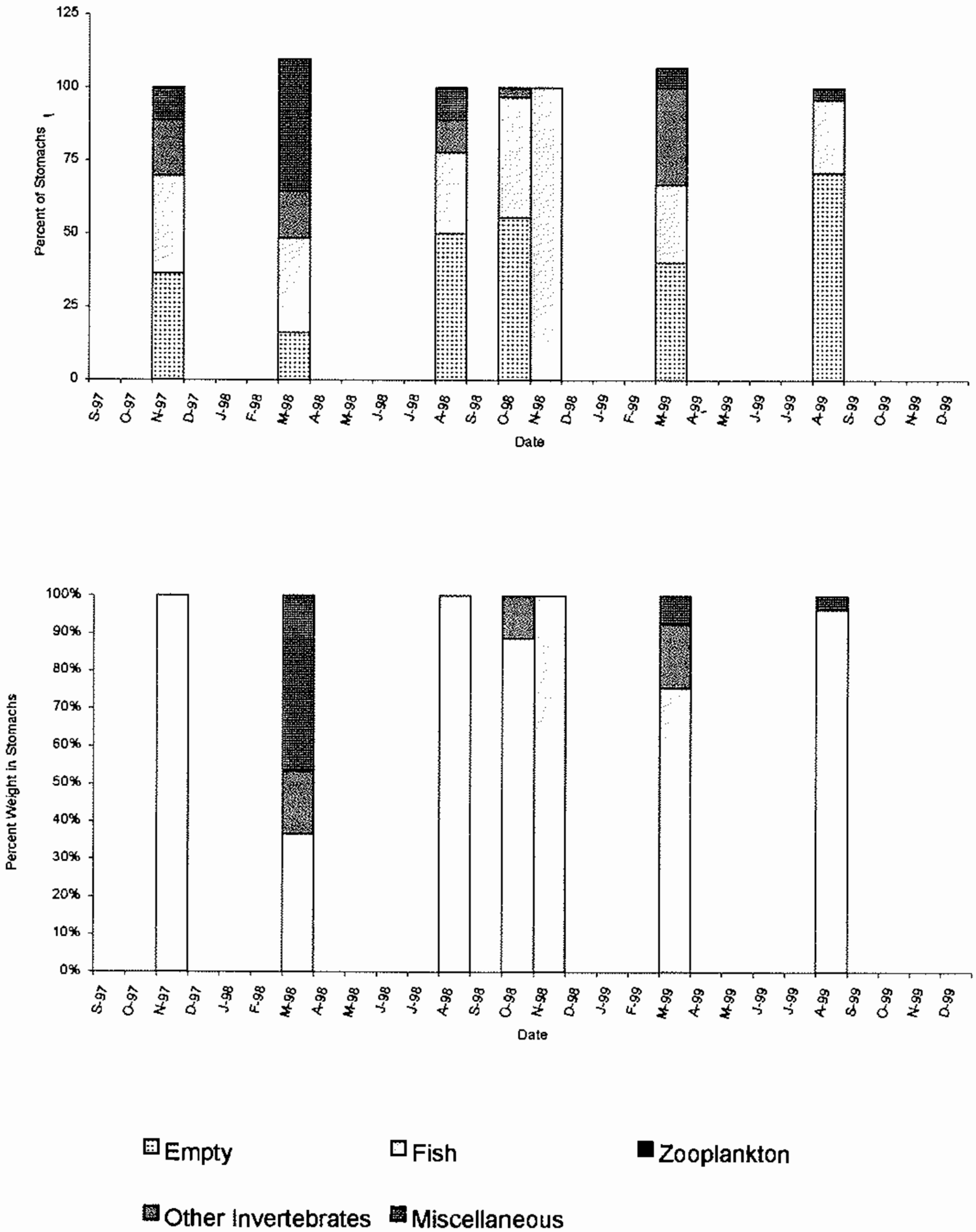


Figure 10.6. Monthly percentage of stomachs containing each food type (top), and percentage total weight of each food type in stomachs (bottom) for largemouth bass captured from Lake of Egypt during September 1997 through December 1999.

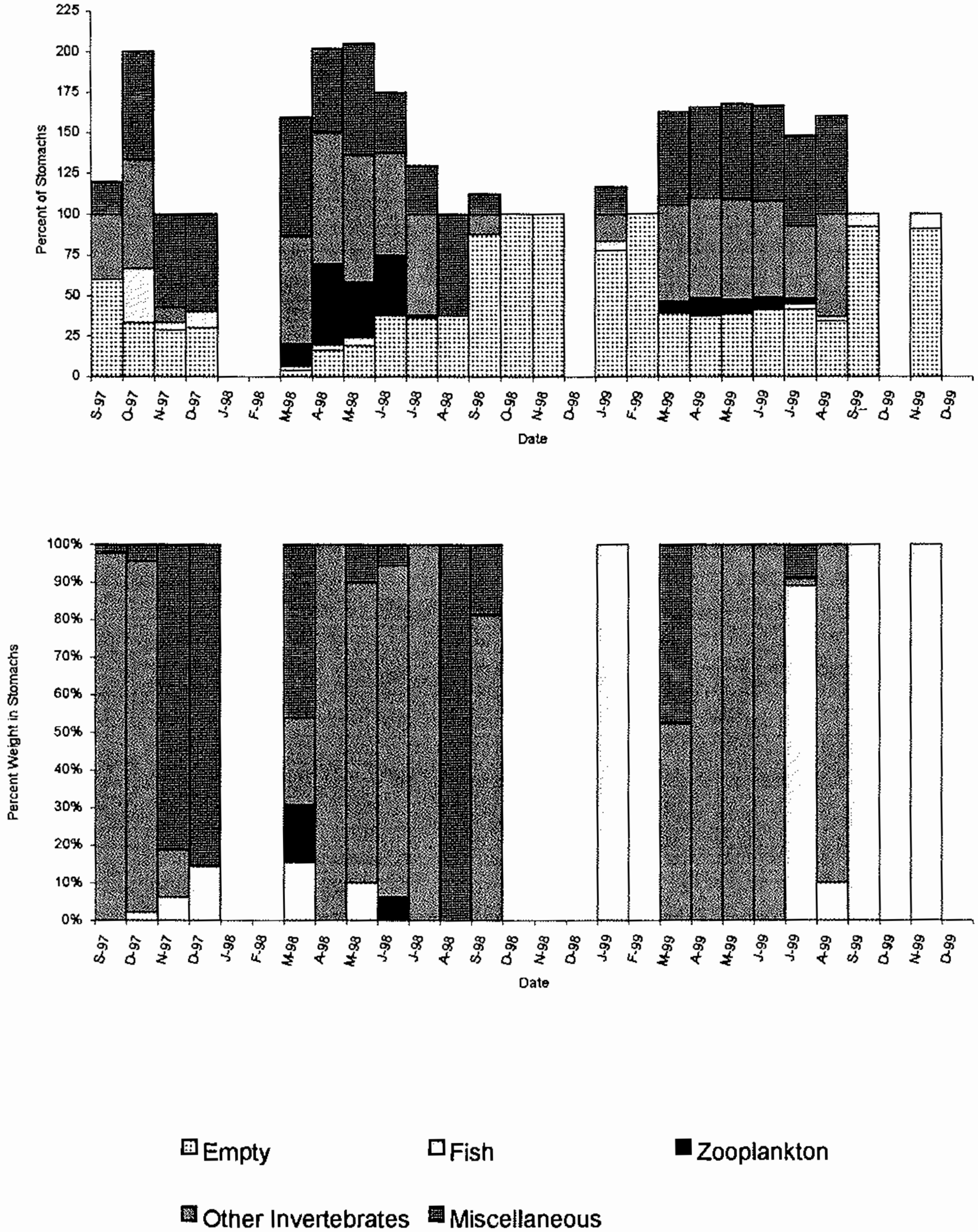


Figure 10.7. Monthly percentage of stomachs containing each food type (top), and percentage total weight of each food type in stomachs (bottom) for channel catfish captured from Newton Lake during September 1997 through December 1999.

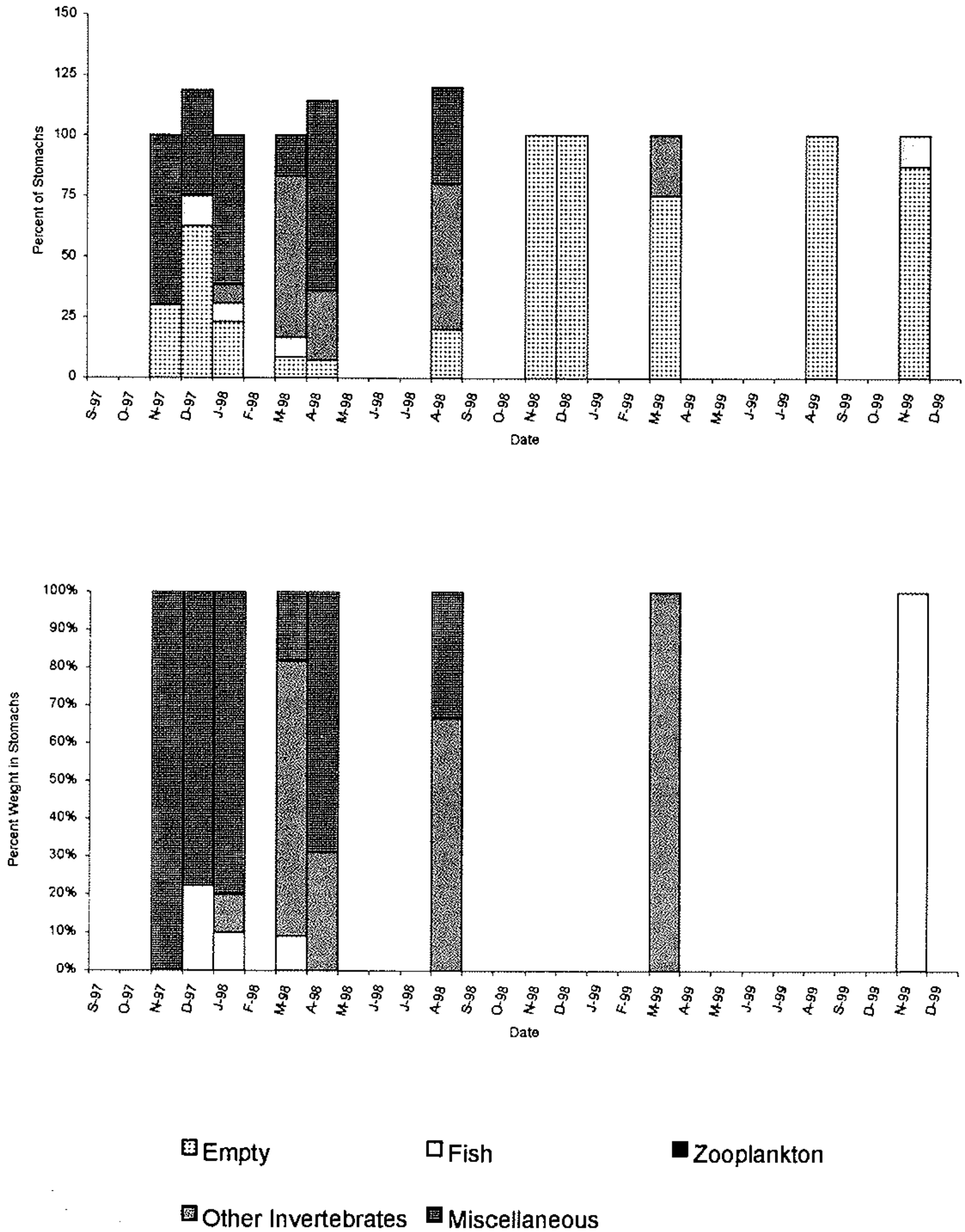
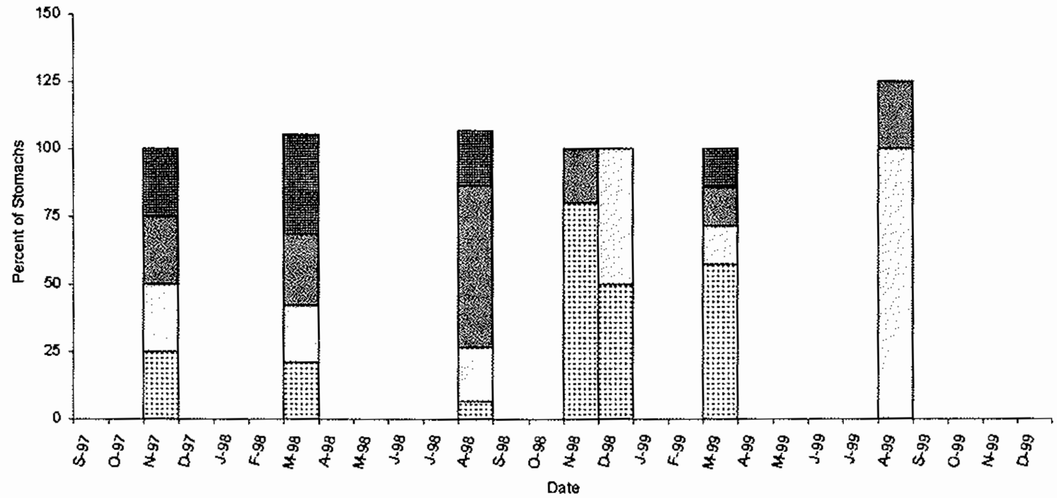


Figure 10.8. Monthly percentage of stomachs containing each food type (top), and percentage total weight of each food type in stomachs (bottom) for channel catfish captured from Coffeen Lake during September 1997 through December 1999.



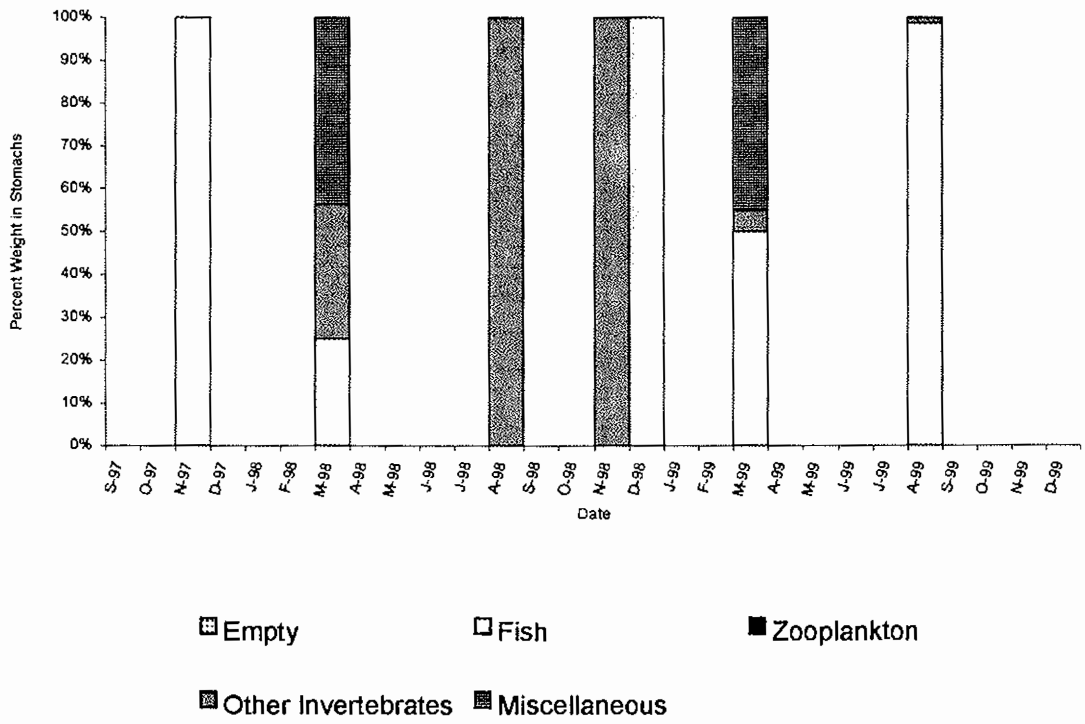
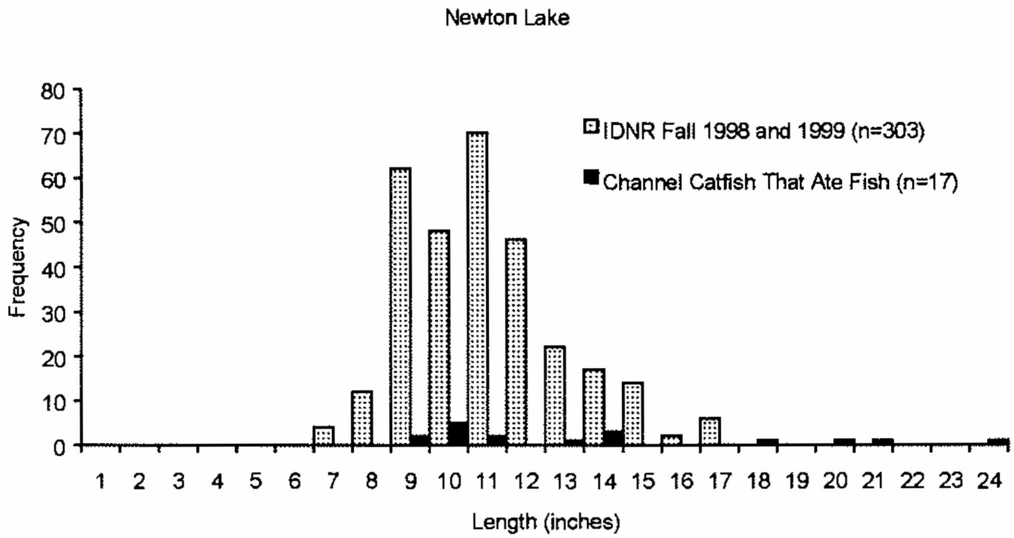


Figure 10.9. Monthly percentage of stomachs containing each food type (top), and percentage total weight of each food type in stomachs (bottom) for channel catfish captured from Lake of Egypt during September 1997 through December 1999.



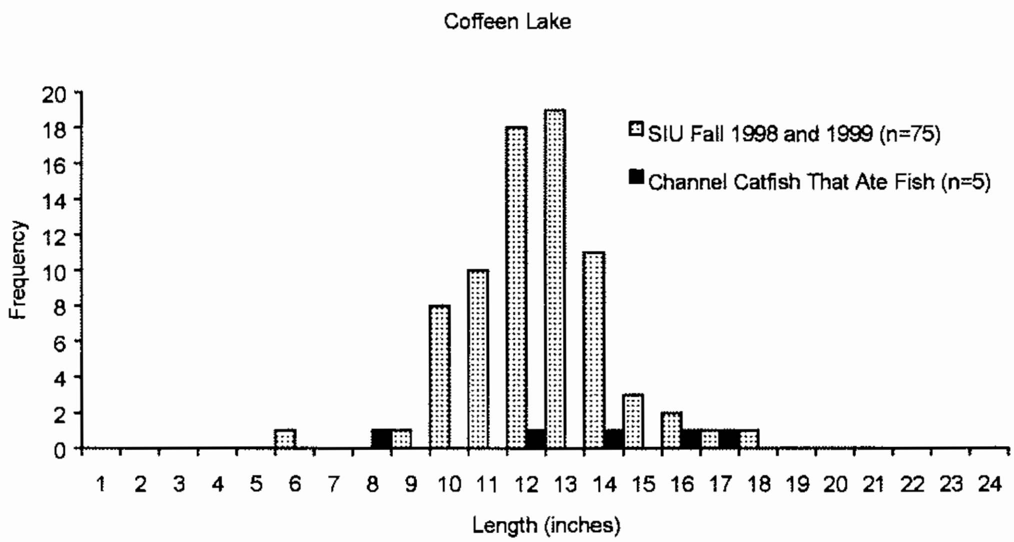


Figure 10.10. Comparison of length frequencies of channel catfish captured during 1997, 1998, and 1999 from Newton Lake and Coffeen Lake that had fish in their diet with samples taken from each lake as a whole during 1998 and 1999. The whole lake samples for Newton Lake were obtained by the Illinois Department of Natural Resources (IDNR), the Coffeen Lake Samples were obtained by SIU.

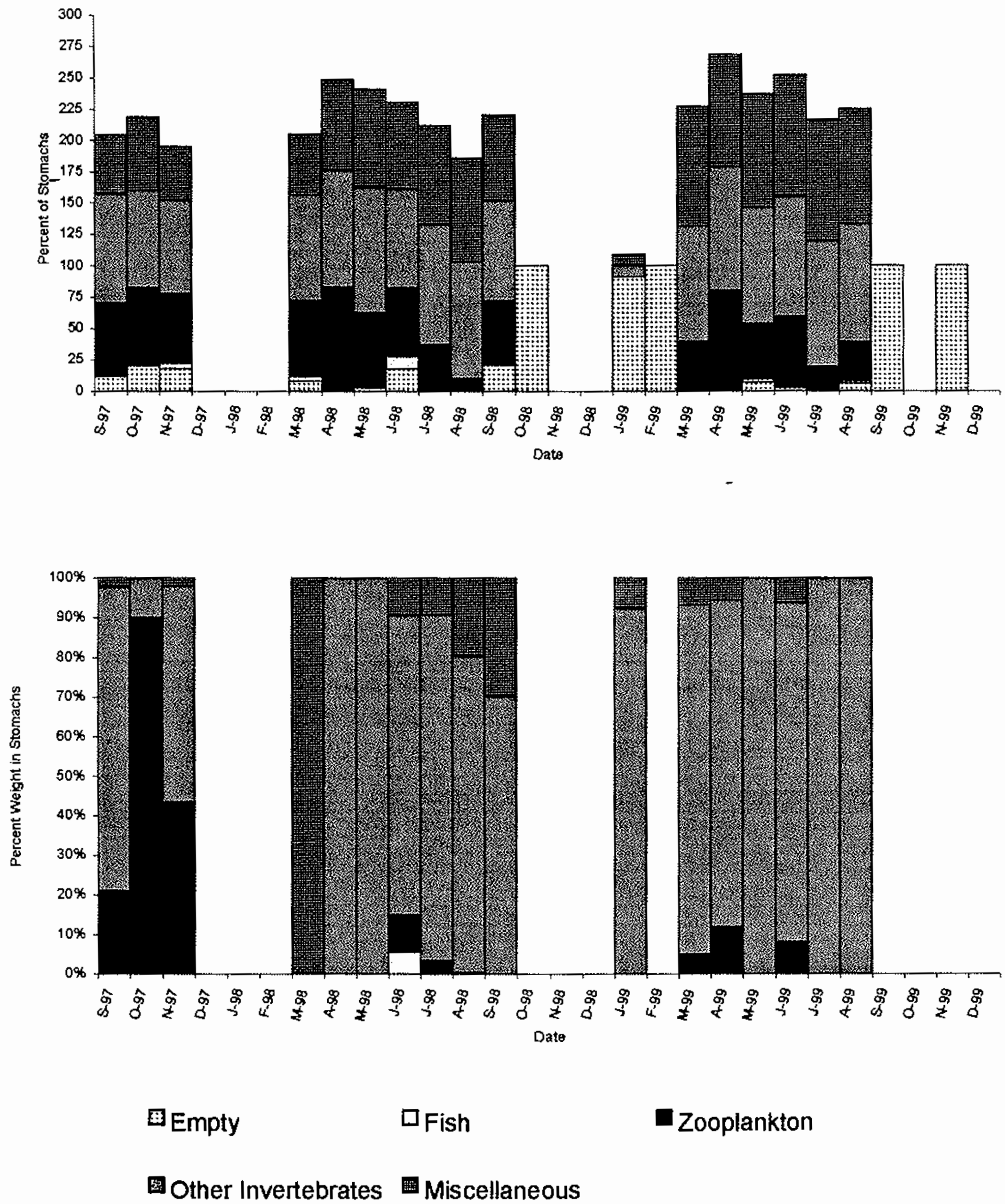


Figure 10.11. Monthly percentage of stomachs containing each food type (top), and percentage total weight of each food type in stomachs (bottom) for bluegill captured from Newton Lake during September 1997 through December 1999.

Chapter 10. Appendix: Supplemental Figures and Data Tables

Legend for Food Habits Charts

Empty	Decapoda	Unid. Invertebrate
Dorosoma	*Lepomis*	Unid. Fish
Other	Pelecypoda	*Micropterus*
Plant Material	Cyprinidae	Gastropoda
Eggs	*Pomoxis*	Ephemeroptera
Diptera	Odonata	Hemiptera
Ostracoda	Miscellaneous	Arachnida
Coleoptera	Bryozoa	Cladocera
Ichtalurus	Trichoptera	Copepoda
Orthoptera	Isopoda	Amphipoda
Hymenoptera	Collembola	Oligochaeta

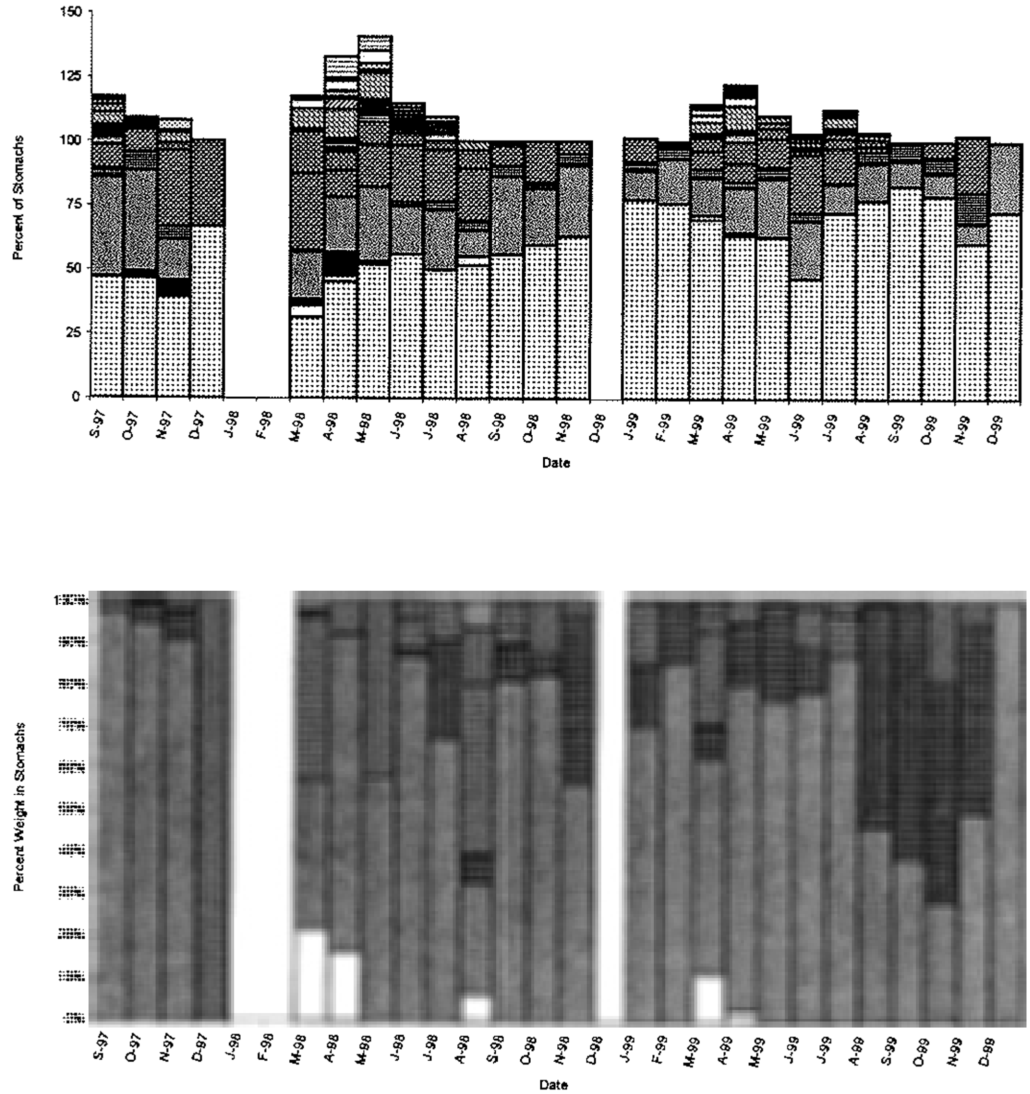


Figure 10.A1. Monthly percentage of stomachs containing each taxon grouping (top), and percentage total weight of each group in stomachs (bottom) for largemouth bass captured from Newton Lake during September 1997 through December 1999.

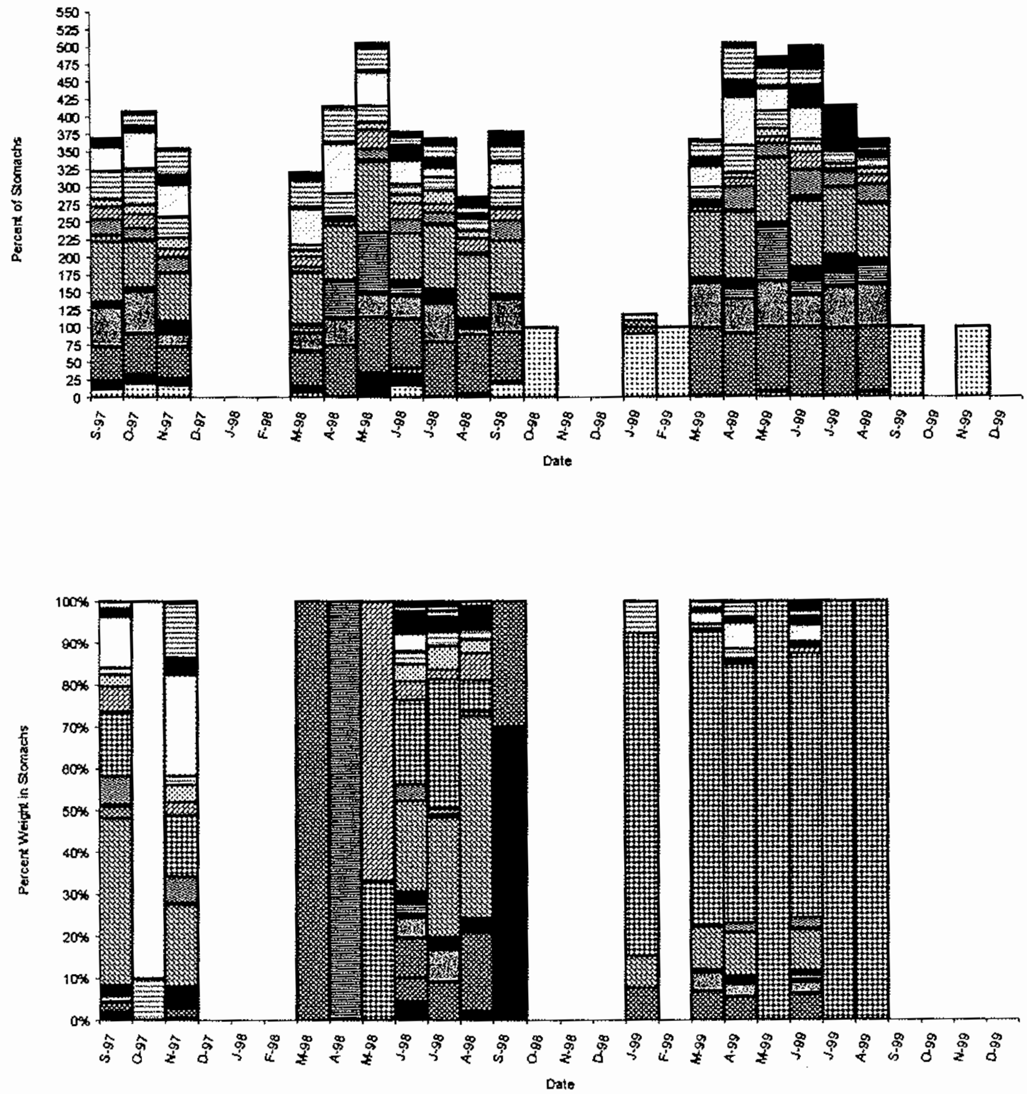
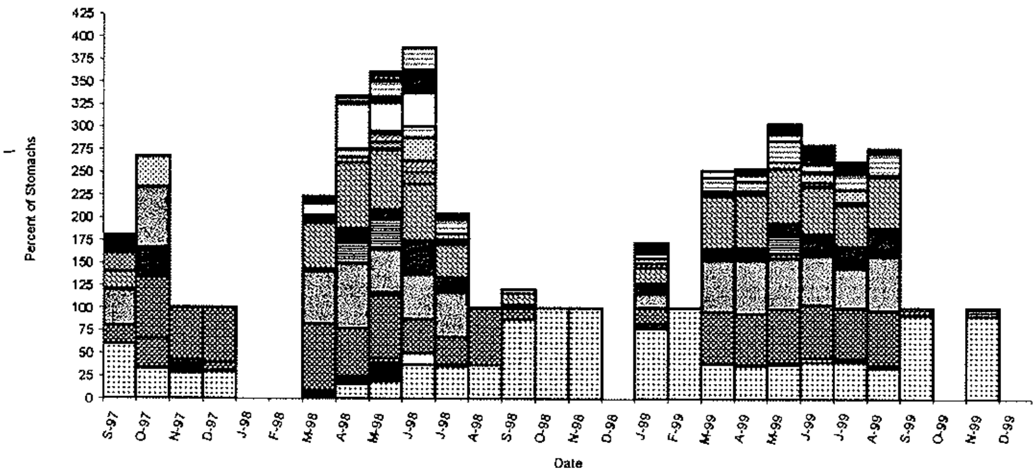


Figure 10.A2. Monthly percentage of stomachs containing each taxon grouping (top), and percentage total weight of each group in stomachs (bottom) for bluegill captured from Newton Lake during September 1997 through December 1999.



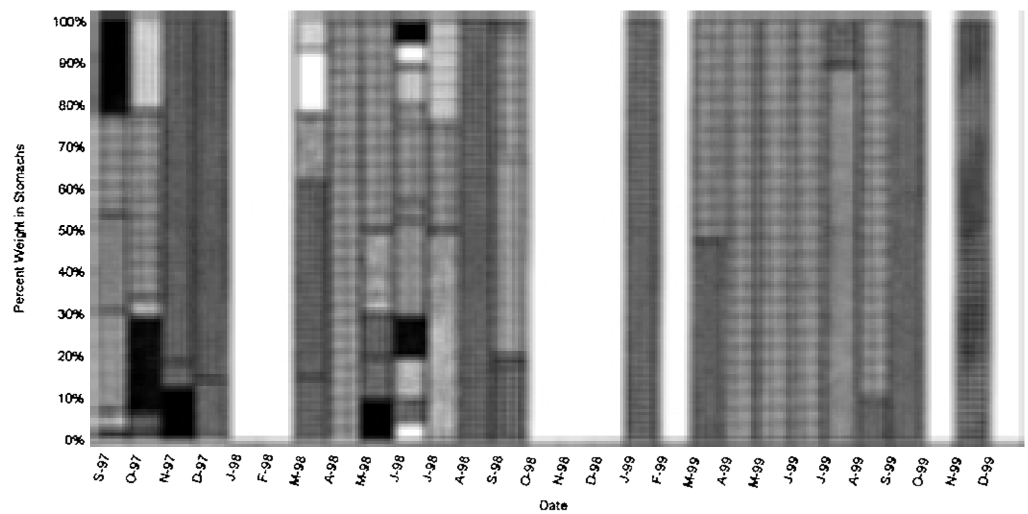
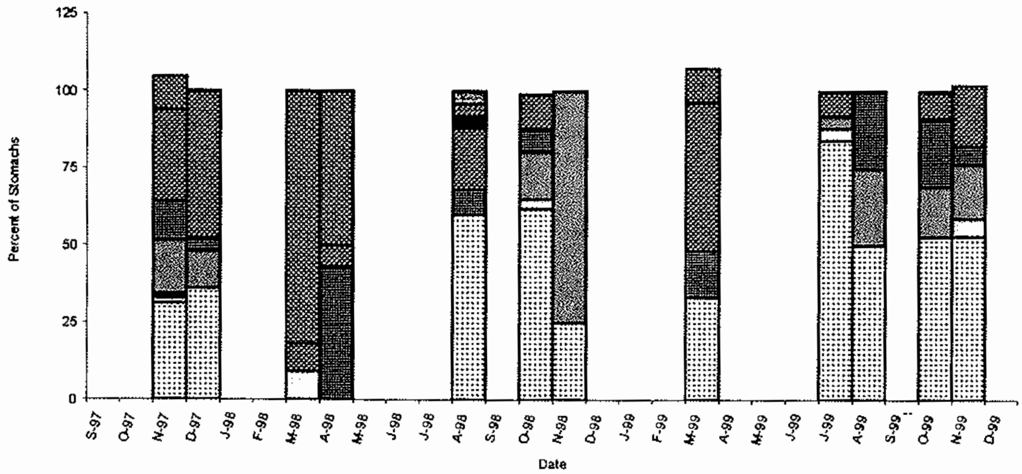


Figure 10.A3. Monthly percentage of stomachs containing each taxon grouping (top), and percentage total weight of each group in stomachs (bottom) for channel catfish captured from Newton Lake during September 1997 through December 1999.



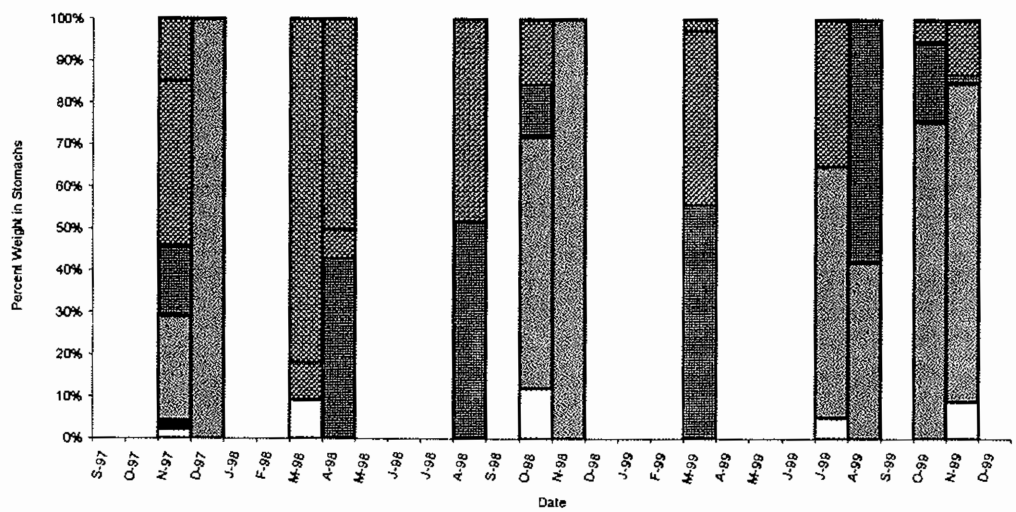


Figure 10.A4. Monthly percentage of stomachs containing each taxon grouping (top), and percentage total weight of each group in stomachs (bottom) for largemouth bass captured from Coffeen Lake during September 1997 through December 1999.

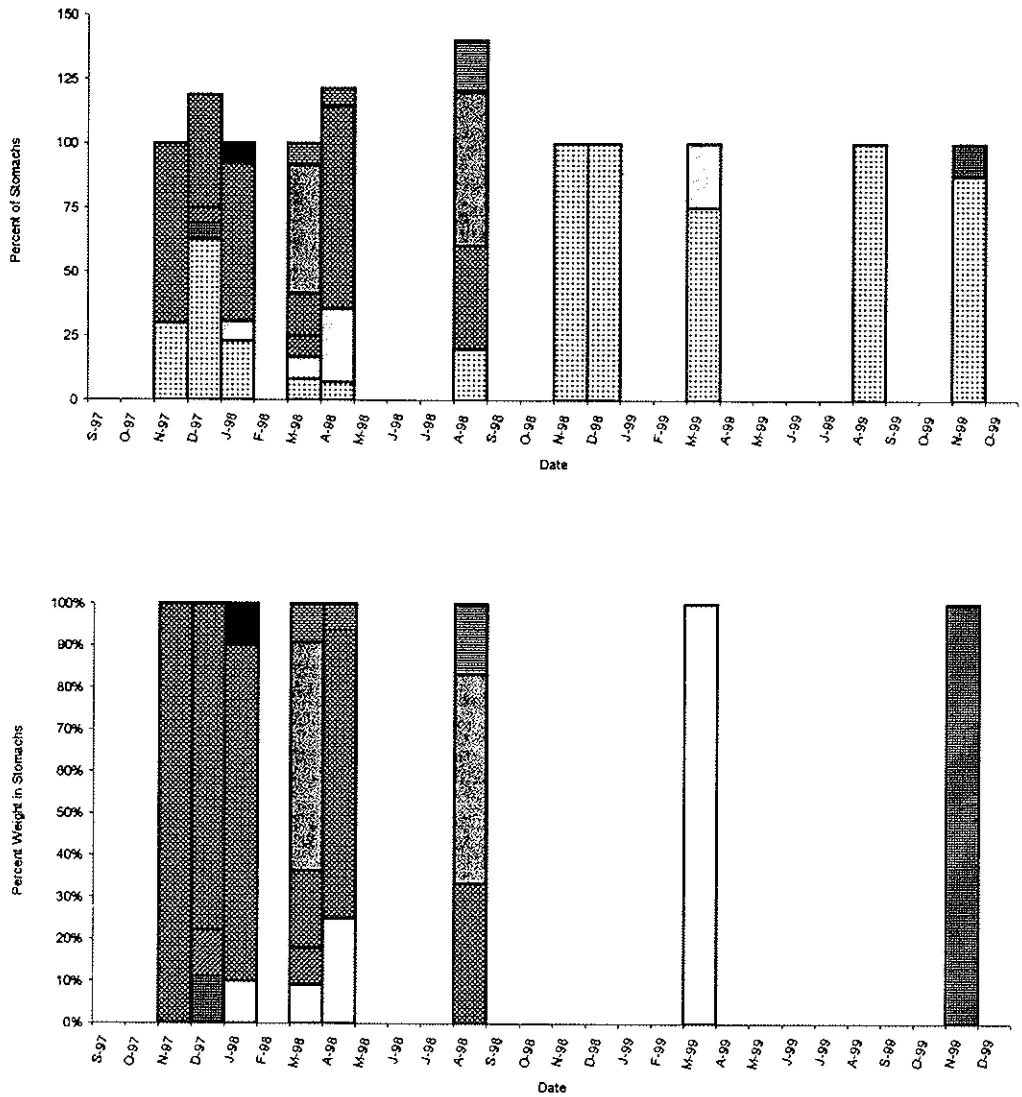


Figure 10.A5. Monthly percentage of stomachs containing each taxon grouping (top), and percentage total weight of each group in stomachs (bottom) for channel catfish captured from Coffeen Lake during September 1997 through December 1999.

Table 10.A1. Overall food habits reported at the lowest identifiable taxon, expressed as number of stomachs an item occurred in (n), percent of stomachs an item occurred in (%n), and the percentage of the total weight of items in the stomachs of fishes sampled from each of the three lakes during 1997, 1998, and 1999.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Coffeen	1997	Largemouth bass	Gizzard shad	18	20.2	100.0
			Unid. Fish	31	34.8	Trace
			Unknown	7	7.9	Trace
			Lepomis spp.	5	5.6	Trace
			Bluegill	4	4.5	Trace
			Crayfish	1	1.1	Trace
			Unid. Invertebrate	1	1.1	Trace
			Empty	29	32.6	Trace
		Channel catfish	Unknown	14	53.8	87.5
			Unid. Fish	1	3.8	6.3
			Lepomis spp.	1	3.8	6.3
			Empty	15	57.7	
	1998	Largemouth bass	Gizzard shad	20	13.2	62.4
			Lepomis spp.	16	10.6	12.7
			Unid. Fish	19	12.6	11.2
			Crayfish	4	2.6	8.6
			Largemouth bass	1	0.7	3.6
			Mussel	1	0.7	1.0
			Topminnow	1	0.7	0.5
			Unknown	16	10.6	Trace
			Plant	1	0.7	Trace
			Spheridae	1	0.7	Trace
			Empty	76	50.3	
		Bluegill	Unknown	1	5.3	100.0
			Empty	18	94.7	
		Channel catfish	Unknown	23	34.3	53.5
			Plant	9	13.4	20.9
			Crayfish	6	9.0	14.0
			Gastropoda	2	3.0	4.7
			Unid. Fish	1	1.5	2.3
			Shiner	1	1.5	2.3
			Eggs	1	1.5	2.3

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Coffeen	1998	Channel catfish	Empty	29	43.3	
	1999	Largemouth bass	Gizzard shad	31	15.7	62.2
			Lepomis spp.	29	14.6	16.0
			Unid. Fish	35	17.7	15.1
			Crayfish	4	2.0	4.3
			Bluegill	1	0.5	1.9
			Unknown	3	1.5	0.4
			Gambusia spp.	2	1.0	Trace
			Empty	107	54.0	
		Bluegill	Empty	1	100.0	
		Channel catfish	Crayfish	2	11.8	53.8
			Bluegill	2	11.8	46.2
			Empty	14	82.4	
Egypt	1997	Largemouth bass	Bluegill	2	2.0	100.0
			Unid. Fish	24	24.2	Trace
			Crayfish	19	19.2	Trace
			Unknown	11	11.1	Trace
			Lepomis spp.	6	6.1	Trace
			Minnow	1	1.0	Trace
			Empty	36	36.4	
		Channel catfish	Bluegill	1	25.0	100.0
			Crayfish	1	25.0	Trace
			Unknown	1	25.0	Trace
			Empty	1	25.0	
	1998	Largemouth bass	White crappie	1	0.7	29.0
			Lepomis spp.	12	8.5	25.5
			Black crappie	1	0.7	23.1
			Unid. Fish	31	21.8	9.2
			Gizzard shad	8	5.6	5.9
			Crayfish	11	7.7	5.0
			Largemouth bass	2	1.4	1.2
			Minnow	1	0.7	0.9
			Brook silverside	1	0.7	0.2
			Unknown	16	11.3	Trace
			Empty	64	45.1	
		Bluegill	Empty	26	100.0	
		Channel catfish	Plant	8	19.5	88.4
			Unid. Fish	3	7.3	7.2

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Egypt	1998	Channel catfish	Crayfish	8	19.5	4.3
			Unknown	10	24.4	Trace
			Gizzard shad	2	4.9	Trace
			Lepomis spp.	2	4.9	Trace
			Pomoxis spp.	1	2.4	Trace
			Empty	10	24.4	
	1999	Largemouth bass	*Lepomis* spp.	8	14.8	73.7
			Crayfish	9	16.7	14.7
			Snake	2	3.7	7.0
			Unid. Fish	5	9.3	2.7
			Annelida	1	1.9	1.3
			Unknown	2	3.7	0.3
			Gizzard shad	1	1.9	0.2
			Plant	1	1.9	0.2
			Empty	29	53.7	
		Bluegill	Empty	1	100.0	
		Channel catfish	Bluegill	7	63.6	40.9
			Gizzard shad	2	18.2	23.5
			Unid. Fish	1	9.1	17.4
			Unknown	1	9.1	15.7
			Crayfish	1	9.1	1.7
			Leech	1	9.1	0.9
			Empty	4	36.4	
Newton	1997	Largemouth bass	Gizzard shad	118	44.4	95.0
			Lepomis spp.	15	5.6	3.2
			Unid. Fish	52	19.5	1.8
			Dipteran	6	2.3	Trace
			Chironomida	5	1.9	Trace
			Coleoptera	5	1.9	Trace
			Unid. Invertebrate	8	3.0	Trace
			Ephemeroptera	3	1.1	Trace
			Other			Trace
			Anisopteran	2	0.8	Trace
			Hemiptera	2	0.8	Trace
			Ostracoda	1	0.4	Trace
			Arachnida	1	0.4	Trace
			Unknown	3	1.1	Trace
			Plant	2	0.8	Trace

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Newton	1997	Largemouth bass	Bryozoa	1	0.4	Trace
			Empty	120	45.1	
		Bluegill	*Daphnia lumholtzi*	64	20.9	90.0
			Bryozoa	113	36.9	10.0
			Chironomida	221	72.2	Trace
			Other			Trace
			Ostracoda	63	20.6	Trace
			Calanoida	54	17.6	Trace
			Dipteran	53	17.3	Trace
			Chydoridae	43	14.1	Trace
			Coleoptera	43	14.1	Trace
			Trichoptera	34	11.1	Trace
			Sididae	34	11.1	Trace
			Cyclopoida	31	10.1	Trace
			Ephemeroptera	32	10.5	Trace
			Bosmina spp.	29	9.5	Trace
			Hydracarina	26	8.5	Trace
			Unknown	151	49.3	Trace
			Arachnida	21	6.9	Trace
			Diaphanosoma spp.	18	5.9	Trace
			Unid. Invertebrate	29	9.5	Trace
			Daphnia spp.	13	4.2	Trace
			Plant	114	37.3	Trace
			Argulus spp.	9	2.9	Trace
			Bosminidae	9	2.9	Trace
			Eggs	6	2.0	Trace
			Anisopteran	5	1.6	Trace
			Heleidae	5	1.6	Trace
			Zygoptera	3	1.0	Trace
			Hemiptera	3	1.0	Trace
			Hymenoptera	2	0.7	Trace
			Leptidora	2	0.7	Trace
			Orthoptera	1	0.3	Trace
			Collembola	1	0.3	Trace
			Cladocera	1	0.3	Trace
			Argulus spp.	1	0.3	Trace
			Unid. Fish	7	2.3	Trace
			Empty	52	17.0	

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Newton	1997	Channel catfish	Other			27.0
			Unknown	22	56.4	19.8
			Chironomida	1	2.6	9.0
			Zygoptera	1	2.6	9.0
			Coleoptera	1	2.6	9.0
			Trichoptera	1	2.6	9.0
			Pelecypoda	1	2.6	9.0
			Plant	4	10.3	3.6
			Unid. Fish	3	7.7	2.7
			Unid. Invertebrate	2	5.1	1.8
			Empty	13	33.3	
	1998	Largemouth bass	Gizzard shad	193	28.2	63.8
			Unid. Fish	179	26.2	16.5
			Lepomis spp.	16	2.3	9.4
			Crayfish	9	1.3	5.6
			Hybrid sunfish	1	0.1	2.3
			Largemouth bass	3	0.4	1.2
			Bluegill	1	0.1	0.4
			Channel catfish	2	0.3	0.4
			Gambusia spp.	1	0.1	0.4
			Unknown	36	5.3	Trace
			Homoptera	1	0.1	Trace
			Other			Trace
			Dipteran	19	2.8	Trace
			Ephemeroptera	11	1.6	Trace
			Chironomida	15	2.2	Trace
			Argulus spp.	4	0.6	Trace
			Plant	4	0.6	Trace
			Coleoptera	2	0.3	Trace
			Diaphanosoma spp.	7	1.0	Trace
			Eggs	5	0.7	Trace
			Hemiptera	5	0.7	Trace
			Unid. Invertebrate	13	1.9	Trace
			Calanoida	4	0.6	Trace
			Daphnia spp.	3	0.4	Trace
			Bryozoa	3	0.4	Trace
			Orthoptera	1	0.1	Trace
			Arachnida	1	0.1	Trace

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Newton	1998	Largemouth bass	Cyclopoida	5	0.7	Trace
			Bosminidae	2	0.3	Trace
			Daphnia lumholtzi	1	0.1	Trace
			Ostracoda	1	0.1	Trace
			Trichoptera	1	0.1	Trace
			Chaoborus spp.	1	0.1	Trace
			Nematomorpha	1	0.1	Trace
			Empty	353	51.6	
		Bluegill	Unid. Invertebrate	50	10.2	66.0
			Unknown	341	69.5	30.2
			Hydracarina	38	7.7	1.9
			Other			0.9
			Eggs	132	26.9	0.9
			Chironomida	364	74.1	Trace
			Dipteran	141	28.7	Trace
			Plant	175	35.6	Trace
			Coleoptera	44	9.0	Trace
			Bryozoa	100	20.4	Trace
			Trichoptera	39	7.9	Trace
			Arachnida	23	4.7	Trace
			Ephemeroptera	32	6.5	Trace
			Ceratopogonidae	31	6.3	Trace
			Cyclopoida	102	20.8	Trace
			Unid. Fish	17	3.5	Trace
			Chaoborus spp.	31	6.3	Trace
			Diaphanosoma spp.	58	11.8	Trace
			Daphnia spp.	42	8.6	Trace
			Hymenoptera	14	2.9	Trace
			Argulus spp.	15	3.1	Trace
			Podocopa	24	4.9	Trace
			Ostracoda	39	7.9	Trace
			Sididae	57	11.6	Trace
			Daphnia lumholtzi	29	5.9	Trace
			Gastropoda	14	2.9	Trace
			Calanoida	42	8.6	Trace
			Chydoridae	45	9.2	Trace
			Acarina	17	3.5	Trace
			Bosminidae	34	6.9	Trace

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Newton	1998	Bluegill	Tipulidae	4	0.8	Trace
			Lepidoptera	4	0.8	Trace
			Zygoptera	3	0.6	Trace
			Orthoptera	2	0.4	Trace
			Odonata	2	0.4	Trace
			Argulus spp.	5	1.0	Trace
			Nematoda	4	0.8	Trace
			Oligochaeta	4	0.8	Trace
			Collembola	3	0.6	Trace
			Heleidae	2	0.4	Trace
			Hemiptera	2	0.4	Trace
			Basommatophora	2	0.4	Trace
			Choncostraca	2	0.4	Trace
			Leptidora	1	0.2	Trace
			Stratiomyidae	1	0.2	Trace
			Culicidae	1	0.2	Trace
			Trichoptera cases	1	0.2	Trace
			Bosmina spp.	3	0.6	Trace
			Nematomorpha	3	0.6	Trace
			Copepoda	2	0.4	Trace
			Decapoda	2	0.4	Trace
			Amphipoda	2	0.4	Trace
			Shiner	1	0.2	Trace
			Pelecypoda	1	0.2	Trace
			Araneae	1	0.2	Trace
			Isopoda	1	0.2	Trace
			Hirudinea	1	0.2	Trace
			Cladocera	1	0.2	Trace
			Empty	37	7.5	
		Channel catfish	Other			55.3
			Unknown	158	49.2	14.9
			Plant	145	45.2	12.8
			Unid. Fish	6	1.9	6.4
			Chydoridae	17	5.3	4.3
			Unid. Invertebrate	18	5.6	2.1
			Bryozoa	18	5.6	2.1
			Collembola	2	0.6	2.1
			Chironomida	141	43.9	Trace

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Newton	1998	Channel ctafish	Dipteran	51	15.9	Trace
			Ephemeroptera	27	8.4	Trace
			Eggs	31	9.7	Trace
			Ceratopogonidae	14	4.4	Trace
			Trichoptera	9	2.8	Trace
			Chaoborus spp.	10	3.1	Trace
			Coleoptera	11	3.4	Trace
			Sididae	26	8.1	Trace
			Arachnida	4	1.2	Trace
			Lepidoptera	3	0.9	Trace
			Anisopteran	2	0.6	Trace
			Homoptera	2	0.6	Trace
			Diaphanosoma spp.	16	5.0	Trace
			Bosminidae	13	4.0	Trace
			Cyclopoida	13	4.0	Trace
			Ostracoda	4	1.2	Trace
			Oligochaeta	4	1.2	Trace
			Argulus spp.	3	0.9	Trace
			Zygoptera	2	0.6	Trace
			Decapoda	2	0.6	Trace
			Crayfish	1	0.3	Trace
			Pelecypoda	1	0.3	Trace
			Gastropoda	1	0.3	Trace
			Spheridae	1	0.3	Trace
			Nematoda	1	0.3	Trace
			Araneae	1	0.3	Trace
			Tabinidae	1	0.3	Trace
			Hirudinea	1	0.3	Trace
			Hydracarina	2	0.6	Trace
			Calanoida	2	0.6	Trace
			Hemiptera	2	0.6	Trace
			Podocopa	2	0.6	Trace
			Cladocera	2	0.6	Trace
			Lepomis spp.	1	0.3	Trace
			Daphnia spp.	1	0.3	Trace
			Bosmina spp.	1	0.3	Trace
			Veneroida	1	0.3	Trace
			Tipulidae	1	0.3	Trace

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Newton	1998	Channel catfish	Empty	101	31.5	
	1999	Largemouth bass	Gizzard shad	170	18.8	70.5
			Lepomis spp.	51	5.6	17.0
			Unid. Fish	108	11.9	6.9
			Bluegill	4	0.4	3.4
			Crayfish	3	0.3	1.2
			Largemouth bass	8	0.9	0.6
			Unknown	22	2.4	0.3
			Other			Trace
			Dipteran	17	1.9	Trace
			Chironomida	14	1.5	Trace
			Ephemeroptera	2	0.2	Trace
			Anisopteran	1	0.1	Trace
			Sididae	6	0.7	Trace
			Plant	5	0.6	Trace
			Dipteran (Adult)	5	0.6	Trace
			Hymenoptera	4	0.4	Trace
			Cyclopoida	4	0.4	Trace
			Chaoborus spp.	2	0.2	Trace
			Channel catfish	1	0.1	Trace
			Eggs	1	0.1	Trace
			Argulus spp.	1	0.1	Trace
			Zygoptera	1	0.1	Trace
			Podocopa	1	0.1	Trace
			Lumbriculida	1	0.1	Trace
			Isopoda	1	0.1	Trace
			Amphipoda	1	0.1	Trace
			Empty	693	76.6	
		Bluegill	Other			100.0
			Unknown	299	87.9	Trace
			Chironomida	283	83.2	Trace
			Plant	183	53.8	Trace
			Dipteran	157	46.2	Trace
			Sididae	89	26.2	Trace
			Eggs	77	22.6	Trace
			Podocopa	76	22.4	Trace
			Cyclopoida	74	21.8	Trace
			Bryozoa	72	21.2	Trace

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Newton	1999	Bluegill	Trichoptera	53	15.6	Trace
			Dipteran (Adult)	45	13.2	Trace
			Ephemeroptera	38	11.2	Trace
			Hymenoptera	37	10.9	Trace
			Chydoridae	37	10.9	Trace
			Hydracarina	30	8.8	Trace
			Coleoptera	26	7.6	Trace
			Chaoborus spp.	14	4.1	Trace
			Ceratopogonidae	12	3.5	Trace
			Daphnia lumholtzi	9	2.6	Trace
			Bosminidae	9	2.6	Trace
			Arachnida	6	1.8	Trace
			Basommatophora	6	1.8	Trace
			Argulus spp.	5	1.5	Trace
			Daphnia spp.	5	1.5	Trace
			Coleopteran (Adult)	5	1.5	Trace
			Zygoptera	4	1.2	Trace
			Calanoida	4	1.2	Trace
			Hemiptera	4	1.2	Trace
			Lepidoptera	3	0.9	Trace
			Unid. Fish	2	0.6	Trace
			Gastropoda	2	0.6	Trace
			Tubificidae	2	0.6	Trace
			Nematoda	2	0.6	Trace
			Amphipoda	2	0.6	Trace
			Decapoda	1	0.3	Trace
			Lumbriculida	1	0.3	Trace
			Homoptera	1	0.3	Trace
			Megaloptera	1	0.3	Trace
			Empty	39	11.5	
		Channel catfish	Gizzard shad	1	0.3	43.2
			Other			40.8
			Unknown	188	48.5	9.2
			Unid. Fish	6	1.5	3.4
			Lepomis spp.	1	0.3	3.4
			Plant	186	47.9	Trace
			Chironomida	167	43.0	Trace
			Dipteran	96	24.7	Trace

Table 10A.1. Continued.

Lake	Year	Fish Species	Item Name[1]	n	% n	% weight[2]
Newton	1999	Channel catfish	Bryozoa	49	12.6	Trace
			Ephemeroptera	51	13.1	Trace
			Eggs	25	6.4	Trace
			Trichoptera	19	4.9	Trace
			Coleoptera	18	4.6	Trace
			Dipteran (Adult)	13	3.4	Trace
			Sididae	11	2.8	Trace
			Ceratopogonidae	11	2.8	Trace
			Hymenoptera	8	2.1	Trace
			Chydoridae	8	2.1	Trace
			Chaoborus spp.	7	1.8	Trace
			Coleopteran (Adult)	6	1.5	Trace
			Arachnida	5	1.3	Trace
			Veneroida	5	1.3	Trace
			Decapoda	3	0.8	Trace
			Gastropoda	3	0.8	Trace
			Argulus spp.	2	0.5	Trace
			Zygoptera	2	0.5	Trace
			Lepidoptera	2	0.5	Trace
			Actheres	2	0.5	Trace
			Hydracarina	1	0.3	Trace
			Bosminidae	1	0.3	Trace
			Orthoptera	1	0.3	Trace
			Hemiptera	1	0.3	Trace
			Tubificidae	1	0.3	Trace
			Podocopa	1	0.3	Trace
			Tabinidae	1	0.3	Trace
			Basommatophora	1	0.3	Trace
			Amphipoda	1	0.3	Trace
			Empty	198	51.0	

1/ "Other" Item includes *en masse* weight of "Trace" weight items.
2/ "Trace" percent weights are items that were to light to weigh individually.

Table 10.A2. Overall food habits by group, expressed as number of stomachs an item occurred in (n), percent of stomachs an item occurred in (%n), and the percentage of the total weight of items in the stomachs of fishes sampled from each of the three lakes during 1997, 1998, and 1999.

Lake	Year	Fish Species	Group Name[1]	n	%n	% weight[2]
Coffeen	1997	Largemouth bass	*Dorosoma* spp.	14	15.7	100.0
			Unid. Fish	31	34.8	Trace
			Lepomis spp.	9	10.1	Trace
			Miscellaneous	7	7.9	Trace
			Decapoda	1	1.1	Trace
			Unid. Invertebrate	1	1.1	Trace
			Empty	29	32.6	
		Channel catfish	Miscellaneous	14	53.8	87.5
			Lepomis spp.	1	3.8	6.3
			Unid. Fish	1	3.8	6.3
			Empty	13	50.0	
	1998	Largemouth bass	*Dorosoma* spp.	18	11.9	62.4
			Lepomis spp.	15	9.9	12.7
			Unid. Fish	19	12.6	11.7
			Decapoda	4	2.6	8.6
			Micropterus spp.	1	0.7	3.6
			Pelecypoda	2	1.3	1.0
			Miscellaneous	16	10.6	Trace
			Plant Material	1	0.7	Trace
			Empty	76	50.3	
		Bluegill	Miscellaneous	1	5.3	100.0
			Empty	18	94.7	
		Channel catfish	Miscellaneous	23	34.3	53.5
			Plant Material	9	13.4	20.9
			Decapoda	6	9.0	14.0
			Gastropoda	2	3.0	4.7
			Unid. Fish	1	1.5	2.3
			Cyprinidae	1	1.5	2.3
			Eggs	1	1.5	2.3
			Empty	29	43.3	
	1999	Largemouth bass	*Dorosoma* spp.	26	13.1	62.2
			Lepomis spp.	28	14.1	17.9

Table 10A.2. Continued.

Lake	Year	Fish Species	Group Name[1]	n	%n	% weight[2]
Coffeen	1999	Largemouth bass	Unid. Fish	34	17.2	15.1
			Decapoda	4	2.0	4.3
			Miscellaneous	3	1.5	0.4
			Empty	107	54.0	
		Bluegill	Empty	1	100.0	
		Channel catfish	Decapoda	2	11.8	53.8
			Lepomis spp.	1	5.9	46.2
			Empty	14	82.4	
Egypt	1997	Largemouth bass	*Lepomis* spp.	8	8.1	100.0
			Unid. Fish	24	24.2	Trace
			Decapoda	19	19.2	Trace
			Miscellaneous	11	11.1	Trace
			Cyprinidae	1	1.0	Trace
			Empty	36	36.4	
		Channel catfish	*Lepomis* spp.	1	25.0	100.0
			Decapoda	1	25.0	Trace
			Miscellaneous	1	25.0	Trace
			Empty	1	25.0	
	1998	Largemouth bass	*Pomoxis* spp.	2	1.4	52.1
			Lepomis spp.	11	7.7	25.5
			Unid. Fish	32	22.5	9.4
			Dorosoma spp.	7	4.9	5.9
			Decapoda	10	7.0	5.0
			Micropterus spp.	2	1.4	1.2
			Cyprinidae	1	0.7	0.9
			Miscellaneous	16	11.3	Trace
			Empty	64	45.1	
		Bluegill	Empty	26	100.0	
		Channel catfish	Plant Material	8	19.5	88.4
			Unid. Fish	3	7.3	7.2
			Decapoda	8	19.5	4.3
			Miscellaneous	10	24.4	Trace
			Dorosoma spp.	2	4.9	Trace
			Lepomis spp.	2	4.9	Trace
			Pomoxis spp.	1	2.4	Trace
			Empty	10	24.4	
	1999	Largemouth bass	*Lepomis* spp.	8	14.8	73.7
			Decapoda	8	14.8	14.7

Table 10A.2. Continued.

Lake	Year	Fish Species	Group Name[1]	n	%n	% weight[2]
Egypt	1999	Largemouth bass	Miscellaneous	3	5.6	7.3
			Unid. Fish	5	9.3	2.7
			Unid. Invertebrate	1	1.9	1.3
			Dorosoma spp.	1	1.9	0.2
			Plant Material	1	1.9	0.2
			Empty	29	53.7	
		Bluegill	Empty	1	100.0	
		Channel catfish	*Lepomis* spp.	4	36.4	40.9
			Dorosoma spp.	2	18.2	23.5
			Unid. Fish	1	9.1	17.4
			Miscellaneous	1	9.1	15.7
			Decapoda	1	9.1	1.7
			Hirudinea	1	9.1	0.9
			Empty	4	36.4	
Newton	1997	Largemouth bass	*Dorosoma* spp.	76	28.6	95.0
			Lepomis spp.	13	4.9	3.2
			Unid. Fish	48	18.0	1.8
			Diptera	8	3.0	Trace
			Coleoptera	5	1.9	Trace
			Unid. Invertebrate	8	3.0	Trace
			Ephemeroptera	3	1.1	Trace
			Other			Trace
			Odonata	2	0.8	Trace
			Hemiptera	2	0.8	Trace
			Arachnida	1	0.4	Trace
			Ostracoda	1	0.4	Trace
			Miscellaneous	3	1.1	Trace
			Plant Material	2	0.8	Trace
			Bryozoa	1	0.4	Trace
			Empty	120	45.1	
		Bluegill	Cladocera	138	45.1	90.0
			Bryozoa	113	36.9	10.0
			Diptera	219	71.6	Trace
			Other			Trace
			Copepoda	77	25.2	Trace
			Ostracoda	63	20.6	Trace
			Arachnida	45	14.7	Trace
			Coleoptera	43	14.1	Trace

Table 10A.2. Continued.

Lake	Year	Fish Species	Group Name[1]	n	%n	% weight[2]
Newton	1997	Bluegill	Trichoptera	33	10.8	Trace
			Ephemeroptera	32	10.5	Trace
			Miscellaneous	146	47.7	Trace
			Unid. Invertebrate	29	9.5	Trace
			Plant Material	114	37.3	Trace
			Odonata	8	2.6	Trace
			Eggs	6	2.0	Trace
			Hemiptera	3	1.0	Trace
			Hymenoptera	2	0.7	Trace
			Orthoptera	1	0.3	Trace
			Collembola	1	0.3	Trace
			Unid. Fish	7	2.3	Trace
			Empty	52	17.0	
		Channel catfish	Other			27.0
			Miscellaneous	21	53.8	19.8
			Diptera	1	2.6	9.0
			Odonata	1	2.6	9.0
			Coleoptera	1	2.6	9.0
			Trichoptera	1	2.6	9.0
			Pelecypoda	1	2.6	9.0
			Plant Material	4	10.3	3.6
			Unid. Fish	3	7.7	2.7
			Unid. Invertebrate	2	5.1	1.8
			Empty	13	33.3	
	1998	Largemouth bass	*Dorosoma* spp.	160	23.4	63.8
			Unid. Fish	110	16.1	16.8
			Lepomis spp.	14	2.0	12.1
			Decapoda	7	1.0	5.6
			Micropterus spp.	3	0.4	1.2
			Ichtalurus spp.	2	0.3	0.4
			Miscellaneous	35	5.1	Trace
			Homoptera	1	0.1	Trace
			Other			Trace
			Diptera	27	3.9	Trace
			Ephemeroptera	11	1.6	Trace
			Copepoda	12	1.8	Trace
			Cladocera	12	1.8	Trace
			Plant Material	4	0.6	Trace

Table 10A.2. Continued.

Lake	Year	Fish Species	Group Name[1]	n	%n	% weight[2]
Newton	1998	Largemouth bass	Coleoptera	2	0.3	Trace
			Eggs	5	0.7	Trace
			Hemiptera	5	0.7	Trace
			Unid. Invertebrate	12	1.8	Trace
			Bryozoa	3	0.4	Trace
			Arachnida	1	0.1	Trace
			Orthoptera	1	0.1	Trace
			Trichoptera	1	0.1	Trace
			Ostracoda	1	0.1	Trace
			Nematomorpha	1	0.1	Trace
			Empty	353	51.6	
		Bluegill	Unid. Invertebrate	48	9.8	66.0
			Miscellaneous	340	69.2	30.2
			Arachnida	78	15.9	1.9
			Other			0.9
			Eggs	132	26.9	0.9
			Diptera	390	79.4	Trace
			Plant Material	175	35.6	Trace
			Cladocera	199	40.5	Trace
			Coleoptera	44	9.0	Trace
			Copepoda	140	28.5	Trace
			Bryozoa	100	20.4	Trace
			Trichoptera	39	7.9	Trace
			Ostracoda	63	12.8	Trace
			Ephemeroptera	32	6.5	Trace
			Unid. Fish	12	2.4	Trace
			Hymenoptera	14	2.9	Trace
			Gastropoda	16	3.3	Trace
			Odonata	5	1.0	Trace
			Lepidoptera	4	0.8	Trace
			Orthoptera	2	0.4	Trace
			Oligochaeta	4	0.8	Trace
			Nematoda	4	0.8	Trace
			Collembola	3	0.6	Trace
			Hemiptera	2	0.4	Trace
			Choncostraca	2	0.4	Trace
			Nematomorpha	3	0.6	Trace
			Amphipoda	2	0.4	Trace

Table 10A.2. Continued.

Lake	Year	Fish Species	Group Name[1]	n	%n	% weight[2]
Newton	1998	Bluegill	Decapoda	2	0.4	Trace
			Pelecypoda	1	0.2	Trace
			Isopoda	1	0.2	Trace
			Hirudinea	1	0.2	Trace
			Cyprinidae	1	0.2	Trace
			Empty	37	7.5	
		Channel catfish	Other			55.3
			Miscellaneous	158	49.2	14.9
			Plant Material	145	45.2	12.8
			Unid. Fish	6	1.9	6.4
			Cladocera	59	18.4	4.3
			Unid. Invertebrate	16	5.0	2.1
			Bryozoa	18	5.6	2.1
			Collembola	2	0.6	2.1
			Diptera	145	45.2	Trace
			Ephemeroptera	27	8.4	Trace
			Eggs	31	9.7	Trace
			Trichoptera	9	2.8	Trace
			Coleoptera	11	3.4	Trace
			Arachnida	6	1.9	Trace
			Odonata	4	1.2	Trace
			Copepoda	18	5.6	Trace
			Pelecypoda	3	0.9	Trace
			Decapoda	3	0.9	Trace
			Lepidoptera	3	0.9	Trace
			Homoptera	2	0.6	Trace
			Ostracoda	6	1.9	Trace
			Oligochaeta	4	1.2	Trace
			Gastropoda	1	0.3	Trace
			Hirudinea	1	0.3	Trace
			Nematoda	1	0.3	Trace
			Hemiptera	2	0.6	Trace
			Lepomis spp.	1	0.3	Trace
			Empty	101	31.5	
	1999	Largemouth bass	*Dorosoma* spp.	133	14.7	70.5
			Lepomis spp.	42	4.6	20.4
			Unid. Fish	85	9.4	6.9
			Decapoda	3	0.3	1.2

Table 10A.2. Continued.

Lake	Year	Fish Species	Group Name[1]	n	%n	% weight[2]
Newton	1999	Largemouth bass	*Micropterus* spp.	6	0.7	0.6
			Miscellaneous	22	2.4	0.3
			Other			Trace
			Diptera	24	2.7	Trace
			Ephemeroptera	2	0.2	Trace
			Odonata	2	0.2	Trace
			Cladocera	6	0.7	Trace
			Copepoda	5	0.6	Trace
			Plant Material	5	0.6	Trace
			Hymenoptera	4	0.4	Trace
			Isopoda	1	0.1	Trace
			Ostracoda	1	0.1	Trace
			Amphipoda	1	0.1	Trace
			Oligochaeta	1	0.1	Trace
			Ichtalurus spp.	1	0.1	Trace
			Eggs	1	0.1	Trace
			Empty	628	69.4	
		Bluegill	Other			100.0
			Diptera	293	86.2	Trace
			Miscellaneous	299	87.9	Trace
			Plant Material	183	53.8	Trace
			Cladocera	110	32.4	Trace
			Copepoda	78	22.9	Trace
			Eggs	77	22.6	Trace
			Ostracoda	76	22.4	Trace
			Bryozoa	72	21.2	Trace
			Trichoptera	53	15.6	Trace
			Ephemeroptera	38	11.2	Trace
			Hymenoptera	37	10.9	Trace
			Arachnida	35	10.3	Trace
			Coleoptera	31	9.1	Trace
			Gastropoda	8	2.4	Trace
			Odonata	4	1.2	Trace
			Hemiptera	4	1.2	Trace
			Oligochaeta	3	0.9	Trace
			Lepidoptera	3	0.9	Trace
			Amphipoda	2	0.6	Trace
			Nematoda	2	0.6	Trace

Table 10A.2. Continued.

Lake	Year	Fish Species	Group Name[1]	n	%n	% weight[2]
Newton	1999	Bluegill	Unid. Fish	2	0.6	Trace
			Decapoda	1	0.3	Trace
			Homoptera	1	0.3	Trace
			Megaloptera	1	0.3	Trace
			Empty	29	8.5	
		Channel catfish	*Dorosoma* spp.	1	0.3	43.2
			Other			40.8
			Miscellaneous	188	48.5	9.2
			Unid. Fish	5	1.3	3.4
			Lepomis spp.	1	0.3	3.4
			Diptera	181	46.6	Trace
			Plant Material	186	47.9	Trace
			Bryozoa	49	12.6	Trace
			Ephemeroptera	51	13.1	Trace
			Eggs	25	6.4	Trace
			Coleoptera	23	5.9	Trace
			Cladocera	19	4.9	Trace
			Trichoptera	19	4.9	Trace
			Hymenoptera	8	2.1	Trace
			Arachnida	6	1.5	Trace
			Pelecypoda	5	1.3	Trace
			Gastropoda	4	1.0	Trace
			Copepoda	4	1.0	Trace
			Decapoda	3	0.8	Trace
			Odonata	2	0.5	Trace
			Lepidoptera	2	0.5	Trace
			Hemiptera	1	0.3	Trace
			Ostracoda	1	0.3	Trace
			Amphipoda	1	0.3	Trace
			Oligochaeta	1	0.3	Trace
			Orthoptera	1	0.3	Trace
			Empty	184	47.4	

1/ "Other" group includes *en masse* weight of "Trace" weight items.

2/ "Trace" percent weights are items that were to light to weigh individually.

Table 10.A3. Overall food habits to the lowest identifiable taxon expressed as number of stomachs an item occurred in (n), percent of stomachs an item occurred in, and a percentage of the total weight of items in the stomachs of bluegill sampled from each of the four segments of Newton Lake during 1997, 1998 and 1999.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1997	1	*Daphnia lumholtzi*	13	15.5	90.0
1997	1	Bryozoa	35	41.7	10.0
1997	1	Chironomida	60	71.4	Trace
1997	1	Other			Trace
1997	1	Ostracoda	30	35.7	Trace
1997	1	Dipteran	20	23.8	Trace
1997	1	Chydoridae	17	20.2	Trace
1997	1	Coleoptera	17	20.2	Trace
1997	1	Calanoida	14	16.7	Trace
1997	1	*Bosmina* spp.	13	15.5	Trace
1997	1	Ephemeroptera	9	10.7	Trace
1997	1	Unknown	54	64.3	Trace
1997	1	Hydracarina	6	7.1	Trace
1997	1	Trichoptera	6	7.1	Trace
1997	1	Sididae	6	7.1	Trace
1997	1	Cyclopoida	6	7.1	Trace
1997	1	*Diaphanosoma* spp.	5	6.0	Trace
1997	1	*Daphnia* spp.	5	6.0	Trace
1997	1	Arachnida	5	6.0	Trace
1997	1	Unid. Invertebrate	8	9.5	Trace
1997	1	*Argulus* spp.	4	4.8	Trace
1997	1	Plant	34	40.5	Trace
1997	1	Eggs	3	3.6	Trace
1997	1	Heleidae	3	3.6	Trace
1997	1	Zygoptera	2	2.4	Trace
1997	1	Bosminidae	2	2.4	Trace
1997	1	Hymenoptera	1	1.2	Trace
1997	1	Unid. Fish	2	2.4	Trace
1997	1	Empty	10	11.9	
1998	1	Unknown	68	64.8	99.8
1998	1	Other			Trace
1998	1	Chironomida	65	61.9	Trace
1998	1	Eggs	34	32.4	Trace

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1998	1	Dipteran	27	25.7	Trace
1998	1	Plant	40	38.1	Trace
1998	1	Bryozoa	29	27.6	Trace
1998	1	Coleoptera	8	7.6	Trace
1998	1	Unid. Invertebrate	9	8.6	Trace
1998	1	Arachnida	5	4.8	Trace
1998	1	Ostracoda	10	9.5	Trace
1998	1	*Argulus* spp.	5	4.8	Trace
1998	1	Trichoptera	4	3.8	Trace
1998	1	Sididae	21	20.0	Trace
1998	1	Gastropoda	3	2.9	Trace
1998	1	Cyclopoida	14	13.3	Trace
1998	1	Hymenoptera	2	1.9	Trace
1998	1	Odonata	2	1.9	Trace
1998	1	Calanoida	8	7.6	Trace
1998	1	Chydoridae	14	13.3	Trace
1998	1	*Chaoborus* spp.	4	3.8	Trace
1998	1	*Daphnia* spp.	4	3.8	Trace
1998	1	Hydracarina	2	1.9	Trace
1998	1	Ceratopogonidae	2	1.9	Trace
1998	1	Basommatophora	1	1.0	Trace
1998	1	Leptidora	1	1.0	Trace
1998	1	Culicidae	1	1.0	Trace
1998	1	*Diaphanosoma* spp.	9	8.6	Trace
1998	1	Bosminidae	7	6.7	Trace
1998	1	Podocopa	3	2.9	Trace
1998	1	*Bosmina* spp.	1	1.0	Trace
1998	1	*Argulus* spp.	1	1.0	Trace
1998	1	Acarina	1	1.0	Trace
1998	1	Empty	7	6.7	
1999	1	Other			100.0
1999	1	Unknown	76	89.4	Trace
1999	1	Chironomida	72	84.7	Trace
1999	1	Plant	48	56.5	Trace
1999	1	Dipteran	38	44.7	Trace
1999	1	Bryozoa	34	40.0	Trace
1999	1	Podocopa	29	34.1	Trace
1999	1	Sididae	24	28.2	Trace

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1999	1	Eggs	20	23.5	Trace
1999	1	Cyclopoida	15	17.6	Trace
1999	1	Dipteran (Adult)	14	16.5	Trace
1999	1	Chydoridae	8	9.4	Trace
1999	1	Trichoptera	7	8.2	Trace
1999	1	*Chaoborus* spp.	7	8.2	Trace
1999	1	Coleoptera	5	5.9	Trace
1999	1	Hymenoptera	5	5.9	Trace
1999	1	Ephemeroptera	3	3.5	Trace
1999	1	Hydracarina	3	3.5	Trace
1999	1	Bosminidae	3	3.5	Trace
1999	1	Ceratopogonidae	2	2.4	Trace
1999	1	Hemiptera	1	1.2	Trace
1999	1	Decapoda	1	1.2	Trace
1999	1	Tubificidae	1	1.2	Trace
1999	1	Coleopteran (Adult)	1	1.2	Trace
1999	1	Empty	7	8.2	
1997	2	Chironomida	51	65.4	19.0
1997	2	Other			16.6
1997	2	Ostracoda	19	24.4	7.3
1997	2	Sididae	14	17.9	5.4
1997	2	Dipteran	12	15.4	4.6
1997	2	Ephemeroptera	11	14.1	4.2
1997	2	Cyclopoida	11	14.1	4.2
1997	2	Calanoida	11	14.1	4.2
1997	2	Hydracarina	11	14.1	3.9
1997	2	Trichoptera	9	11.5	3.5
1997	2	*Daphnia lumholtzi*	8	10.3	3.1
1997	2	Chydoridae	8	10.3	3.1
1997	2	*Bosmina* spp.	7	9.0	2.7
1997	2	Coleoptera	7	9.0	2.4
1997	2	Unknown	30	38.5	2.2
1997	2	Bryozoa	20	25.6	1.8
1997	2	*Diaphanosoma* spp.	4	5.1	1.5
1997	2	Bosminidae	4	5.1	1.5
1997	2	Plant	40	51.3	1.5
1997	2	Unid. Invertebrate	4	5.1	1.2
1997	2	*Daphnia* spp.	3	3.8	1.2

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1997	2	Anisopteran	3	3.8	1.2
1997	2	Arachnida	3	3.8	1.2
1997	2	Hemiptera	2	2.6	0.8
1997	2	*Argulus* spp.	1	1.3	0.4
1997	2	Zygoptera	1	1.3	0.4
1997	2	Collembola	1	1.3	0.4
1997	2	Cladocera	1	1.3	0.4
1997	2	Empty	18	23.1	
1998	2	Hydracarina	14	10.9	66.6
1998	2	Other			33.3
1998	2	Chironomida	95	73.6	Trace
1998	2	Unknown	96	74.4	Trace
1998	2	Eggs	42	32.6	Trace
1998	2	Dipteran	21	16.3	Trace
1998	2	Plant	60	46.5	Trace
1998	2	Podocopa	12	9.3	Trace
1998	2	Bryozoa	35	27.1	Trace
1998	2	Trichoptera	11	8.5	Trace
1998	2	Ephemeroptera	8	6.2	Trace
1998	2	Unid. Invertebrate	10	7.8	Trace
1998	2	Coleoptera	6	4.7	Trace
1998	2	*Chaoborus* spp.	5	3.9	Trace
1998	2	Hymenoptera	4	3.1	Trace
1998	2	*Argulus* spp.	3	2.3	Trace
1998	2	Ostracoda	17	13.2	Trace
1998	2	Sididae	16	12.4	Trace
1998	2	Cyclopoida	25	19.4	Trace
1998	2	Ceratopogonidae	4	3.1	Trace
1998	2	Calanoida	15	11.6	Trace
1998	2	*Diaphanosoma* spp.	12	9.3	Trace
1998	2	*Daphnia lumholtzi*	3	2.3	Trace
1998	2	Chydoridae	11	8.5	Trace
1998	2	Arachnida	2	1.6	Trace
1998	2	*Daphnia* spp.	10	7.8	Trace
1998	2	Hemiptera	1	0.8	Trace
1998	2	Gastropoda	1	0.8	Trace
1998	2	Tipulidae	1	0.8	Trace
1998	2	Bosminidae	9	7.0	Trace

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1998	2	*Argulus* spp.	3	2.3	Trace
1998	2	Shiner	1	0.8	Trace
1998	2	*Bosmina* spp.	1	0.8	Trace
1998	2	Nematoda	1	0.8	Trace
1998	2	Acarina	1	0.8	Trace
1998	2	Choncostraca	1	0.8	Trace
1998	2	Lepidoptera	1	0.8	Trace
1998	2	Empty	12	9.3	
1999	2	Other			62.9
1999	2	Unknown	72	84.7	6.0
1999	2	Chironomida	69	81.2	5.8
1999	2	Plant	51	60.0	4.3
1999	2	Dipteran	36	42.4	3.0
1999	2	Sididae	32	37.6	2.7
1999	2	Cyclopoida	25	29.4	2.1
1999	2	Bryozoa	22	25.9	1.8
1999	2	Podocopa	22	25.9	1.8
1999	2	Trichoptera	16	18.8	1.3
1999	2	Chydoridae	16	18.8	1.3
1999	2	Eggs	14	16.5	1.2
1999	2	Ephemeroptera	13	15.3	1.1
1999	2	Hymenoptera	11	12.9	0.9
1999	2	Hydracarina	8	9.4	0.7
1999	2	Dipteran (Adult)	8	9.4	0.7
1999	2	Zygoptera	4	4.7	0.3
1999	2	Coleoptera	4	4.7	0.3
1999	2	Arachnida	4	4.7	0.3
1999	2	*Chaoborus* spp.	2	2.4	0.2
1999	2	Ceratopogonidae	2	2.4	0.2
1999	2	Basommatophora	2	2.4	0.2
1999	2	Lepidoptera	2	2.4	0.2
1999	2	*Argulus* spp.	1	1.2	Trace
1999	2	*Daphnia* spp.	1	1.2	Trace
1999	2	Bosminidae	1	1.2	Trace
1999	2	Calanoida	1	1.2	Trace
1999	2	Gastropoda	1	1.2	Trace
1999	2	Homoptera	1	1.2	Trace
1999	2	Coleopteran (Adult)	1	1.2	Trace

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1999	2	Empty	13	15.3	
1997	3	Chironomida	65	80.2	18.5
1997	3	Other			17.6
1997	3	*Daphnia lumholtzi*	27	33.3	8.5
1997	3	Dipteran	19	23.5	6.0
1997	3	Calanoida	16	19.8	5.0
1997	3	Chydoridae	15	18.5	4.7
1997	3	Coleoptera	15	18.5	3.9
1997	3	Ostracoda	12	14.8	3.5
1997	3	Sididae	11	13.6	3.5
1997	3	Arachnida	10	12.3	3.1
1997	3	Cyclopoida	9	11.1	2.8
1997	3	*Bosmina* spp.	9	11.1	2.8
1997	3	Ephemeroptera	8	9.9	2.5
1997	3	Trichoptera	7	8.6	2.2
1997	3	Unknown	36	44.4	2.0
1997	3	*Diaphanosoma* spp.	6	7.4	1.9
1997	3	Bryozoa	38	46.9	1.8
1997	3	Hydracarina	5	6.2	1.3
1997	3	*Daphnia* spp.	4	4.9	1.3
1997	3	Unid. Invertebrate	12	14.8	1.2
1997	3	Eggs	3	3.7	0.9
1997	3	*Argulus* spp.	3	3.7	0.9
1997	3	Bosminidae	3	3.7	0.9
1997	3	Plant	29	35.8	0.9
1997	3	Anisopteran	2	2.5	0.6
1997	3	Heleidae	2	2.5	0.6
1997	3	Leptidora	2	2.5	0.6
1997	3	Hymenoptera	1	1.2	0.3
1997	3	Unid. Fish	2	2.5	Trace
1997	3	Empty	11	13.6	
1998	3	Unknown	72	62.1	99.7
1998	3	Other			Trace
1998	3	Chironomida	88	75.9	Trace
1998	3	Dipteran	42	36.2	Trace
1998	3	Plant	33	28.4	Trace
1998	3	Coleoptera	19	16.4	Trace
1998	3	Eggs	27	23.3	Trace

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1998	3	Unid. Invertebrate	13	11.2	Trace
1998	3	*Diaphanosoma* spp.	19	16.4	Trace
1998	3	*Daphnia* spp.	15	12.9	Trace
1998	3	Unid. Fish	8	6.9	Trace
1998	3	Trichoptera	9	7.8	Trace
1998	3	Ephemeroptera	6	5.2	Trace
1998	3	Cyclopoida	27	23.3	Trace
1998	3	Arachnida	4	3.4	Trace
1998	3	*Daphnia lumholtzi*	12	10.3	Trace
1998	3	*Argulus* spp.	3	2.6	Trace
1998	3	Hydracarina	10	8.6	Trace
1998	3	Ostracoda	9	7.8	Trace
1998	3	Acarina	9	7.8	Trace
1998	3	*Chaoborus* spp.	7	6.0	Trace
1998	3	Calanoida	14	12.1	Trace
1998	3	Gastropoda	5	4.3	Trace
1998	3	Hymenoptera	3	2.6	Trace
1998	3	Ceratopogonidae	3	2.6	Trace
1998	3	Orthoptera	2	1.7	Trace
1998	3	Lepidoptera	2	1.7	Trace
1998	3	Bryozoa	7	6.0	Trace
1998	3	Bosminidae	11	9.5	Trace
1998	3	Sididae	11	9.5	Trace
1998	3	Chydoridae	10	8.6	Trace
1998	3	*Argulus* spp.	1	0.9	Trace
1998	3	Tipulidae	1	0.9	Trace
1998	3	Choncostraca	1	0.9	Trace
1998	3	Pelecypoda	1	0.9	Trace
1998	3	Collembola	1	0.9	Trace
1998	3	Hemiptera	1	0.9	Trace
1998	3	Decapoda	1	0.9	Trace
1998	3	*Bosmina* spp.	1	0.9	Trace
1998	3	Podocopa	1	0.9	Trace
1998	3	Oligochaeta	1	0.9	Trace
1998	3	Amphipoda	1	0.9	Trace
1998	3	Empty	7	6.0	
1999	3	Other			100.0
1999	3	Unknown	76	86.4	Trace

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1999	3	Chironomida	66	75.0	Trace
1999	3	Dipteran	42	47.7	Trace
1999	3	Plant	40	45.5	Trace
1999	3	Eggs	23	26.1	Trace
1999	3	Podocopa	16	18.2	Trace
1999	3	Trichoptera	15	17.0	Trace
1999	3	Sididae	14	15.9	Trace
1999	3	Cyclopoida	14	15.9	Trace
1999	3	Ephemeroptera	11	12.5	Trace
1999	3	Hymenoptera	10	11.4	Trace
1999	3	Dipteran (Adult)	8	9.1	Trace
1999	3	Hydracarina	6	6.8	Trace
1999	3	*Daphnia lumholtzi*	6	6.8	Trace
1999	3	Coleoptera	6	6.8	Trace
1999	3	Bryozoa	6	6.8	Trace
1999	3	Chydoridae	5	5.7	Trace
1999	3	Ceratopogonidae	5	5.7	Trace
1999	3	*Daphnia* spp.	4	4.5	Trace
1999	3	*Argulus* spp.	3	3.4	Trace
1999	3	*Chaoborus* spp.	3	3.4	Trace
1999	3	Bosminidae	2	2.3	Trace
1999	3	Basommatophora	2	2.3	Trace
1999	3	Arachnida	1	1.1	Trace
1999	3	Empty	16	18.2	
1997	4	Chironomida	45	71.4	23.8
1997	4	Other			19.0
1997	4	*Daphnia lumholtzi*	16	25.4	9.8
1997	4	Calanoida	13	20.6	7.4
1997	4	Trichoptera	12	19.0	7.4
1997	4	Cyclopoida	5	7.9	3.1
1997	4	Unknown	31	49.2	3.0
1997	4	Bryozoa	20	31.7	2.9
1997	4	Unid. Invertebrate	5	7.9	2.5
1997	4	Ephemeroptera	4	6.3	2.5
1997	4	Hydracarina	4	6.3	2.5
1997	4	Coleoptera	4	6.3	2.5
1997	4	*Diaphanosoma* spp.	3	4.8	1.8
1997	4	Sididae	3	4.8	1.8

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1997	4	Chydoridae	3	4.8	1.8
1997	4	Arachnida	3	4.8	1.8
1997	4	Dipteran	2	3.2	1.2
1997	4	Ostracoda	2	3.2	1.2
1997	4	Plant	11	17.5	0.7
1997	4	*Argulus* spp.	1	1.6	0.6
1997	4	*Daphnia* spp.	1	1.6	0.6
1997	4	Orthoptera	1	1.6	0.6
1997	4	Hemiptera	1	1.6	0.6
1997	4	*Argulus* spp.	1	1.6	0.6
1997	4	Unid. Fish	3	4.8	0.2
1997	4	Empty	13	20.6	
1998	4	Unid. Invertebrate	16	14.3	69.3
1998	4	Unknown	81	72.3	29.7
1998	4	Eggs	29	25.9	1.0
1998	4	Other			Trace
1998	4	Chironomida	92	82.1	Trace
1998	4	Dipteran	35	31.3	Trace
1998	4	Plant	39	34.8	Trace
1998	4	Bryozoa	24	21.4	Trace
1998	4	Ceratopogonidae	19	17.0	Trace
1998	4	Unid. Fish	9	8.0	Trace
1998	4	Coleoptera	8	7.1	Trace
1998	4	Arachnida	7	6.3	Trace
1998	4	Trichoptera	13	11.6	Trace
1998	4	Cyclopoida	34	30.4	Trace
1998	4	Ephemeroptera	14	12.5	Trace
1998	4	*Daphnia lumholtzi*	14	12.5	Trace
1998	4	*Chaoborus* spp.	10	8.9	Trace
1998	4	*Diaphanosoma* spp.	18	16.1	Trace
1998	4	Sididae	9	8.0	Trace
1998	4	*Daphnia* spp.	13	11.6	Trace
1998	4	*Argulus* spp.	4	3.6	Trace
1998	4	Hydracarina	11	9.8	Trace
1998	4	Zygoptera	2	1.8	Trace
1998	4	Hymenoptera	2	1.8	Trace
1998	4	Chydoridae	10	8.9	Trace
1998	4	Acarina	6	5.4	Trace

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1998	4	Gastropoda	5	4.5	Trace
1998	4	Oligochaeta	3	2.7	Trace
1998	4	Nematoda	3	2.7	Trace
1998	4	Heleidae	2	1.8	Trace
1998	4	Tipulidae	2	1.8	Trace
1998	4	Stratiomyidae	1	0.9	Trace
1998	4	Lepidoptera	1	0.9	Trace
1998	4	Podocopa	8	7.1	Trace
1998	4	Bosminidae	7	6.3	Trace
1998	4	Ostracoda	3	2.7	Trace
1998	4	Calanoida	3	2.7	Trace
1998	4	Nematomorpha	3	2.7	Trace
1998	4	Copepoda	2	1.8	Trace
1998	4	Collembola	1	0.9	Trace
1998	4	Decapoda	1	0.9	Trace
1998	4	Araneae	1	0.9	Trace
1998	4	Isopoda	1	0.9	Trace
1998	4	Basommatophora	1	0.9	Trace
1998	4	Amphipoda	1	0.9	Trace
1998	4	Hirudinea	1	0.9	Trace
1998	4	Cladocera	1	0.9	Trace
1998	4	Empty	11	9.8	
1999	4	Other			100.0
1999	4	Chironomida	76	92.7	Trace
1999	4	Unknown	75	91.5	Trace
1999	4	Plant	44	53.7	Trace
1999	4	Dipteran	41	50.0	Trace
1999	4	Eggs	20	24.4	Trace
1999	4	Cyclopoida	20	24.4	Trace
1999	4	Sididae	19	23.2	Trace
1999	4	Trichoptera	15	18.3	Trace
1999	4	Dipteran (Adult)	15	18.3	Trace
1999	4	Hydracarina	13	15.9	Trace
1999	4	Ephemeroptera	11	13.4	Trace
1999	4	Coleoptera	11	13.4	Trace
1999	4	Hymenoptera	11	13.4	Trace
1999	4	Bryozoa	10	12.2	Trace
1999	4	Podocopa	9	11.0	Trace

Table 10.A3. Continued.

Year	Segment	Item Name[1]	n	% n	% weight[2]
1999	4	Chydoridae	8	9.8	Trace
1999	4	*Daphnia lumholtzi*	3	3.7	Trace
1999	4	Bosminidae	3	3.7	Trace
1999	4	Calanoida	3	3.7	Trace
1999	4	Hemiptera	3	3.7	Trace
1999	4	Ceratopogonidae	3	3.7	Trace
1999	4	Coleopteran (Adult)	3	3.7	Trace
1999	4	Unid. Fish	2	2.4	Trace
1999	4	*Chaoborus* spp.	2	2.4	Trace
1999	4	Nematoda	2	2.4	Trace
1999	4	Basommatophora	2	2.4	Trace
1999	4	Amphipoda	2	2.4	Trace
1999	4	*Argulus* spp.	1	1.2	Trace
1999	4	Gastropoda	1	1.2	Trace
1999	4	Arachnida	1	1.2	Trace
1999	4	Tubificidae	1	1.2	Trace
1999	4	Lumbriculida	1	1.2	Trace
1999	4	Lepidoptera	1	1.2	Trace
1999	4	Megaloptera	1	1.2	Trace
1999	4	Empty	3	3.7	

1/ "Other" items includes *en masse* weight of "Trace" weight items.
2/ "Trace" percent weights are items that were to light to weigh individually.

Table 10.A4. Overall Food habits by grouping expressed as number of stomachs an item occurred in (n), percent of stomachs an item occurred in, and a percentage of the total weight of items in the stomachs of bluegill sampled from each of the four segments of Newton Lake during 1997, 1998 and 1999.

Year	Segment	Group Name[1]	n	% n	% weight[2]
1997	1	Cladocera	40	47.6	90.0
1997	1	Bryozoa	35	41.7	10.0
1997	1	Diptera	61	72.6	Trace
1997	1	Other			Trace
1997	1	Ostracoda	30	35.7	Trace
1997	1	Copepoda	20	23.8	Trace
1997	1	Coleoptera	17	20.2	Trace
1997	1	Arachnida	10	11.9	Trace
1997	1	Ephemeroptera	9	10.7	Trace
1997	1	Miscellaneous	54	64.3	Trace
1997	1	Trichoptera	5	6.0	Trace
1997	1	Unid. Invertebrate	8	9.5	Trace
1997	1	Plant Material	34	40.5	Trace
1997	1	Eggs	3	3.6	Trace
1997	1	Odonata	2	2.4	Trace
1997	1	Hymenoptera	1	1.2	Trace
1997	1	Unid. Fish	2	2.4	Trace
1997	1	Empty	10	11.9	
1998	1	Miscellaneous	68	64.8	99.8
1998	1	Diptera	77	73.3	Trace
1998	1	Other			Trace
1998	1	Eggs	34	32.4	Trace
1998	1	Plant Material	40	38.1	Trace
1998	1	Bryozoa	29	27.6	Trace
1998	1	Cladocera	37	35.2	Trace
1998	1	Coleoptera	8	7.6	Trace
1998	1	Copepoda	26	24.8	Trace
1998	1	Unid. Invertebrate	9	8.6	Trace
1998	1	Arachnida	8	7.6	Trace
1998	1	Gastropoda	4	3.8	Trace
1998	1	Ostracoda	13	12.4	Trace
1998	1	Trichoptera	4	3.8	Trace
1998	1	Odonata	2	1.9	Trace

Table 10.A4. Continued.

Year	Segment	Group Name[1]	n	% n	% weight[2]
1998	1	Hymenoptera	2	1.9	Trace
1998	1	Empty	7	6.7	
1999	1	Other			100.0
1999	1	Diptera	77	90.6	Trace
1999	1	Miscellaneous	76	89.4	Trace
1999	1	Plant Material	48	56.5	Trace
1999	1	Cladocera	27	31.8	Trace
1999	1	Bryozoa	34	40.0	Trace
1999	1	Ostracoda	29	34.1	Trace
1999	1	Eggs	20	23.5	Trace
1999	1	Copepoda	15	17.6	Trace
1999	1	Trichoptera	7	8.2	Trace
1999	1	Coleoptera	6	7.1	Trace
1999	1	Hymenoptera	5	5.9	Trace
1999	1	Ephemeroptera	3	3.5	Trace
1999	1	Arachnida	3	3.5	Trace
1999	1	Hemiptera	1	1.2	Trace
1999	1	Oligochaeta	1	1.2	Trace
1999	1	Decapoda	1	1.2	Trace
1999	1	Empty	5	5.9	
1997	2	Diptera	50	64.1	23.6
1997	2	Cladocera	30	38.5	18.9
1997	2	Other			16.6
1997	2	Copepoda	17	21.8	8.9
1997	2	Ostracoda	19	24.4	7.3
1997	2	Arachnida	13	16.7	5.1
1997	2	Ephemeroptera	11	14.1	4.2
1997	2	Trichoptera	9	11.5	3.5
1997	2	Coleoptera	7	9.0	2.4
1997	2	Miscellaneous	29	37.2	2.2
1997	2	Bryozoa	20	25.6	1.8
1997	2	Odonata	4	5.1	1.5
1997	2	Plant Material	40	51.3	1.5
1997	2	Unid. Invertebrate	4	5.1	1.2
1997	2	Hemiptera	2	2.6	0.8
1997	2	Collembola	1	1.3	0.4
1997	2	Empty	18	23.1	
1998	2	Arachnida	17	13.2	66.6

Table 10.A4. Continued.

Year	Segment	Group Name[1]	n	% n	% weight[2]
1998	2	Other			33.3
1998	2	Diptera	96	74.4	Trace
1998	2	Miscellaneous	95	73.6	Trace
1998	2	Eggs	42	32.6	Trace
1998	2	Plant Material	60	46.5	Trace
1998	2	Ostracoda	29	22.5	Trace
1998	2	Bryozoa	35	27.1	Trace
1998	2	Cladocera	50	38.8	Trace
1998	2	Trichoptera	11	8.5	Trace
1998	2	Copepoda	39	30.2	Trace
1998	2	Ephemeroptera	8	6.2	Trace
1998	2	Unid. Invertebrate	9	7.0	Trace
1998	2	Coleoptera	6	4.7	Trace
1998	2	Hymenoptera	4	3.1	Trace
1998	2	Hemiptera	1	0.8	Trace
1998	2	Gastropoda	1	0.8	Trace
1998	2	Choncostraca	1	0.8	Trace
1998	2	Lepidoptera	1	0.8	Trace
1998	2	Nematoda	1	0.8	Trace
1998	2	Cyprinidae	1	0.8	Trace
1998	2	Empty	12	9.3	
1999	2	Other			62.9
1999	2	Diptera	71	83.5	9.8
1999	2	Miscellaneous	72	84.7	6.0
1999	2	Plant Material	51	60.0	4.3
1999	2	Cladocera	36	42.4	4.2
1999	2	Copepoda	26	30.6	2.3
1999	2	Bryozoa	22	25.9	1.8
1999	2	Ostracoda	22	25.9	1.8
1999	2	Trichoptera	16	18.8	1.3
1999	2	Eggs	14	16.5	1.2
1999	2	Ephemeroptera	13	15.3	1.1
1999	2	Arachnida	12	14.1	1.0
1999	2	Hymenoptera	11	12.9	0.9
1999	2	Coleoptera	5	5.9	0.4
1999	2	Odonata	4	4.7	0.3
1999	2	Gastropoda	3	3.5	0.3
1999	2	Lepidoptera	2	2.4	0.2

Table 10.A4. Continued.

Year	Segment	Group Name[1]	n	% n	% weight[2]
1999	2	Homoptera	1	1.2	Trace
1999	2	Empty	10	11.8	
1997	3	Diptera	64	79.0	25.1
1997	3	Cladocera	45	55.6	24.2
1997	3	Other			17.6
1997	3	Copepoda	22	27.2	8.8
1997	3	Arachnida	15	18.5	4.4
1997	3	Coleoptera	15	18.5	3.9
1997	3	Ostracoda	12	14.8	3.5
1997	3	Ephemeroptera	8	9.9	2.5
1997	3	Trichoptera	7	8.6	2.2
1997	3	Miscellaneous	36	44.4	2.0
1997	3	Bryozoa	38	46.9	1.8
1997	3	Unid. Invertebrate	12	14.8	1.2
1997	3	Eggs	3	3.7	0.9
1997	3	Plant Material	29	35.8	0.9
1997	3	Odonata	2	2.5	0.6
1997	3	Hymenoptera	1	1.2	0.3
1997	3	Unid. Fish	2	2.5	Trace
1997	3	Empty	11	13.6	
1998	3	Miscellaneous	72	62.1	99.7
1998	3	Diptera	96	82.8	Trace
1998	3	Other			Trace
1998	3	Cladocera	60	51.7	Trace
1998	3	Plant Material	33	28.4	Trace
1998	3	Coleoptera	19	16.4	Trace
1998	3	Eggs	27	23.3	Trace
1998	3	Copepoda	35	30.2	Trace
1998	3	Arachnida	23	19.8	Trace
1998	3	Unid. Invertebrate	13	11.2	Trace
1998	3	Unid. Fish	5	4.3	Trace
1998	3	Trichoptera	9	7.8	Trace
1998	3	Ephemeroptera	6	5.2	Trace
1998	3	Ostracoda	10	8.6	Trace
1998	3	Gastropoda	5	4.3	Trace
1998	3	Hymenoptera	3	2.6	Trace
1998	3	Orthoptera	2	1.7	Trace
1998	3	Lepidoptera	2	1.7	Trace

Table 10.A4. Continued.

Year	Segment	Group Name[1]	n	% n	% weight[2]
1998	3	Bryozoa	7	6.0	Trace
1998	3	Choncostraca	1	0.9	Trace
1998	3	Pelecypoda	1	0.9	Trace
1998	3	Hemiptera	1	0.9	Trace
1998	3	Amphipoda	1	0.9	Trace
1998	3	Oligochaeta	1	0.9	Trace
1998	3	Collembola	1	0.9	Trace
1998	3	Decapoda	1	0.9	Trace
1998	3	Empty	7	6.0	
1999	3	Other			100.0
1999	3	Diptera	68	77.3	Trace
1999	3	Miscellaneous	76	86.4	Trace
1999	3	Plant Material	40	45.5	Trace
1999	3	Cladocera	22	25.0	Trace
1999	3	Eggs	23	26.1	Trace
1999	3	Copepoda	16	18.2	Trace
1999	3	Ostracoda	16	18.2	Trace
1999	3	Trichoptera	15	17.0	Trace
1999	3	Ephemeroptera	11	12.5	Trace
1999	3	Hymenoptera	10	11.4	Trace
1999	3	Arachnida	7	8.0	Trace
1999	3	Coleoptera	6	6.8	Trace
1999	3	Bryozoa	6	6.8	Trace
1999	3	Gastropoda	2	2.3	Trace
1999	3	Empty	11	12.5	
1997	4	Diptera	44	69.8	25.0
1997	4	Other			19.0
1997	4	Cladocera	23	36.5	16.0
1997	4	Copepoda	18	28.6	11.7
1997	4	Trichoptera	12	19.0	7.4
1997	4	Arachnida	7	11.1	4.3
1997	4	Miscellaneous	27	42.9	3.0
1997	4	Bryozoa	20	31.7	2.9
1997	4	Unid. Invertebrate	5	7.9	2.5
1997	4	Ephemeroptera	4	6.3	2.5
1997	4	Coleoptera	4	6.3	2.5
1997	4	Ostracoda	2	3.2	1.2
1997	4	Plant Material	11	17.5	0.7

Table 10.A4. Continued.

Year	Segment	Group Name[1]	n	% n	% weight[2]
1997	4	Hemiptera	1	1.6	0.6
1997	4	Orthoptera	1	1.6	0.6
1997	4	Unid. Fish	3	4.8	0.2
1997	4	Empty	13	20.6	
1998	4	Unid. Invertebrate	15	13.4	69.3
1998	4	Miscellaneous	81	72.3	29.7
1998	4	Eggs	29	25.9	1.0
1998	4	Diptera	95	84.8	Trace
1998	4	Other			Trace
1998	4	Cladocera	52	46.4	Trace
1998	4	Plant Material	39	34.8	Trace
1998	4	Arachnida	24	21.4	Trace
1998	4	Copepoda	37	33.0	Trace
1998	4	Bryozoa	24	21.4	Trace
1998	4	Unid. Fish	7	6.3	Trace
1998	4	Coleoptera	8	7.1	Trace
1998	4	Trichoptera	13	11.6	Trace
1998	4	Ephemeroptera	14	12.5	Trace
1998	4	Odonata	2	1.8	Trace
1998	4	Hymenoptera	2	1.8	Trace
1998	4	Gastropoda	6	5.4	Trace
1998	4	Oligochaeta	3	2.7	Trace
1998	4	Nematoda	3	2.7	Trace
1998	4	Ostracoda	11	9.8	Trace
1998	4	Lepidoptera	1	0.9	Trace
1998	4	Nematomorpha	3	2.7	Trace
1998	4	Isopoda	1	0.9	Trace
1998	4	Amphipoda	1	0.9	Trace
1998	4	Hirudinea	1	0.9	Trace
1998	4	Collembola	1	0.9	Trace
1998	4	Decapoda	1	0.9	Trace
1998	4	Empty	11	9.8	
1999	4	Other			100.0
1999	4	Diptera	77	93.9	Trace
1999	4	Miscellaneous	75	91.5	Trace
1999	4	Plant Material	44	53.7	Trace
1999	4	Cladocera	25	30.5	Trace
1999	4	Copepoda	21	25.6	Trace

Table 10.A4. Continued.

Year	Segment	Group Name[1]	n	% n	% weight[2]
1999	4	Eggs	20	24.4	Trace
1999	4	Trichoptera	15	18.3	Trace
1999	4	Arachnida	13	15.9	Trace
1999	4	Coleoptera	14	17.1	Trace
1999	4	Ephemeroptera	11	13.4	Trace
1999	4	Hymenoptera	11	13.4	Trace
1999	4	Bryozoa	10	12.2	Trace
1999	4	Ostracoda	9	11.0	Trace
1999	4	Hemiptera	3	3.7	Trace
1999	4	Gastropoda	3	3.7	Trace
1999	4	Amphipoda	2	2.4	Trace
1999	4	Oligochaeta ON	2	2.4	Trace
1999	4	Nematoda	2	2.4	Trace
1999	4	Unid. Fish	2	2.4	Trace
1999	4	Lepidoptera	1	1.2	Trace
1999	4	Megaloptera	1	1.2	Trace
1999	4	Empty	3	3.7	

[1/] "Other" group includes *en masse* weight of "Trace" weight items.

[2/] "Trace" percent weights are items that were to light to weigh individually.

Volume II

AmerenCIPS Newton Lake Project

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Principal Investigators

Roy Heidinger
Robert Sheehan
Ronald Brooks

Fisheries Research Laboratory and Illinois Aquaculture Center
Southern Illinois University at Carbondale

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VOLUME I

Chapter 12. Young-of-the-Year Fish and Recruitment

Introduction:

Documentation of young-of-the-year fish (age-0+) and recruitment (age-1+) is necessary to determine the status of a fish community in terms of sustaining adequate numbers. Depending on the rates of recruitment, exploitation, and natural mortality, failure of only two or three consecutive year-classes could result in a significant reduction in a fishery.

The purpose of this chapter was to monitor reproduction and recruitment of largemouth bass and bluegill in order to determine the future status of those species in each of the three power-cooling lakes.

Methods:

The occurrence of young-of-the-year (y-o-y) fish was documented by shoreline seining once in August 1997 and twice a month during April through August 1998 and 1999. Samples were taken with a 30-ft. long, 6 ft. deep, 0.25-inch bar mesh bag seine. In order to quantify the effort, each seine haul was approximately 200 ft^2 of shore area. Ten seine hauls were made in each of the four lake segments in Newton Lake and each of two segments in Coffeen Lake and Lake of Egypt. Small fish not identifiable at the lakes were fixed in 10% formalin and returned to the laboratory where they were identified to the lowest possible taxa and counted. When large numbers were present, a random subsample of 100 specimens of each target taxa from each lake segment on each sampling date was measured for total length, and the rest of the fish were enumerated.

The three lakes were initially seined in August 1997 to estimate species abundance (catch per seine haul or CPU) and diversity of all fish vulnerable to seining which included age-0+

largemouth bass (*Micropterus salmoides*) and from age-0+ through age-1+ bluegill (*Lepomis macrochirus*). Age-1+ largemouth bass abundance (CPUE) was determined for each lake and year from fall electrofishing samples. Age-1+ largemouth bass were collected by Southern Illinois University personnel during periods when fish were collected for mortality and/or age and growth estimates. Ages were determined by examining saggittae otoliths.

Results:

Age-1+ largemouth bass abundance in Newton Lake was highest in 1998 (9.84 CPUE) and lowest in 1997 (1.94 CPUE, Table 12.1). Both Newton and Coffeen lakes had fall electrofishing CPUEs for age-1+ bass that were higher than Lake of Egypt during 1997 and 1998 when all three lakes were sampled. CPUE for age-1+ bass in Newton Lake was higher in 1998 than 1999, but there were more age-1+ bass collected per hour in Coffeen Lake during 1999 than 1998.

In Newton Lake, the lowest seining CPU for age-0+ bass (1.58) was in 1997 (Table 12.2), and the electrofishing CPUE for age-1+ bass the following year (1998) was 9.84. Age-0+ bass were collected at 5.78 CPU in 1998 or 3.6 times the number of age-0+ fish collected in 1997. Thus, we expected a higher CPUE of age-1+ bass to be collected in 1999 than in 1998. However, the fall electrofishing CPUE for age-1+ bass was only 3.11 in 1999 - or roughly one third the number of the age-1+ bass collected in the previous year. In contrast, age-0+ bass abundance in Coffeen Lake decreased from 1997 (1.50 CPU) to 1998 (0.39 CPU), but age-1+ abundance increased slightly from 1998 to 1999.

Abundance of age-0+ bluegills was highest in Lake of Egypt and lowest in Newton Lake in each of the three years (Table 12.2). Seining CPUs for age-1+ bluegills were variable among the lakes and years within lakes. Trends of bluegill abundance from age-0+ to age-1+ were dependent on the lake sampled. Newton Lake bluegill abundance trends were similar to largemouth bass in the lake. A CPU of 0.23 for age-0+ bluegill in 1997 precluded a 3.45 CPU of age-1+ bluegill in 1998. Age-0+ bluegill abundance was slightly higher in 1998 (0.58 CPU) than 1997, but age-1+ fish numbers decreased to 0.38 CPU in 1999 – a 9-fold decrease from 1998 to 1999. In Coffeen Lake, abundance of age-0+ bluegill was 29% less in 1998 than 1997, and age-1+ bluegill numbers fell in close proportion (35%) from 3.37 CPU in 1998 to 1.18 CPU in 1999. Lake of Egypt age-0+ numbers were 46% lower in 1998 than 1997, but numbers of age-1+ fish collected were similar in 1998 (2.17 CPU) and 1999 (2.14 CPU).

Seining CPUs for all largemouth bass and bluegill in Newton Lake and Coffeen Lake were usually highest in segment 2 (Tables 12.3 and 12.4), but the differences among the segments were not statistically significant in either lake. In both lakes, there were generally fewer bass collected in segment 1 (discharge area) than in the remaining segments following early June of each year (Figures 12.1 and 12.2). There were usually more age-0+ and age-1+ bluegills collected in the cooler segments of Newton Lake during the warmest periods of summer (Figures 12.3 and 12.4). In Coffeen Lake, most age-0+ bluegills were collected from the cooler segment 2 in August 1998 and throughout the 1999 sampling season (Figure 12.5). Age-1+ bluegills in Coffeen Lake were collected at higher CPUs in segment 2 (intake area) than segment 1 (discharge area) on every sampling date except in early April 1999 (Figure 12.6). Seining CPUs in Lake of Egypt were variable between segments for age-0+ largemouth bass and bluegill (Table 12.3). Age-1+ bluegills were collected in higher numbers in segment 2, but there were no significant differences in abundance between segments (Table 12.4). In Lake of Egypt, age-0+ largemouth bass were generally collected at higher CPUs in the cooler portion (segment 2) of the lakes than in the warmer, discharge (segment 1) areas during April through August (Figure 12.7). The opposite was true for age-0+ bluegills in Lake of Egypt (Figure 12.8). Segment collected was not a factor for the age-1+ bluegills in Lake of Egypt (Figure 12.9).

In Newton Lake, there was a 51% decrease in the number of total fish (all species) collected per seine haul from 1998 (16.38 CPU) to 1999 (7.89 CPU, Table 12.5). The number of fish collected in Coffeen Lake decreased by 26% during the same period. In contrast, Lake of Egypt seining CPU increased from 12.44 CPU in 1998 to 30.56 CPU in 1999. There were no statistically significant differences in CPUs among or between segments for all years.

Diversity of species collected in seine hauls was not adversely affected by water conditions in any of the lakes. In Newton Lake, eight fish species were collected in August 1997 (Table 12.6), 11 species in 1998, and 12 species in 1999. Largemouth bass were most abundant in each year. Gizzard shad (*Dorosoma cepedianum*) was the second most abundant species collected in each year, and *Lepomis* spp. was the third.

Fish species in Coffeen Lake were similar to those in Newton Lake, but the highest relative abundance was from bluegill in each year (Table 12.7). In 1998, with the exception of bluegill, gizzard shad (2.01 CPU), and mosquito fish (*Gambusia affinis*) (1.19 CPU) contributed most to the fish collected in Coffeen Lake. No single fish species, other than bluegill, contributed significantly in 1999.

The highest diversity of fish species was collected in Lake of Egypt. Ten fish species were present in August 1997, 16 species were collected during 1998, and 20 in 1999 (Table 12.8). The black-striped topminnow (*Fundulus notatus*) was the most abundant species in the 1997 seine hauls. Bluegills were collected at a higher CPU (6.29) than all other species in Lake of Egypt during 1998. In 1999, silversides were collected at the highest CPU (12.25) of any other fish species, and bluegills were second (8.59 CPU).

Discussion:

Largemouth bass and bluegill cohort abundance at age-1+ is dependent on age-0+ production in the previous year and overwintering survival. Perhaps the most important indicator of a fish population's ability to proliferate is its survival through age-1. After only two years of data, the results of this study are incomplete since probably the most important season of sampling would occur in 2000 – the first year following summer water temperatures that were within range of the new variance. Preliminary indications are that largemouth bass and bluegill abundance trends declined from 1998 to 1999 when compared to the same annual period from 1997 to 1998.

It is worth noting that the numbers most important are the trends of abundance and not the precise numbers reported. For instance, it is impossible to have more age-1+ fish than age-0+ fish of the same species in the following year. Obviously, relatively more bluegills were susceptible to seining at age-1+ than at age-0+. However, it is reasonable to assume that the same proportion of age-0+ bluegill is susceptible in each year. Therefore, seining can be a viable index of age-0+ numbers among years and lakes, and analysis of abundance trends of fish from age-0+ to age-1+ can be made. Trend analysis in Newton Lake indicated that the age-1+ largemouth bass and bluegill were disproportionately lower in 1999 than in 1998. This was not the case for largemouth bass and bluegill in Coffeen Lake. Although age-1+ bluegill abundance was lower in 1999, the decrease was in proportion to the decrease in age-0+ abundance from 1997 to 1998. Thus, the decrease in abundance of bluegill in Coffeen Lake was most likely due to a decrease in reproduction. In Newton Lake, other factors caused the disproportionate shifts in bluegill and bass abundance from age-0+ to age-1+.

Comparisons of seining CPU were biased for 1997 because only late-August sampling was conducted in that year. In Newton Lake, largemouth bass were collected at 1.58 CPU in 1997 and 1.30 CPU in August 1999 (40 seine hauls). However, 400 seine hauls throughout spring and summer in 1998 and 1999 resulted in 41% fewer largemouth bass in 1999 (3.49 CPU) than in 1998 (5.90 CPU, Table 12.6).

The mean number of bass collected in Newton Lake was higher in both years than in Coffeen Lake (Table 12.7) or Lake of Egypt (Table 12.8). In Coffeen Lake, bass were collected at 1.50 CPU in August 1997 (20 seine hauls) and only 0.03 CPU in August 1999 (36 seine hauls). Two hundred seine hauls per year collected less than one half the number of largemouth bass in 1999 (0.17 CPU) than in 1998 (0.40 CPU, Table 12.7). Despite the percentage disparity between the years of collection, it should be pointed out that the CPUs in Coffeen Lake were very low throughout the study.

The number of largemouth bass collected during August in Lake of Egypt was similar in 1997 (2.35 CPU) and 1999 (2.53 CPU). In contrast to Newton and Coffeen lakes, over twice as many largemouth bass were collected per haul (200 hauls per year) in Lake of Egypt during 1999 (2.64 CPU) than in 1998 (1.29 CPU, Table 12.8). However, the CPUs in Lake of Egypt were also very low. An increase of 1.35 CPUs is probably not an indication of a major increase in largemouth bass production in Lake of Egypt during 1999. More important is the fact that the CPU did not decrease substantially in 1999 from 1998.

Seining throughout the spring and summer in Newton Lake resulted in a CPU of bluegill that decreased almost four fold in 1999 (1.06 CPU) as compared to 1998 (4.19 CPU, Table 12.6).

However, bluegills were collected at only 0.43 CPU in August 1997 as compared to 2.75 CPU in August 1999.

Bluegills in Coffeen Lake were less affected by the temperature and water level extremes in 1999. Seining CPUs for bluegill throughout spring and summer were similar in 1998 (6.47) and 1999 (5.81, Table 12.7). August CPUs were 2.90 in 1997 and 6.65 in 1999. In Lake of Egypt, bluegill CPUs increased each year (Table 12.8). The largest bluegill CPU increase occurred with August CPUs from 1997 (1.60) to 1999 (24.38).

In most cases, the use of August samples for comparison was less biased to bluegill CPUs than largemouth bass CPUs. Part of the reason is that age-0+ bluegills do not begin to contribute to the CPUs until June or July. One would expect to see lower CPUs for the entire season because there were at least two months when age-0+ bluegills were not contributing. However, largemouth bass may be negatively affected by August samples. Given the growth rates of largemouth bass young-of-the-year in Newton and Coffeen lakes, they are usually less susceptible to seining by July or August when the fish approach four inches in length. Examinations of length frequencies (Figures 12.10 - 12.21) support the discussion of abundance and trends apparent in Figures 12.1 - 12.9. Most of the contributions to the seining CPUs consisted of age-0+ bass that appear in late April or May and continued to be at least somewhat susceptible until at least late August. However, depending on their rate of growth and propensity to search for deeper water during the warmer months, their susceptibility may have decreased during the latter months of their first growing season. Sufficient largemouth bass reproduction occurred in Newton Lake (Figure 12.13) and Lake of Egypt (Figure 12.14) to further examine the trends described. The decline in largemouth bass numbers throughout the months in Newton

Lake is quite apparent in 1998 and 1999. Growth (thus susceptibility to seining), mortality, and a combination of the factors could account for the decreases over time.

Table 12.1. Electrofishing catch per hour for age-1+ largemouth bass collected by Southern Illinois University personnel during fall of each year. Largemouth bass ages were determined by examining their saggittae otoliths.

	1997		1998		1999	
Lake	Effort (hrs)	Catch per hour	Effort (hrs)	Catch per hour	Effort (hrs)	Catch per hour
Newton	9.3	1.94	6.3	9.84	9	3.11
Coffeen	4.8	3.33	7.3	6.03	5.1	7.06
Lake of Egypt	12.6	1.83	10.2	2.25	---	---

Table 12.2. Largemouth bass and bluegill collected by seining in three Illinois power-cooling lakes during August 1997 and April through August 1998 and 1999. The lakes were seined twice per month. Ten seine hauls were made in each of four segments in Newton Lake and in two segments in the remaining lakes. The number of age-0+ bluegill was extrapolated in relation to relative abundance of identifiable *Lepomis* species collected at each station.

Species	Lake	Year	Number per seine	Range		Standard deviation	Number per seine	Range		Standard deviation	Number of seine hauls
			Age-0				Age-1				
Micropterus salmoides	Coffeen	1997	1.50	0	15	3.35	0.00	0	0	0.00	20
	Coffeen	1998	0.39	0	8	1.11	0.01	0	1	0.10	200
	Coffeen	1999	0.15	0	15	1.12	0.01	0	1	0.07	196
	Egypt	1997	1.20	0	9	2.63	0.05	0	1	0.22	20
	Egypt	1998	1.26	0	12	2.12	0.03	0	2	0.20	200
	Egypt	1999	2.62	0	25	4.24	0.03	0	1	0.16	200
	Newton	1997	1.58	0	29	4.68	0.00	0	0	0.00	40
	Newton	1998	5.88	0	1,001	50.73	0.01	0	1	0.10	400
	Newton	1999	3.49	0	500	26.31	0.00	0	1	0.05	400
Lepomis macrochirus	Coffeen	1997	3.00	0	25	6.22	0.75	0	13	2.90	20
	Coffeen	1998	2.13	0	103	9.46	3.37	0	45	6.02	200
	Coffeen	1999	4.67	0	427	31.71	1.18	0	15	2.55	196
	Egypt	1997	8.00	0	73	17.45	0.50	0	4	1.24	20
	Egypt	1998	3.98	0	118	13.52	2.17	0	25	4.17	200
	Egypt	1999	8.59	0	150	23.82	2.14	0	25	3.93	200
	Newton	1997	0.23	0	4	0.73	0.03	0	1	0.16	40
	Newton	1998	0.58	0	27	2.09	3.45	0	89	9.81	400
	Newton	1999	0.15	0	9	0.68	0.38	0	21	1.41	400

Table 12.3. Age-0+ largemouth bass and bluegill collected by seining in three Illinois power cooling reservoirs. Ten stations were sampled in each segment in each lake twice monthly during August 1997 and April through August 1999.

Species	Lake	Year	Segment 1	Standard deviation	Segment 2	Standard deviation	Segment 3	Standard deviation	Segment 4	Standard deviation
Micropterus salmoides	Newton	1997	0.30	0.48	0.70	1.57	3.40	9.06	1.90	1.91
		1998	3.31	12.35	13.59	100.30	3.88	7.78	2.73	4.34
		1999	1.20	3.63	6.63	49.94	1.72	3.55	4.39	15.85
	Weighted mean		**2.16**	**8.93**	**9.66**	**77.21**	**2.83**	**6.27**	**3.48**	**11.35**
	Coffeen	1997	0.60	0.84	2.40	4.60				
		1998	0.09	0.32	0.68	1.48				
		1999	0.10	0.40	0.20	1.52				
	Weighted mean		**2.29**	**3.70**	**2.94**	**4.72**				
	Egypt	1997	1.60	3.06	0.80	2.20				
		1998	1.26	1.85	1.25	2.36				
		1999	1.77	2.96	2.03	3.76				
	Weighted mean		**0.12**	**0.41**	**0.53**	**1.81**				
Lepomis macrochirus	Newton	1997	0.10	0.32	0.50	1.27	0.30	0.67	0.00	0.00
		1998	0.53	2.23	0.85	3.18	0.39	1.02	0.57	1.21
		1999	0.08	0.27	0.10	0.39	0.17	0.78	0.23	1.00
	Weighted mean		**0.30**	**1.56**	**0.48**	**2.25**	**0.28**	**0.90**	**0.38**	**1.10**
	Coffeen	1997	2.80	4.52	3.20	7.81				
		1998	1.28	4.02	2.97	12.74				
		1999	0.84	2.98	8.34	44.10				
	Weighted mean		**1.15**	**3.60**	**5.54**	**31.75**				
	Egypt	1997	3.80	8.47	12.20	23.07				
		1998	5.59	17.49	2.38	7.49				
		1999	11.00	27.42	6.18	19.41				
	Weighted mean		**8.08**	**22.63**	**4.66**	**15.31**				

Table 12.4. Age-1 bluegill collected by seining in three Illinois power cooling reservoirs. Ten stations were sampled in each segment in each lake twice monthly during August 1997 and April through August 1999.

Species	Lake	Year	Segment 1	Standard deviation	Segment 2	Standard deviation	Segment 3	Standard deviation	Segment 4	Standard deviation
Lepomis macrochirus	Newton	1997	0.00	0.00	0.00	0.00	0.10	0.32	0.00	0.00
		1998	4.12	10.79	6.14	15.17	1.56	3.12	1.96	4.26
		1999	0.68	2.37	0.55	1.31	0.18	0.56	0.11	0.35
	Weighted mean		**2.29**	**7.80**	**3.19**	**10.85**	**0.83**	**2.29**	**0.99**	**3.08**
	Coffeen	1997	0.00	0.00	1.50	4.06				
		1998	2.25	4.66	4.48	6.97				
		1999	0.71	1.91	1.63	2.98				
	Weighted mean		**1.42**	**3.59**	**2.98**	**5.47**				
	Egypt	1997	0.10	0.32	0.90	1.66				
		1998	1.70	3.67	2.63	4.58				
		1999	1.54	2.94	2.73	4.66				
	Weighted mean		**1.55**	**3.25**	**2.60**	**4.53**				

Table 12.5. Fish collected by seining in three power cooling lakes in Illinois during August 1997 and April through August 1998 and 1999.

Segment	Mean number per seine	Range		Standard deviation	Number of seine hauls
		Newton 1997			
1	1.90	0	8	2.56	10
2	1.70	0	9	2.87	10
3	4.00	0	34	10.61	10
4	4.30	0	18	5.12	10
Weighted mean	**2.98**	**0**	**34**	**6.07**	**40**
		Newton 1998			
1	20.44	0	551	57.78	100
2	23.59	0	1,007	101.49	100
3	8.07	0	51	10.22	100
4	13.40	0	347	36.43	100
Weighted mean	**16.38**	**0**	**1,007**	**61.45**	**400**
		Newton 1999			
1	8.78	0	89	14.76	100
2	9.37	0	501	50.01	100
3	5.22	0	76	9.95	100
4	8.18	0	125	17.30	100
Weighted mean	**7.89**	**0**	**501**	**27.86**	**400**
		Coffeen 1997			
1	6.30	0	19	7.13	10
2	11.30	0	50	19.50	10
Weighted mean	**8.80**	**0**	**50**	**14.52**	**20**
		Coffeen 1998			
1	6.68	0	55	10.35	100
2	17.23	0	365	41.40	100
Weighted mean	**11.96**	**0**	**365**	**30.56**	**200**
		Coffeen 1999			
1	3.65	0	40	5.81	96
2	13.80	0	464	47.80	100
Weighted mean	**8.83**	**0**	**464**	**34.67**	**196**

From SAS?
hauls

Table 12.5. Continued.

Segment	Mean number per seine	Range		Standard deviation	Number of seine hauls
		Egypt 1997			
1	19.90	0	51	16.32	10
2	37.80	1	176	55.97	10
Weighted mean	**28.85**	**0**	**176**	**41.16**	**20**
		Egypt 1998			
1	13.16	0	130	22.50	100
2	11.72	0	105	18.63	100
Weighted mean	**12.44**	**0**	**130**	**20.61**	**200**
		Egypt 1999			
1	43.15	0	1,355	153.56	100
2	17.96	0	159	28.26	100
Weighted mean	**30.56**	**0**	**1,355**	**110.85**	**200**

Table 12.6 Fish taxa collected by seining in Newton Lake during August 1997 and April through August 1998 and 1999.

Family	Species	Number per seine	Range		Standard deviation	Number of seine hauls
		1997				
Centrarchidae	*Micropterus salmoides*	1.58	0	29	4.68	40
	Lepomis gulosus	0.05	0	2	0.32	40
	Lepomis macrochirus	0.43	0	7	1.34	40
	Lepomis humilus	0.08	0	1	0.27	40
	Lepomis spp.	0.03	0	1	0.16	40
	Subtotal for *Lepomis* spp.	0.58	0	7	1.57	40
Clupeidae	*Dorosoma cepedianum*	0.65	0	16	2.58	40
Cyprinidae	*Cyprinus carpio*	0.03	0	1	0.16	40
Fundulidae	*Fundulus notatus*	0.23	0	3	0.62	40
		1998				
Centrarchidae	*Micropterus salmoides*	5.90	0	1,001	50.73	400
	Lepomis macrochirus	4.19	0	90	10.36	400
	Lepomis megalotis	0.03	0	2	0.18	400
	Lepomis cyanellus	0.03	0	2	0.19	400
	Lepomis microlophus	0.00	0	1	0.05	400
	Lepomis humilis	0.04	0	2	0.24	400
	Lepomis spp.	0.37	0	21	1.31	400
	Subtotal for *Lepomis* spp.	4.66	0	90	10.46	400
Cyprinidae	*Cyprinus carpio*	0.03	0	1	0.17	400
Ictaluridae	*Ictalurus punctatus*	0.04	0	3	0.23	400
Clupeidae	*Dorosoma cepedianum*	5.49	0	549	33.90	400
Fundulidae	*Fundulus notatus*	0.25	0	27	1.52	400
Moronidae	*Morone chrysops*	0.00	0	1	0.05	400

Table 12.6 Continued.

Family	Species	Number per seine	Range		Standard deviation	Number of seine hauls
	1999					
Centrarchidae	*Micropterus salmoides*	3.49	0	500	26.31	400
	Lepomis macrochirus	1.06	0	23	2.44	400
	Lepomis megalotis	0.12	0	7	0.53	400
	Lepomis cyanellus	0.04	0	4	0.26	400
	Lepomis humilis	0.01	0	1	0.07	400
	Lepomis spp.	0.41	0	89	4.68	400
	Subtotal for *Lepomis* spp.	1.62	0	89	5.27	400
Moronidae	*Morone chrysops*	0.00	0	1	0.05	400
Fundulidae	*Fundulus notatus*	0.22	0	12	1.03	400
Clupeidae	*Dorosoma cepedianum*	2.45	0	76	8.39	400
Cyprinidae	*Cyprinus carpio*	0.02	0	1	0.13	400
	Notemigonus crysoleucas	0.07	0	8	0.61	400
Ictaluridae	*Ictalurus punctatus*	0.01	0	1	0.11	400

Table 12.7. Fish taxa collected by seining in Coffeen Lake during August 1997 and April through August 1998 and 1999.

Family	Species	Number per seine	Range		Standard deviation	Number of seine hauls
		1997				
Centrarchidae	*Micropterus salmoides*	1.50	0	15	3.35	20
	Lepomis macrochirus	2.90	0	21	5.51	20
	Lepomis megalotis	0.05	0	1	0.22	20
	Lepomis spp.	2.30	0	25	7.11	20
	Subtotal for *Lepomis* spp.	5.25	0	47	11.24	20
Ictaluridae	*Noturus* spp.	0.25	0	5	1.12	20
Clupeidae	*Dorosoma cepedianum*	1.05	0	18	4.02	20
Poeciliidae	*Gambusia affinis*	0.30	0	3	0.92	20
Fundulidae	*Fundulus notatus*	0.45	0	5	1.23	20
		1998				
Centrarchidae	*Micropterus salmoides*	0.40	0	8	1.11	200
	Lepomis macrochirus	6.47	0	92	10.20	200
	Lepomis megalotis	0.08	0	4	0.37	200
	Lepomis cyanellus	0.05	0	4	0.34	200
	Lepomis microlophus	0.16	0	4	0.55	200
	Lepomis spp.	1.23	0	71	6.38	200
	Subtotal for *Lepomis* spp.	7.98	0	112	13.52	200
Cyprinidae	*Notemigonus crysoleucas*	0.01	0	1	0.10	200
Ictaluridae	*Ictalurus punctatus*	0.02	0	3	0.22	200
Clupeidae	*Dorosoma cepedianum*	2.01	0	300	21.33	200
Poeciliidae	*Gambusia affinis*	1.19	0	105	8.34	200
	Fundulus notatus	0.36	0	11	1.54	200

Table 12.7. Continued.

Family	Species	Number per seine	Range		Standard deviation	Number of seine hauls
	1999					
Centrarchidae	*Micropterus salmoides*	0.17	0	15	1.13	196
	Lepomis macrochirus	5.81	0	385	28.32	196
	Lepomis megalotis	0.09	0	3	0.38	196
	Lepomis cyanellus	0.02	0	2	0.16	196
	Lepomis microlophus	0.22	0	7	0.75	196
	Lepomis spp.	1.35	0	88	7.77	196
	Subtotal for *Lepomis* spp.	7.48	0	456	33.86	196
Moronidae	*Morone mississippiensis*	0.01	0	1	0.07	196
Atherinidae	*Menidia beryllina*	0.30	0	39	3.12	196
Ictaluridae	*Noturus* spp.	0.01	0	1	0.07	196
	Ictalurus punctatus	0.02	0	1	0.12	196
	Subtotal for Ictaluridae	0.02	0	1.00	0.07	196
Fundulidae	*Fundulus notatus*	0.08	0	5	0.49	196
Poeciliidae	*Gambusia affinis*	0.51	0	30	2.88	196
Clupeidae	*Dorosoma cepedianum*	0.23	0	8	1.06	196

Table 12.8. Fish taxa collected by seining in Lake of Egypt during August 1997 and April through August 1998.

Family	Species	Number per seine	Range		Standard deviation	Number of seine hauls
		1997				
Centrarchidae	*Micropterus salmoides*	1.25	0	9	2.65	20
	Micropterus punctulatus	1.10	0	8	2.22	20
	Subtotal for *Micropterus* spp.	2.35	0	17	4.18	20
	Lepomis macrochirus	1.60	0	5	1.90	20
	Lepomis microlophus	0.10	0	1	0.31	20
	Lepomis spp.	9.40	0	73	17.65	20
	Subtotal for *Lepomis* spp.	11.10	0	75	17.82	20
	Pomoxis nigromacula	0.80	0	13	2.91	20
Cyprinidae	*Pimephales notatus*	0.65	0	11	2.48	20
	Notemigonus crysoleucas	0.15	0	2	0.49	20
	Subtotal for Cyprinidae	0.80	0	12	2.71	20
Ictaluridae	*Noturus* spp.	0.05	0	1	0.22	20
Fundulidae	*Fundulus notatus*	11.00	0	69	19.32	20
Atherinidae	*Menidia beryllina*	2.75	0	49	10.97	20
		1998				
Centrarchidae	*Micropterus salmoides*	1.29	0	13	2.14	200
	Lepomis macrochirus	6.29	0	125	15.14	200
	Lepomis megalotis	0.07	0	4	0.38	200
	Lepomis microlophus	0.58	0	21	1.98	200
	Lepomis humilis	0.02	0	1	0.14	200
	Lepomis spp.	0.37	0	15	1.41	200
	Subtotal for *Lepomis* spp.	7.32	0	126	16.81	200
	Pomoxis nigromaculatus	0.03	0	2	0.20	200
	Pomoxis annularis	0.01	0	1	0.07	200
	Subtotal *Pomoxis* spp.	0.04	0	2	0.21	200
Percidae	*Percina* spp.	0.01	0	1	0.07	200
Clupeidae	*Dorosoma petenense*	0.02	0	3	0.22	200
	Dorosoma cepedianum	0.03	0	2	0.19	200
	Subtotal for Clupeidae	0.05	0	3	0.29	200
Poeciliidae	*Gambusia affinis*	0.01	0	1	0.10	200

Table 12.8 Continued.

Family	Species	Number per seine	Range		Standard deviation	Number of seine hauls
Fundulidae	*Fundulus notatus*	1.08	0	27	3.45	200
Atherinidae	*Menidia beryllina*	2.46	0	59	7.47	200
Cyprinidae	*Pimephales notatus*	0.17	0	7	0.80	200
	Notemigonus crysoleucas	0.03	0	3	0.25	200
	Subtotal for Cyprinidae	0.20	0	7	0.86	200
Esocidae	*Esox niger*	0.01	0	1	0.10	200
		1999				
Centrarchidae	*Micropterus salmoides*	2.64	0	25	4.25	200
	Lepomis macrochirus	8.59	0	151	20.66	200
	Lepomis gulosus	0.03	0	1	0.16	200
	Lepomis megalotis	0.38	0	7	1.02	200
	Lepomis cyanellus	0.01	0	1	0.10	200
	Lepomis microlophus	0.88	0	14	1.98	200
	Lepomis spp.	2.87	0	127	13.91	200
	Subtotal for *Lepomis* spp.	12.75	0	154	25.84	200
	Pomoxis nigromaculatus	0.03	0	4	0.30	200
	Pomoxis annularis	0.02	0	1	0.12	200
	Subtotal *Pomoxis* spp.	0.05	0	4	0.32	200
Clupeidae	*Dorosoma cepedianum*	1.64	0	320	22.63	200
	Dorosoma petenense	0.06	0	5	0.46	200
Atherinidae	*Menidia beryllina*	12.25	0	1020	88.74	200
Fundulidae	*Fundulus notatus*	0.60	0	12	1.51	200
Poeciliidae	*Gambusia affinis*	0.15	0	21	1.51	200
Esocidae	*Esox niger*	0.02	0	1	0.12	200
Ictaluridae	*Ictalurus punctatus*	0.01	0	1	0.07	200
Cyprinidae	*Cyprinus carpio*	0.01	0	1	0.07	200
	Pimephales notatus	0.01	0	1	0.07	200
	Notemigonus crysoleucas	0.05	0	4	0.34	200
	Pimephales notatus	0.32	0	13	1.50	200
Percidae	*Percina* spp.	0.01	0	1	0.07	200

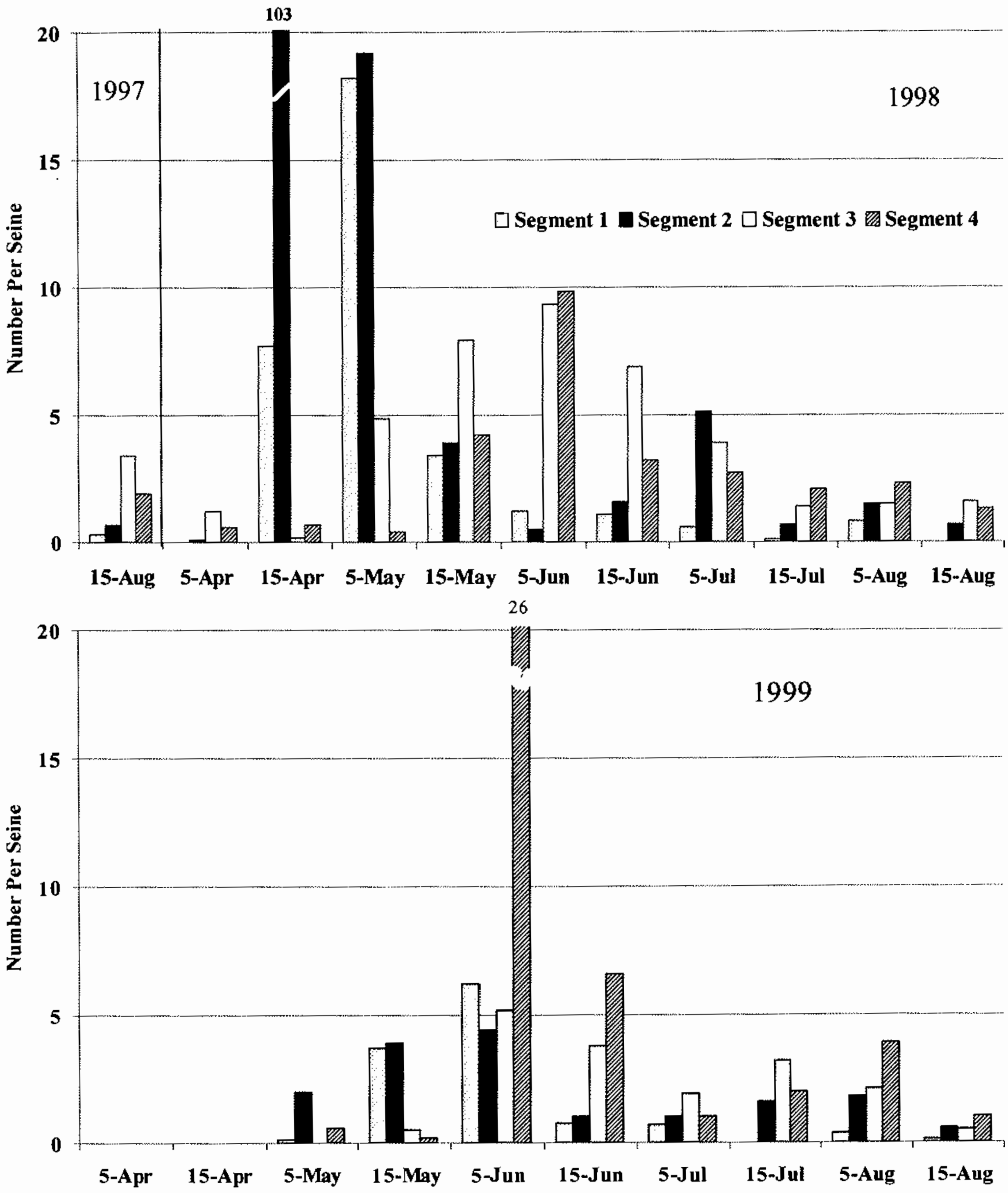


Figure 12.1. Mean number of age-0+ largemouth bass collected by seining in Newton Lake during August 1997, and April through August 1998 and 1999. Ten stations were sampled twice monthly in each segment.

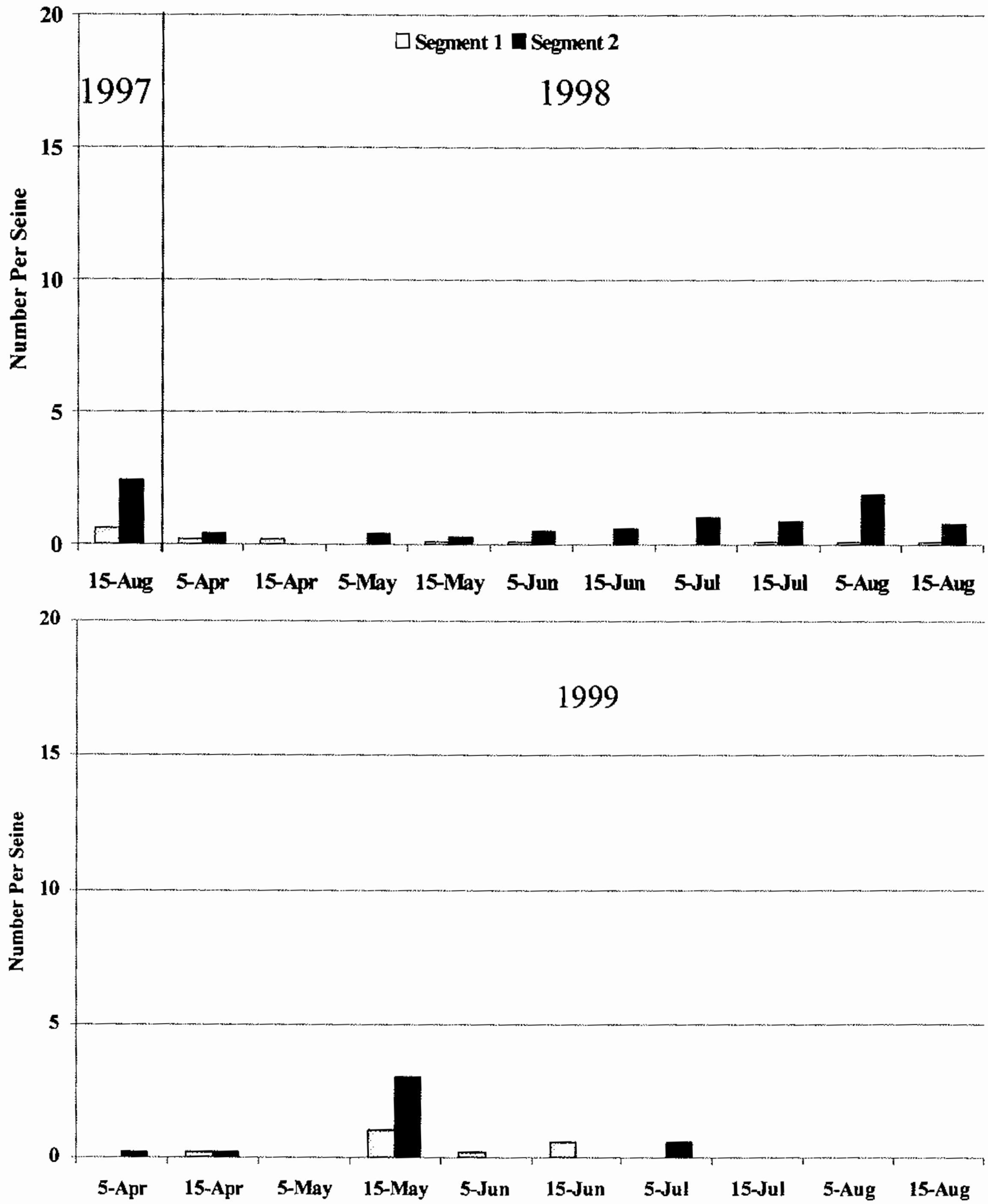


Figure 12.2. Mean number of age-0+ largemouth bass collected by seining in Coffeen Lake during August 1997, and April through August 1998 and 1999. Ten stations were sampled twice monthly in each segment.

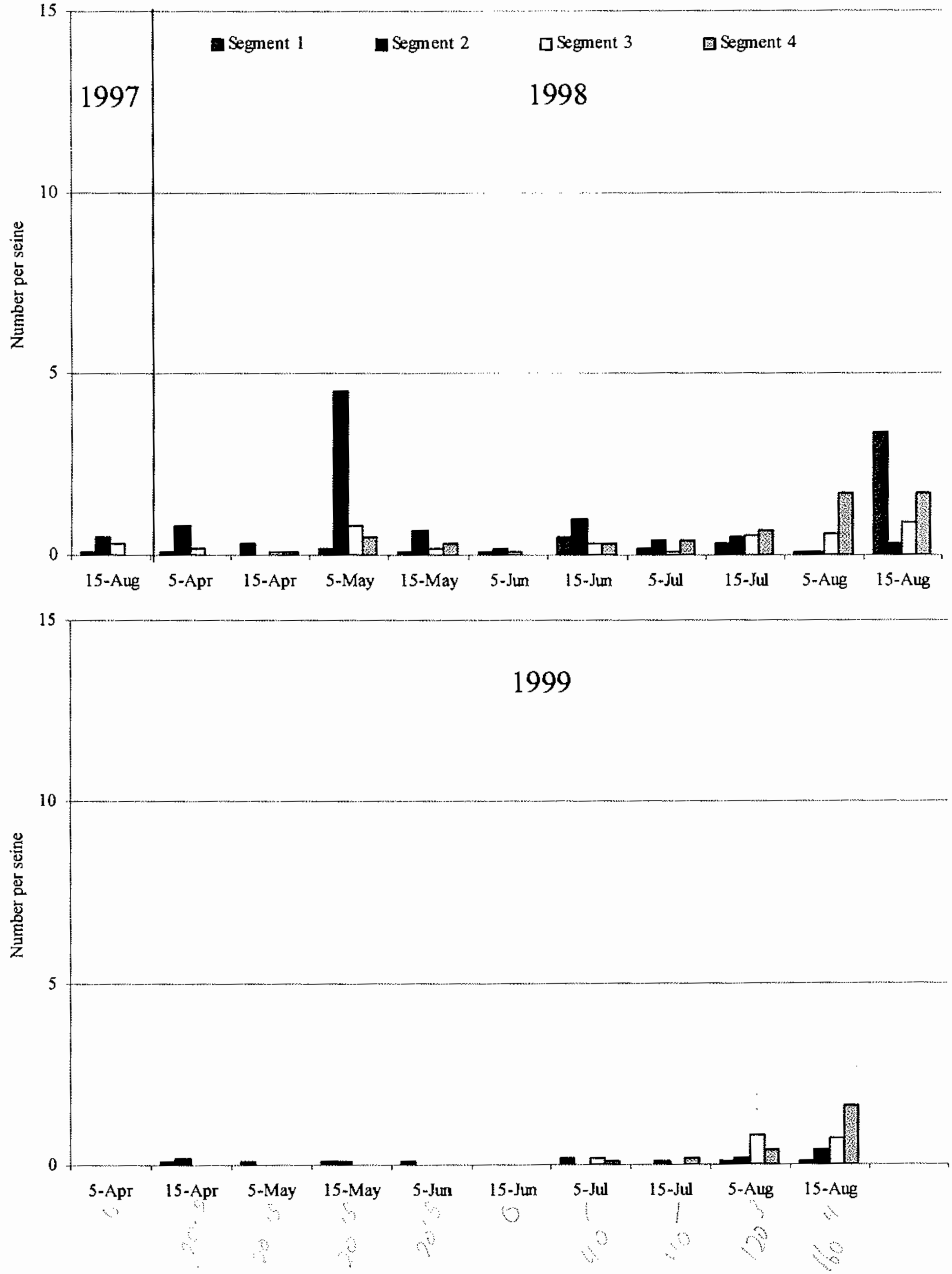


Figure 12.3. Mean number of age-0+ bluegill collected by seining in Newton Lake during August 1997 and April through August 1998 and 1999. Ten stations were sampled twice monthly in each segment.

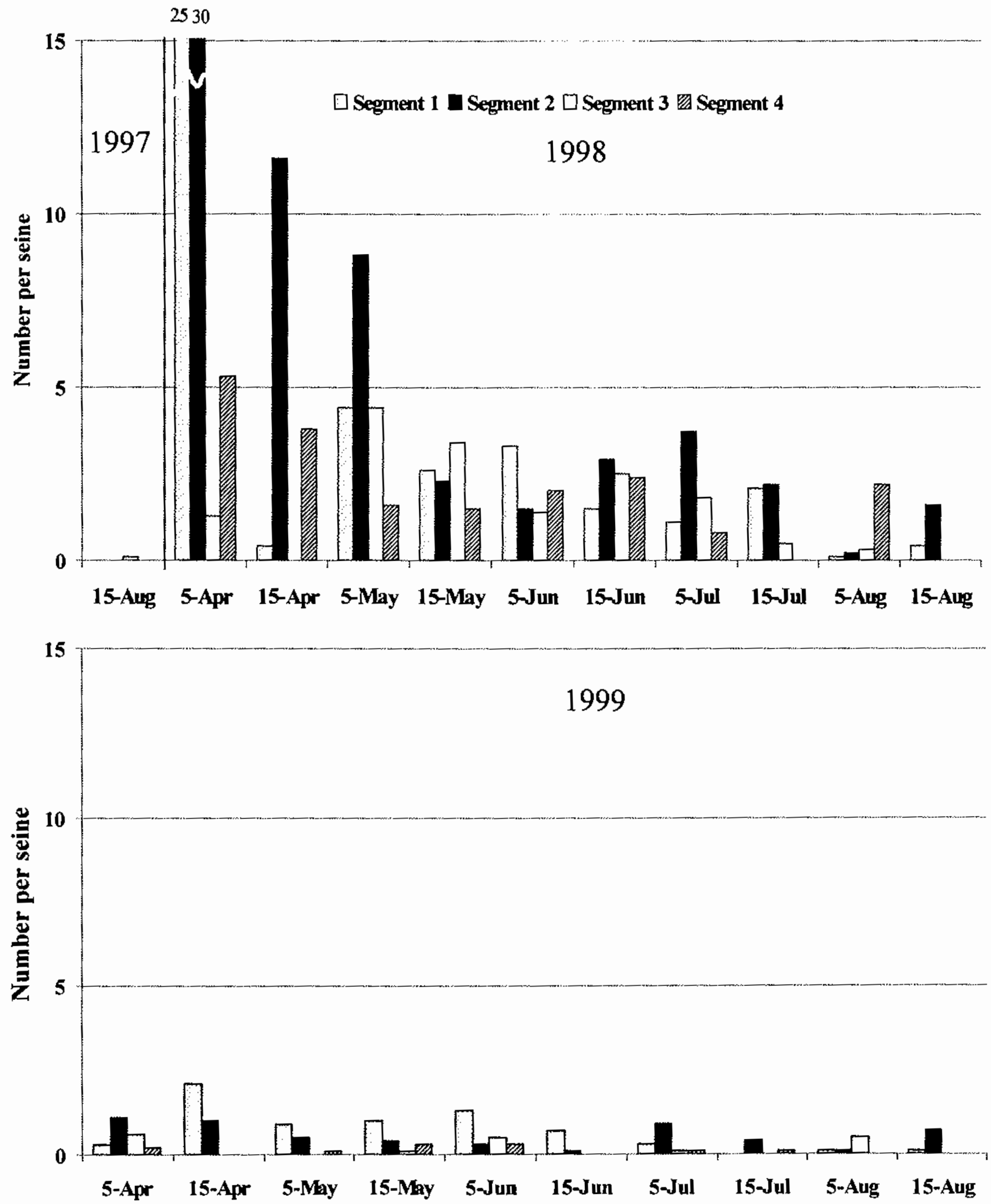


Figure 12.4. Mean number of age-1+ bluegill collected by seining in Newton Lake during August 1997 and April through August 1998 and 1999. Ten stations were sampled twice monthly in each segment.

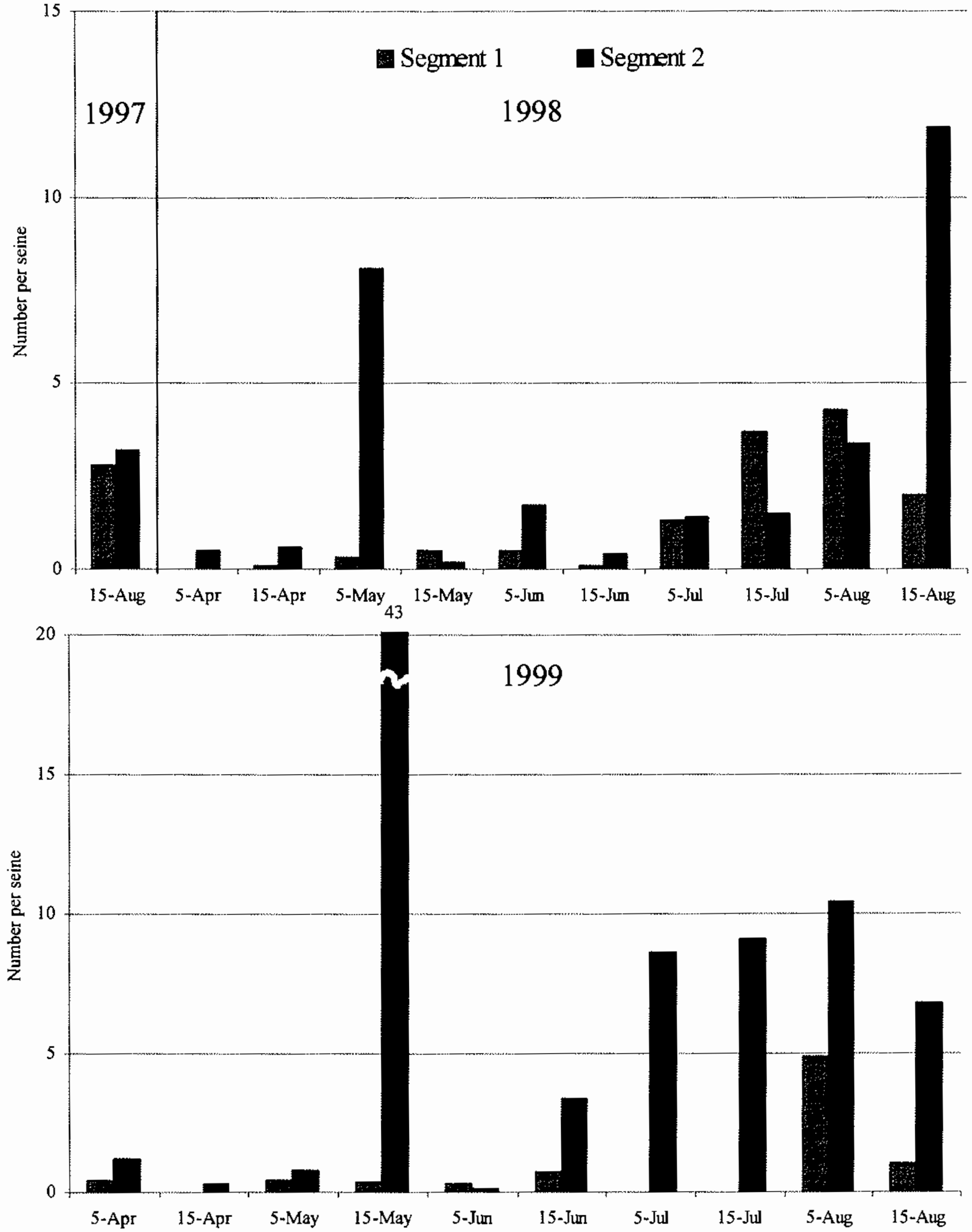


Figure 12.5. Mean number of age-0+ bluegill collected by seining in Coffeen Lake during August 1997 and April through August 1998 and 1999. Ten stations were sampled twice monthly in each segment.

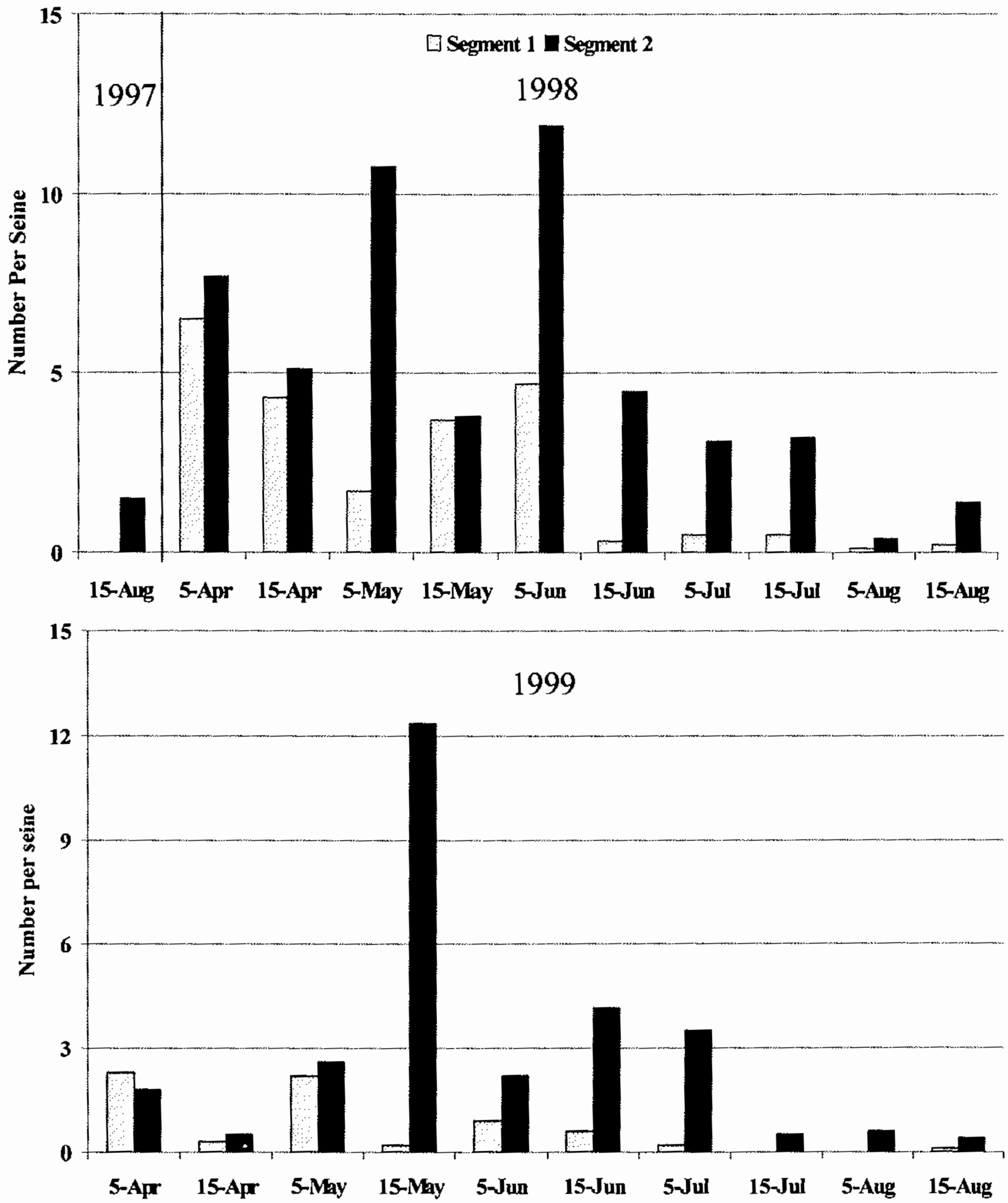


Figure 12.6. Mean number of age-1+ bluegill collected by seining in Coffeen Lake during August 1997 and April through August 1998 and 1999. Ten stations were sampled twice monthly in each segment.

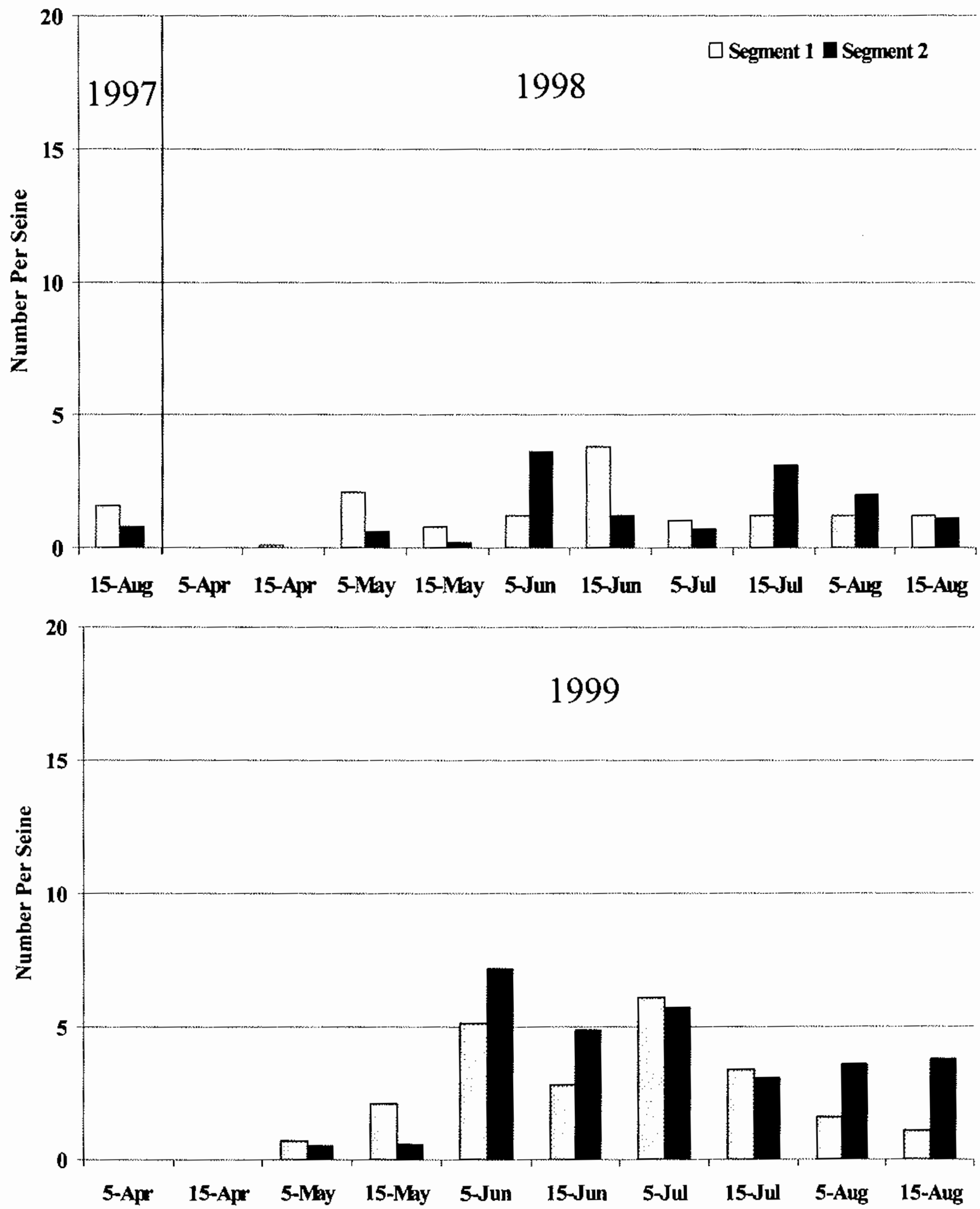
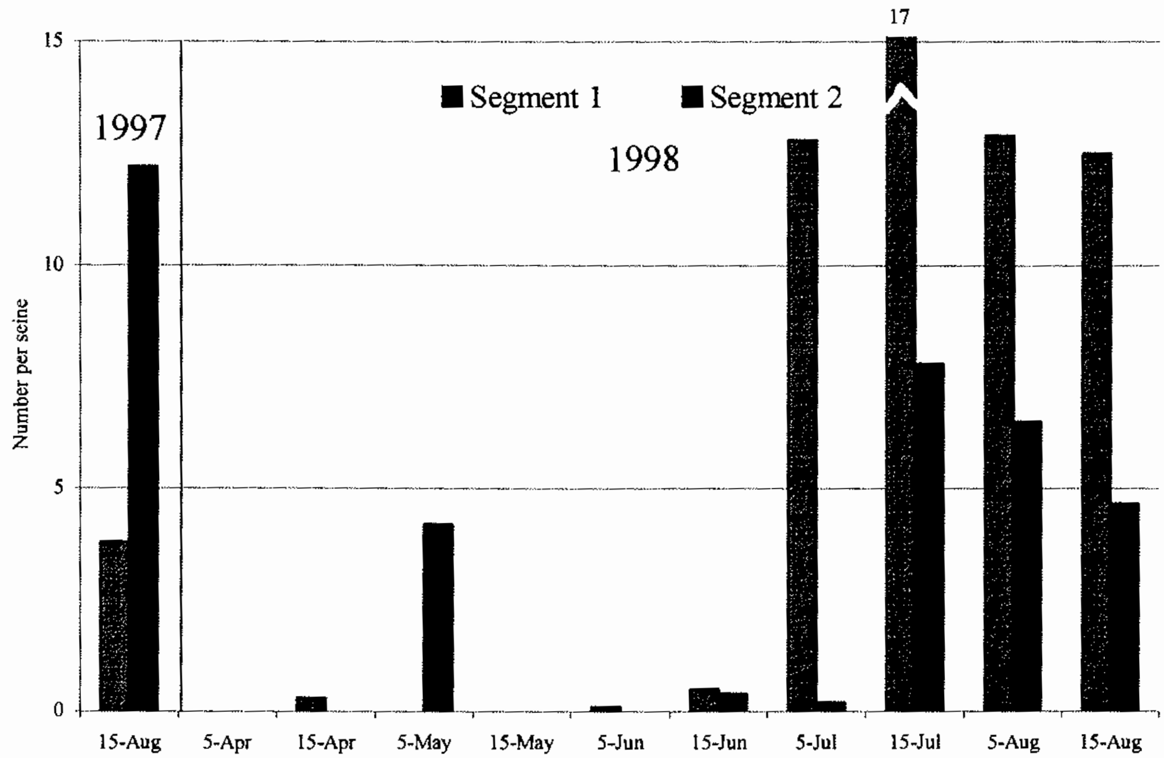


Figure 12.7. Mean number of age-0+ largemouth bass collected by seining in Lake of Egypt during August 1997 and April through August 1998 and 1999. Ten stations were sampled twice monthly in each segment.



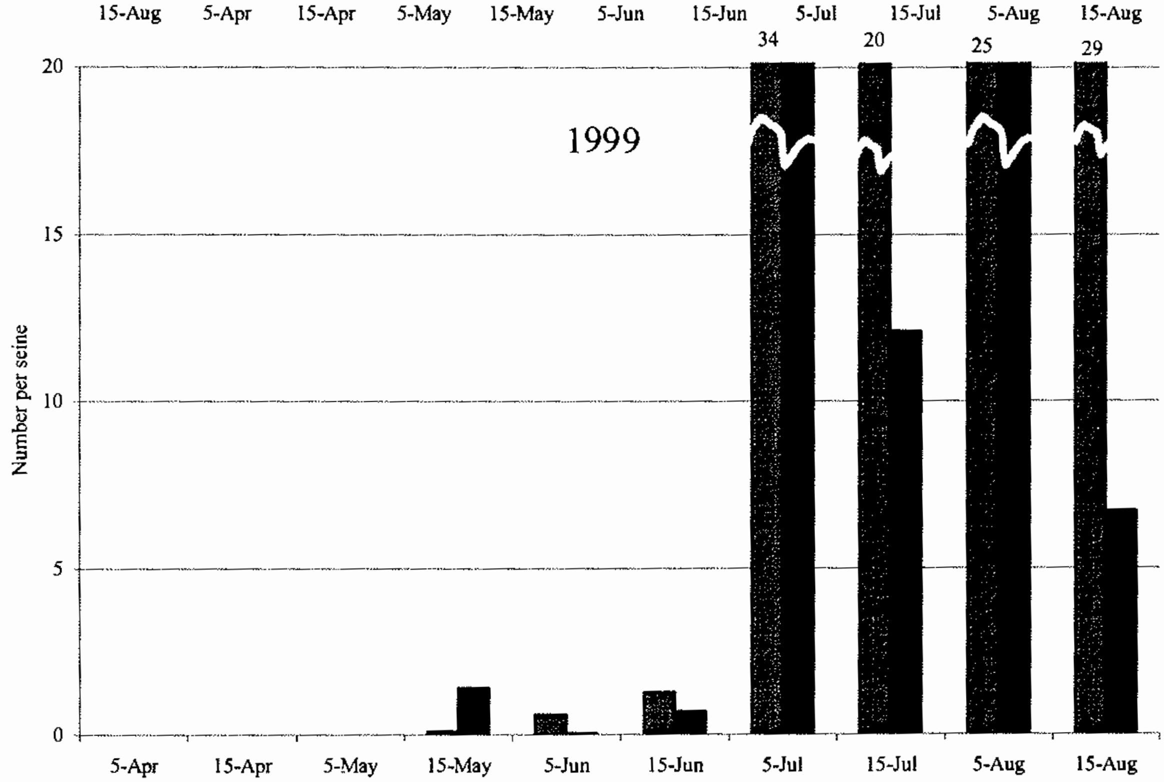


Figure 12.8. Mean number of age-0+ bluegill collected by seining in Lake of Egypt during August 1997 and April through August 1998 and 1999. Ten stations were sampled twice monthly in each segment.

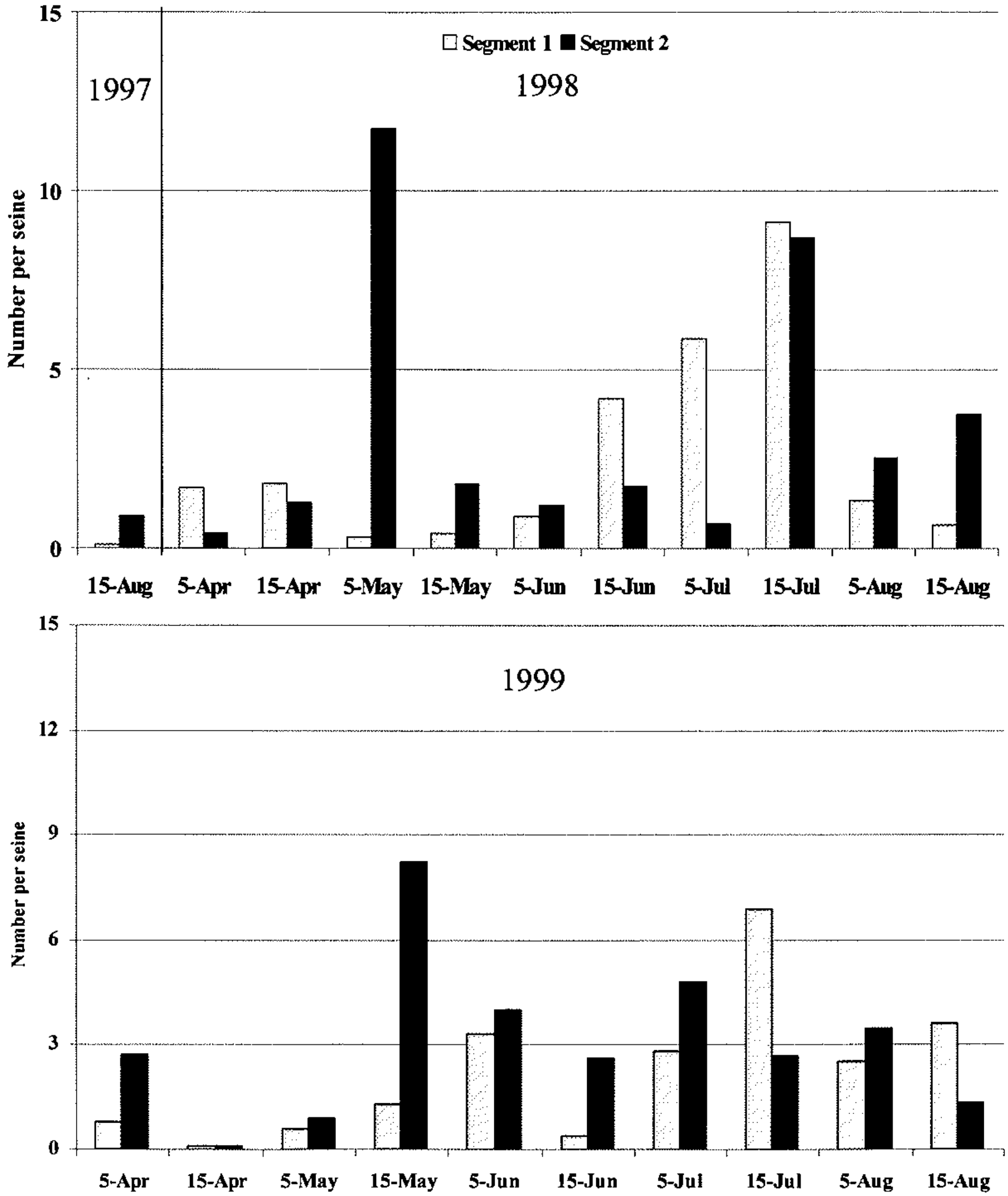


Figure 12.9. Mean number of age-1+ bluegill collected by seining in Lake of Egypt during August 1997 and April through August 1998 and 1999. Ten stations were sampled twice monthly in each segment.

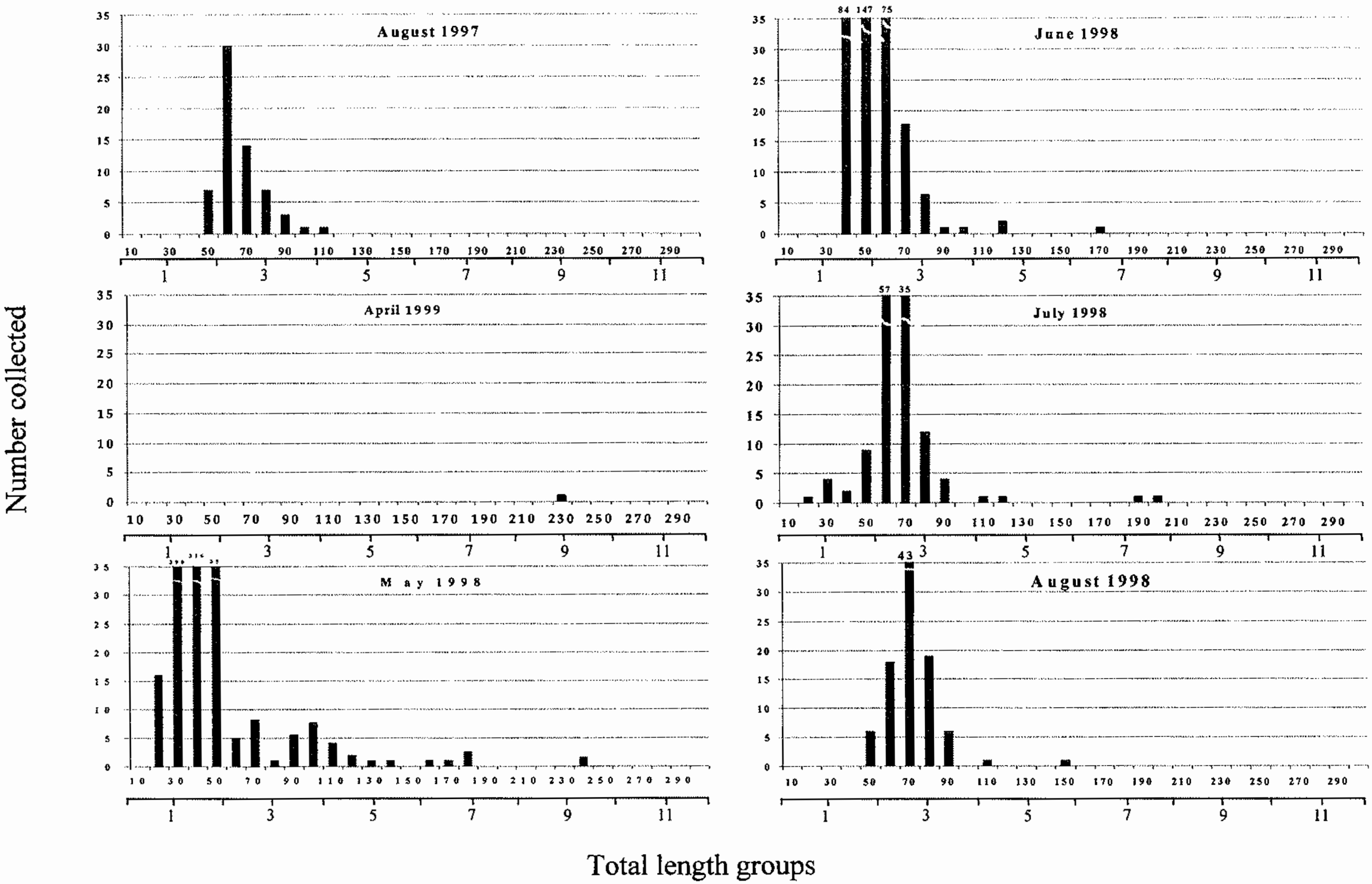


Figure 12.10. Length frequencies of all largemouth bass collected using seine hauls in Newton Lake during August 1997 and April through August 1998. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

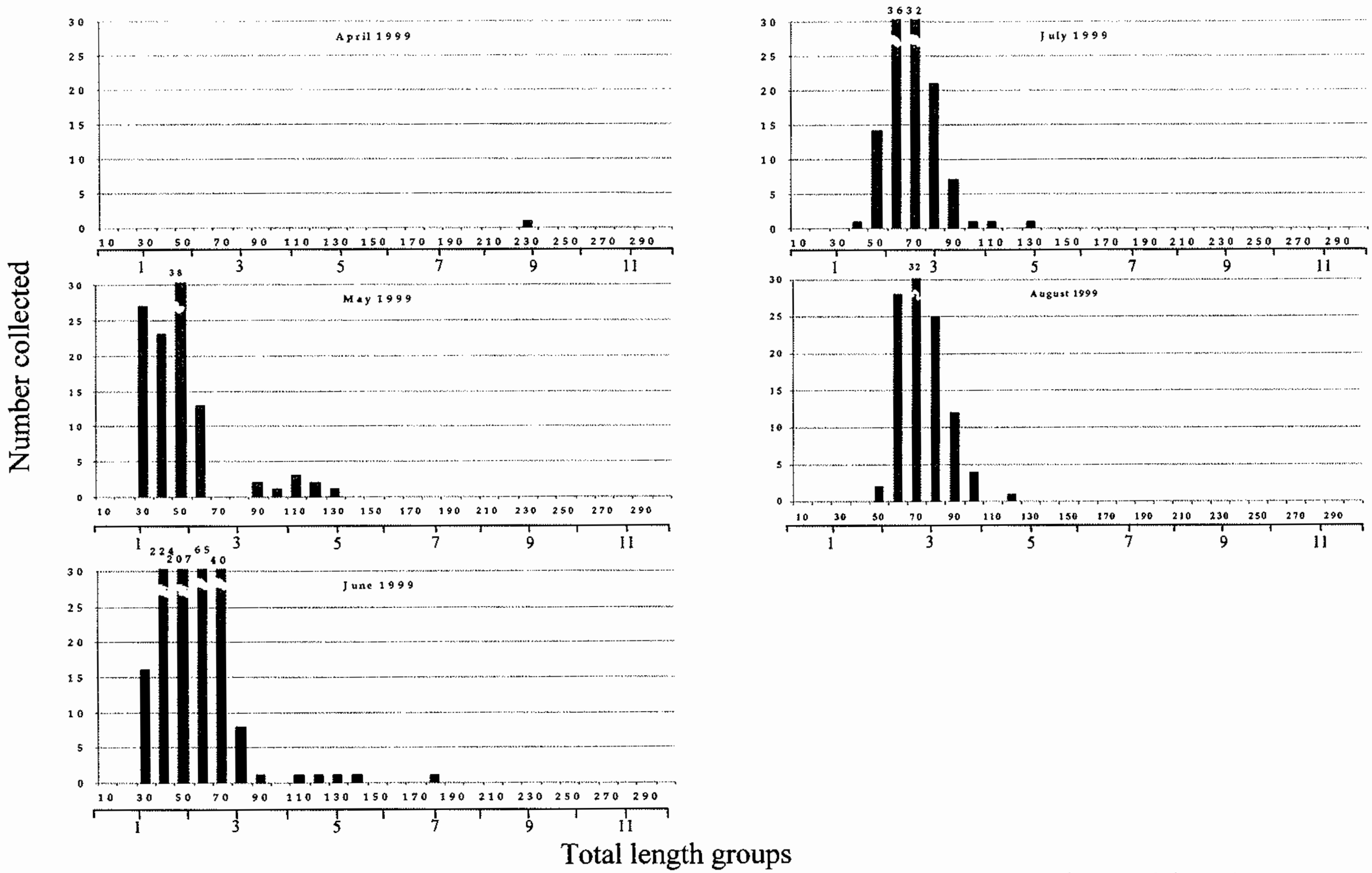


Figure 12.11. Length frequencies of all largemouth bass collected using seine hauls in Newton Lake during April through August 1998. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

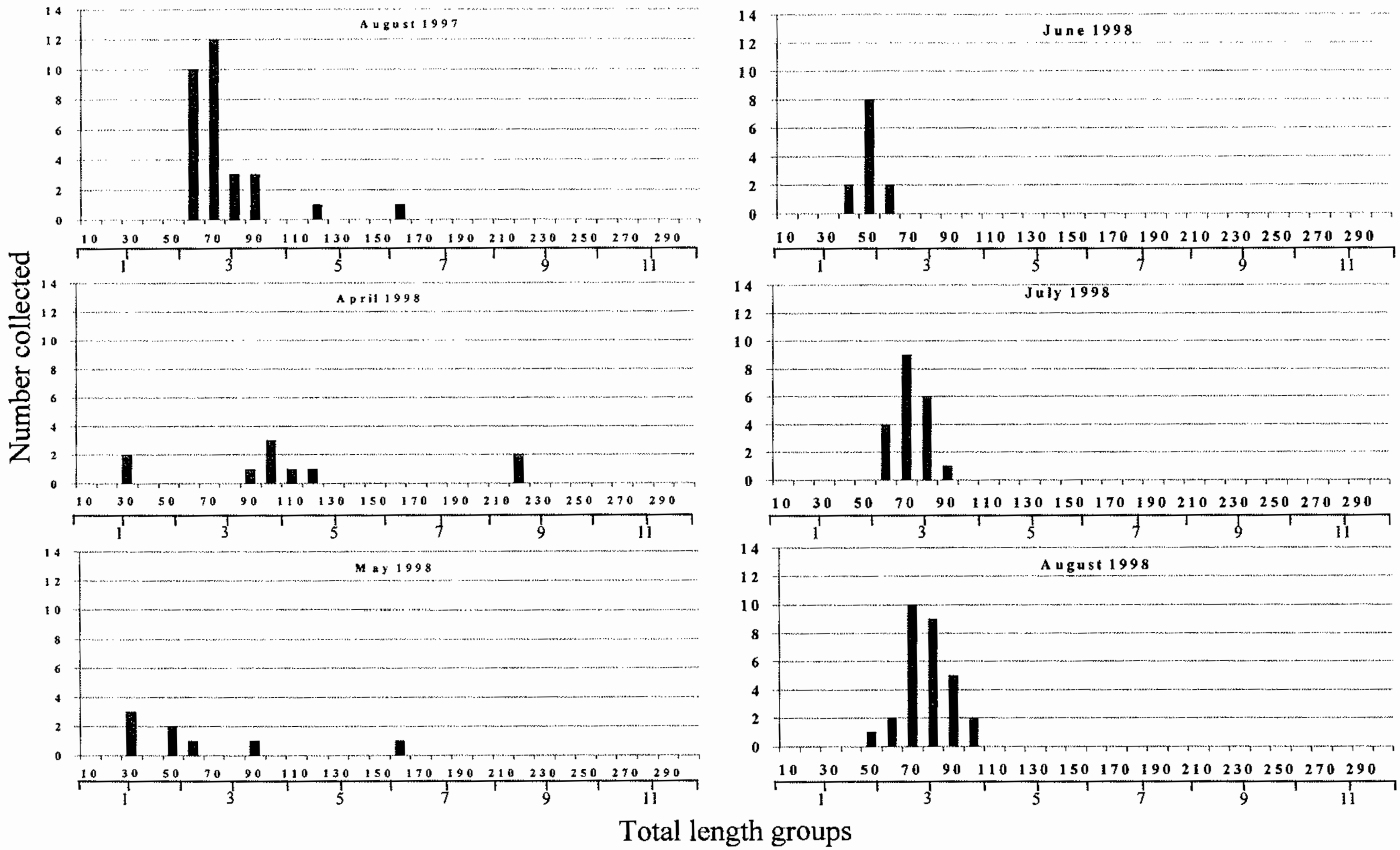


Figure 12.12. Length frequencies of all largemouth bass collected using seine hauls in Coffeen Lake during August 1997 and April through August 1998. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

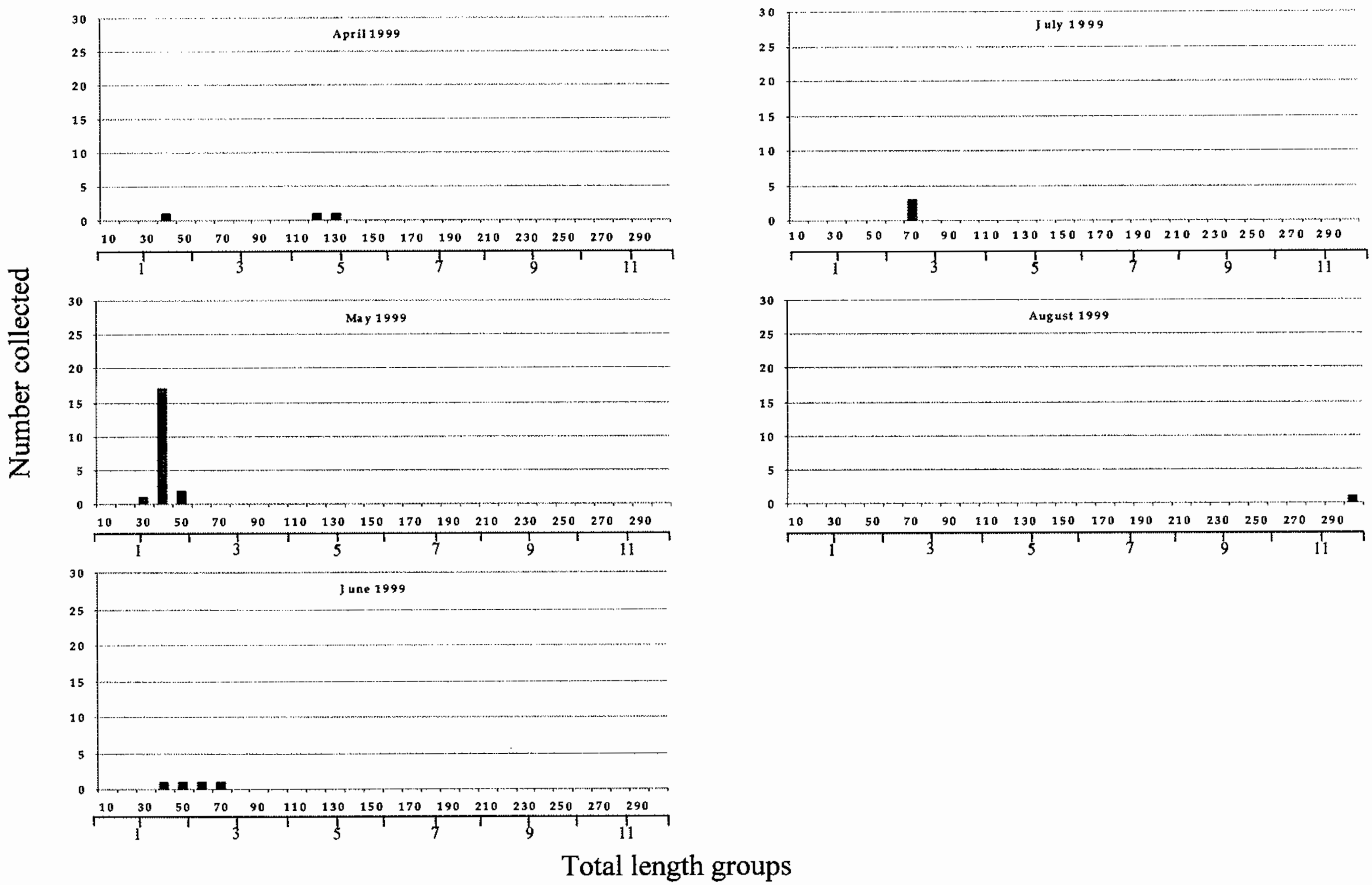


Figure 12.13. Length frequencies of all largemouth bass collected using seine hauls in Coffeen Lake during April through August 1999. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

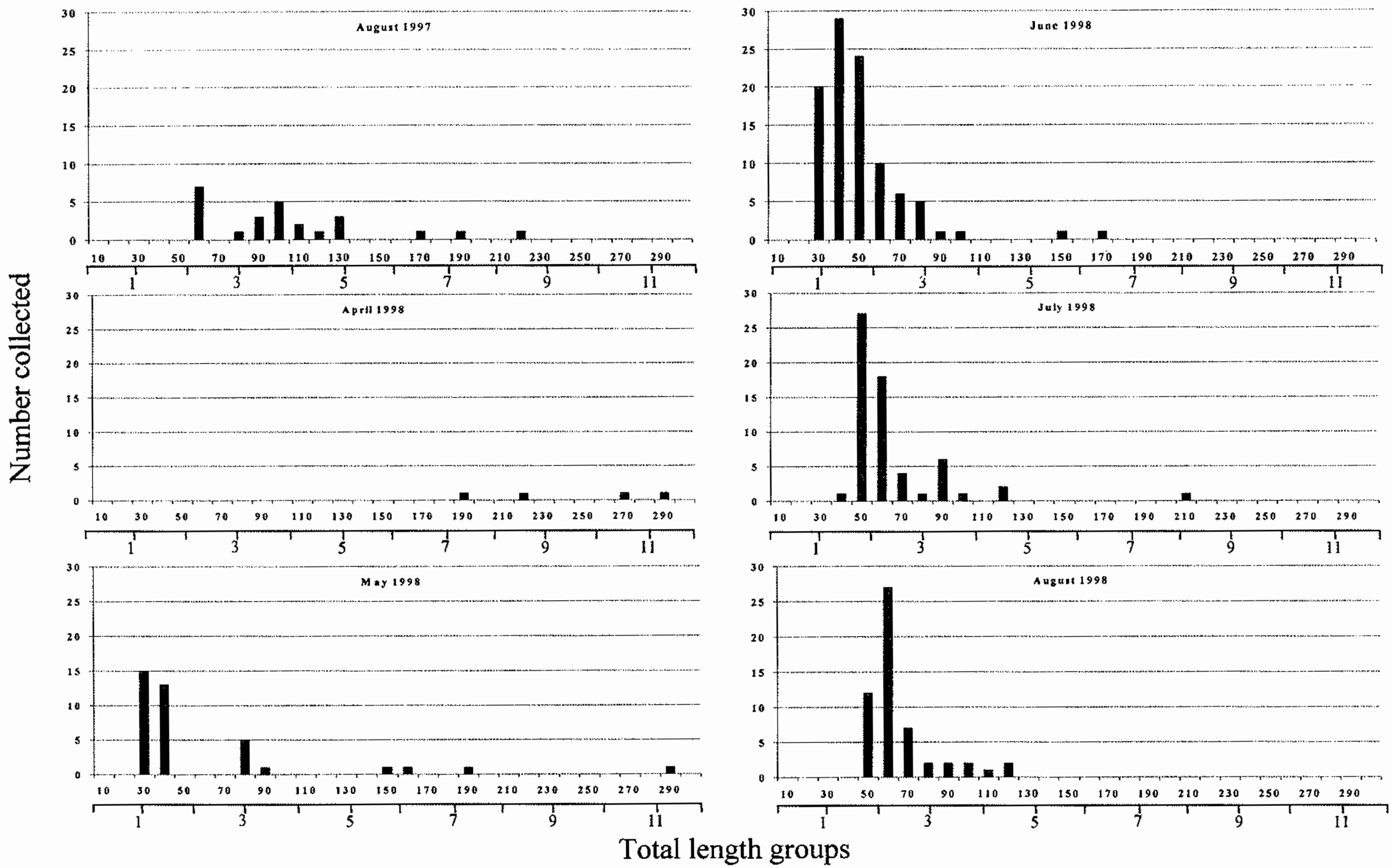


Figure 12.14. Length frequencies of all largemouth bass collected using seine hauls in Lake of Egypt during August 1997 and April through August 1998. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

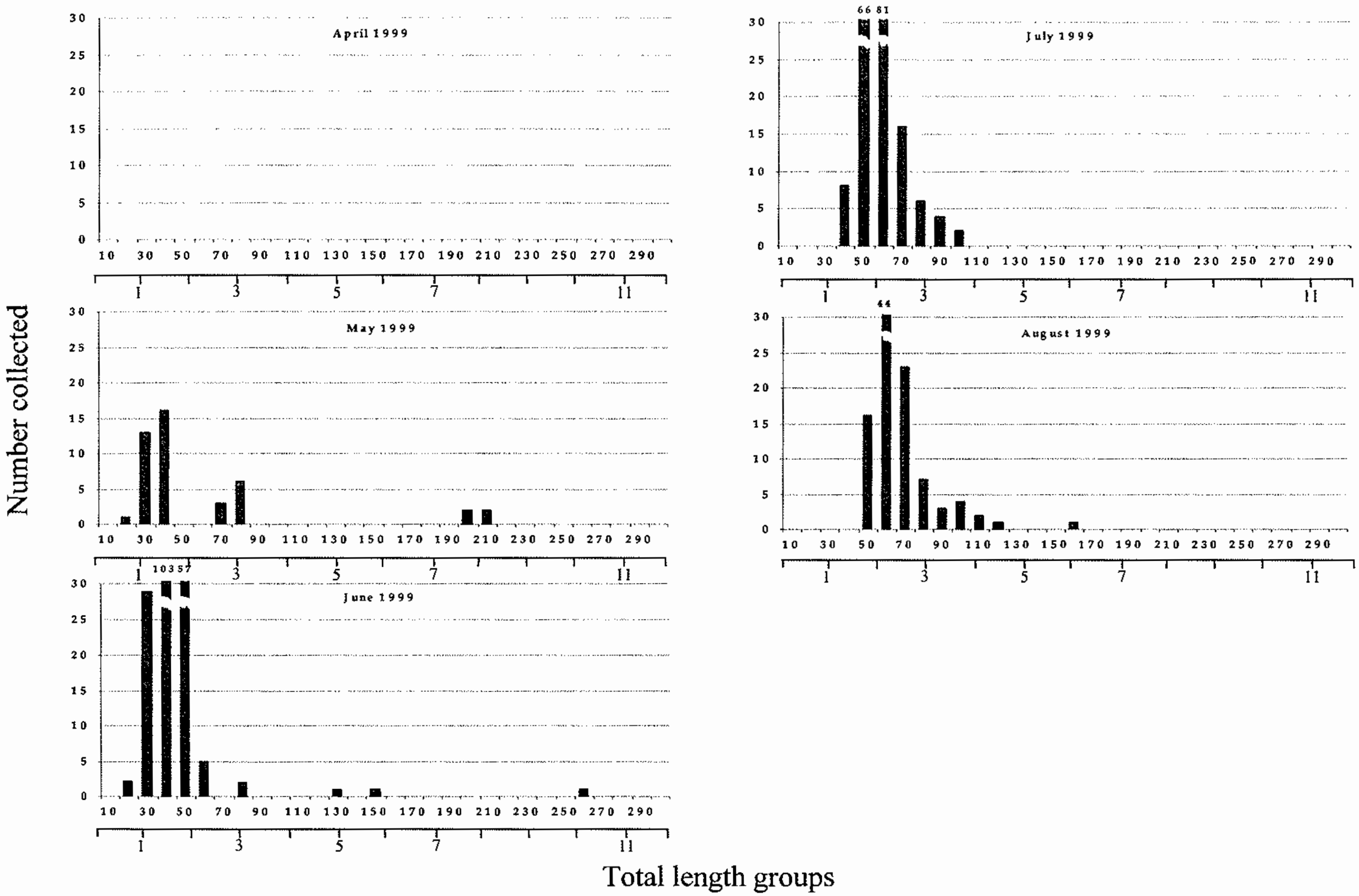


Figure 12.15. Length frequencies of all largemouth bass collected using seine hauls in Lake of Egypt during April through August 1999. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

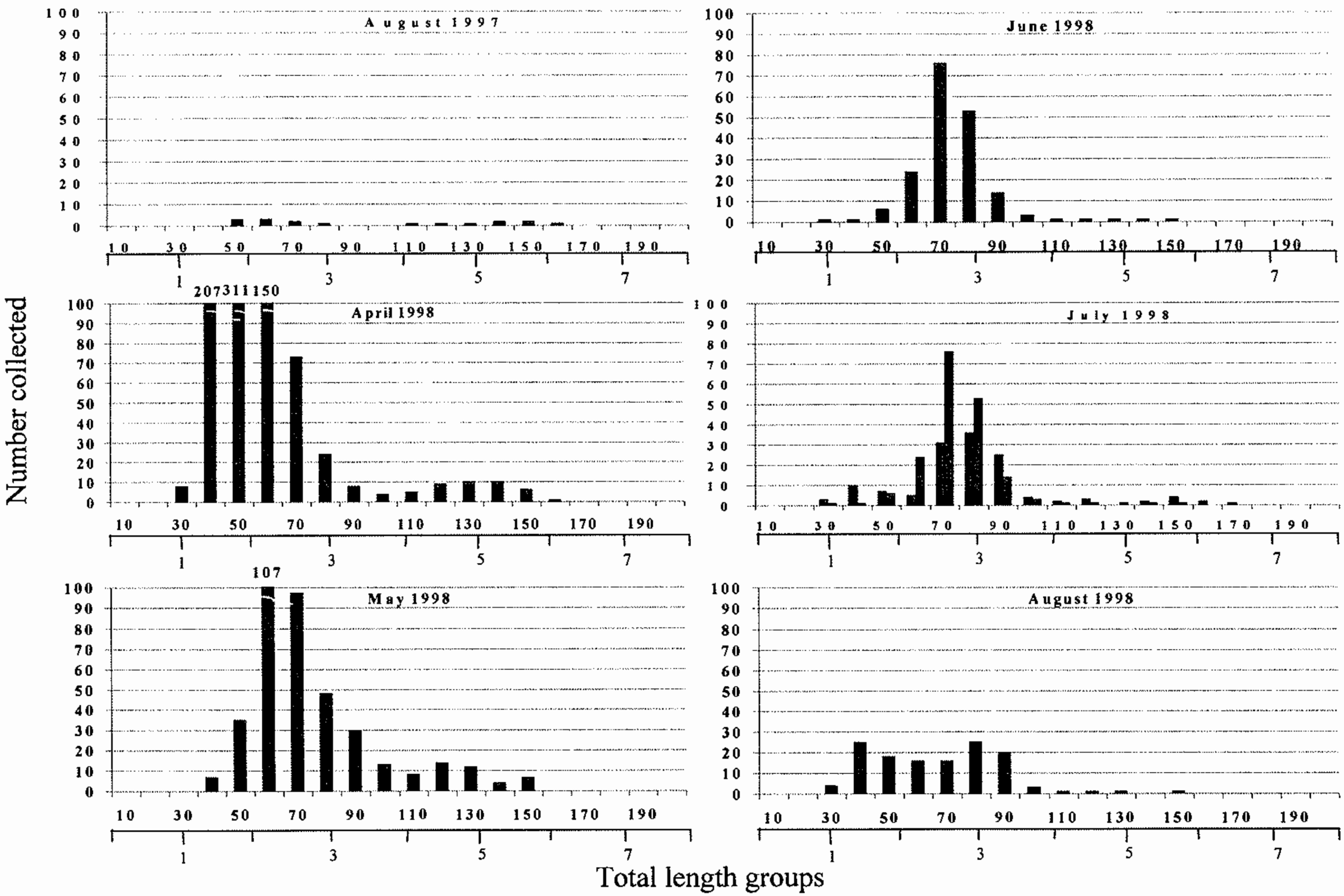


Figure 12.16. Length frequencies of all bluegill collected using seine hauls in Newton Lake during August 1997 and April through August 1998. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

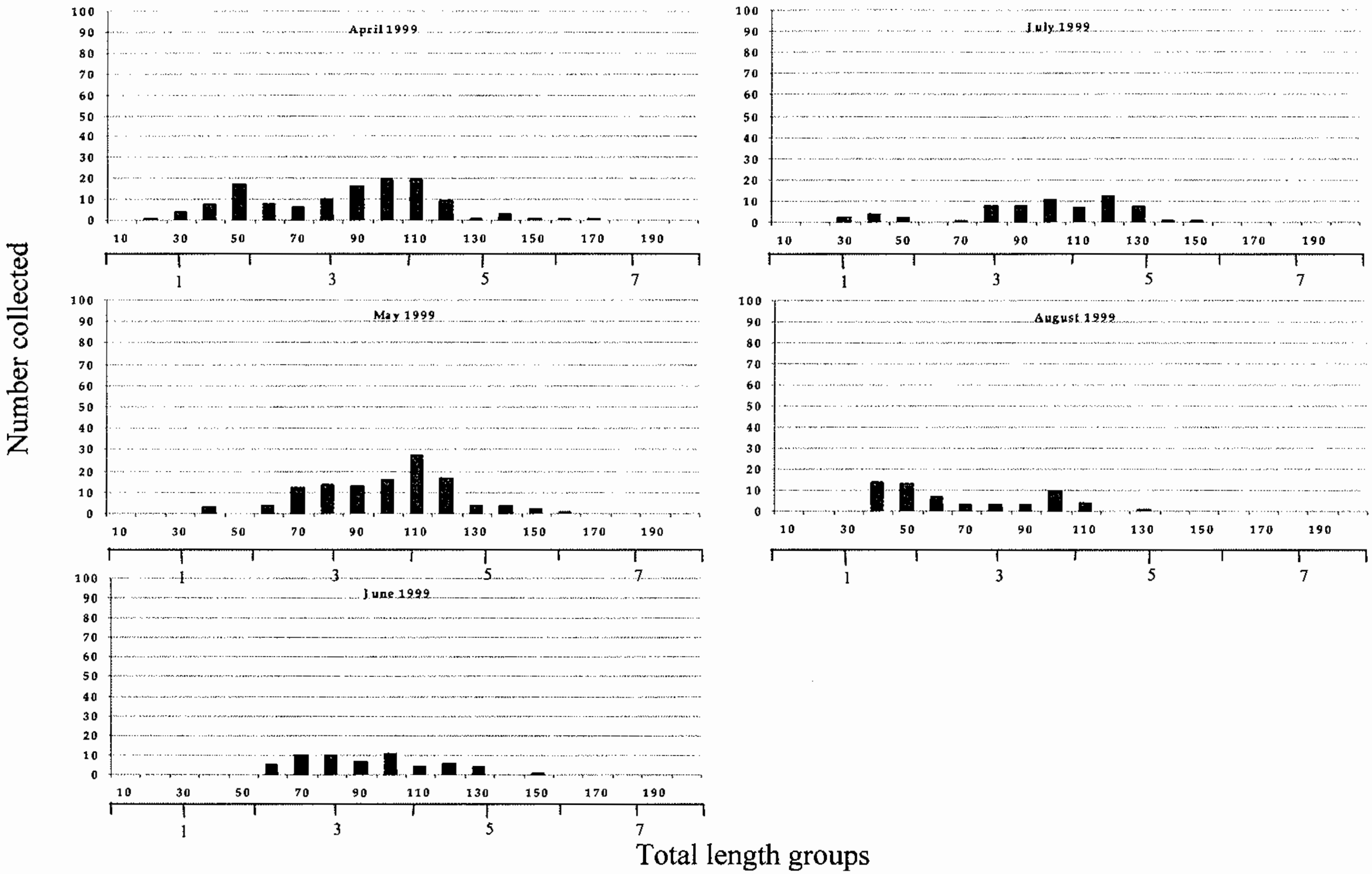


Figure 12.17. Length frequencies of all bluegill collected using seine hauls in Newton Lake during April through August 1999. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

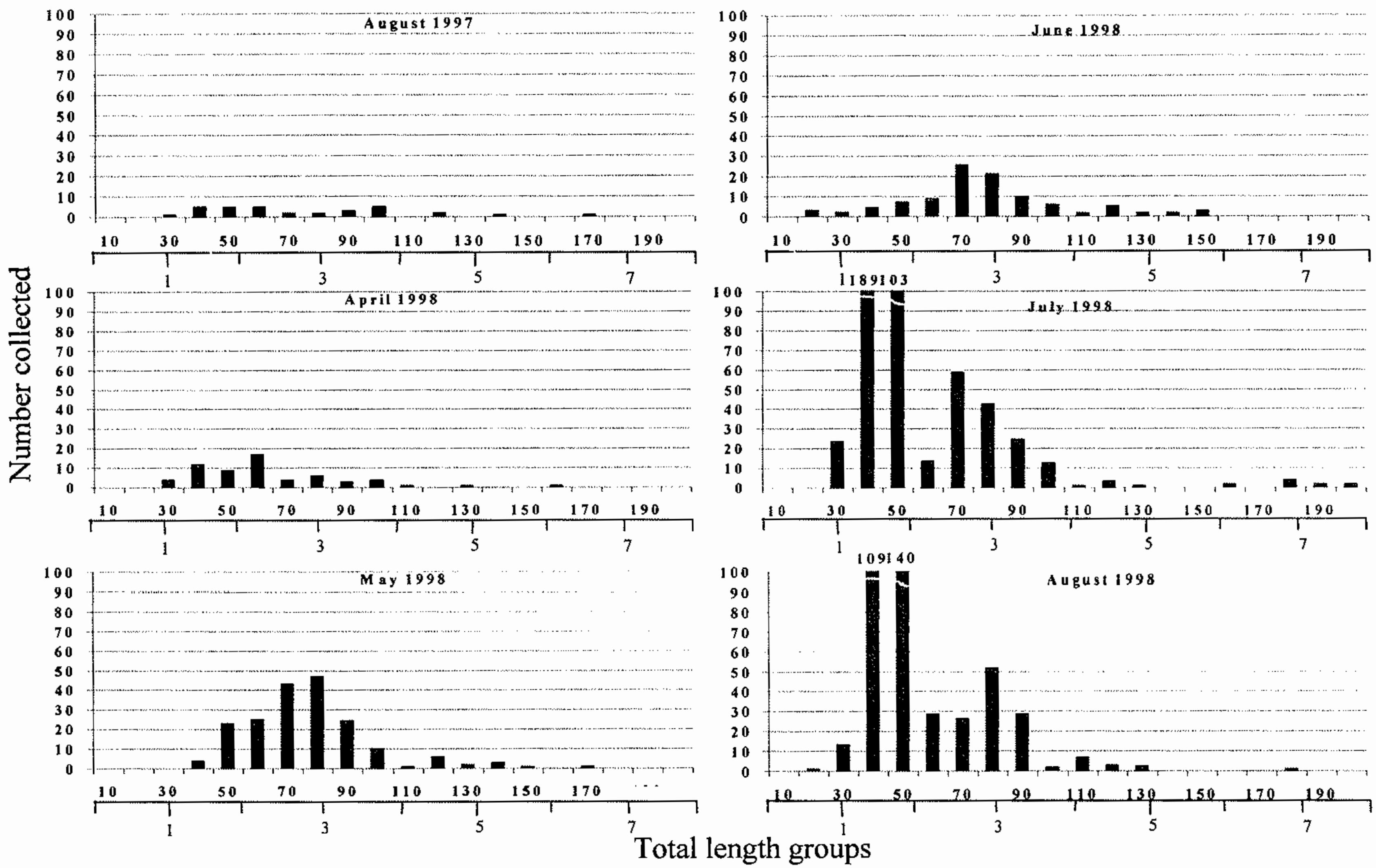


Figure 12.18. Length frequencies of all bluegill collected using seine hauls in Lake of Egypt during August 1997 and April through August 1998.Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

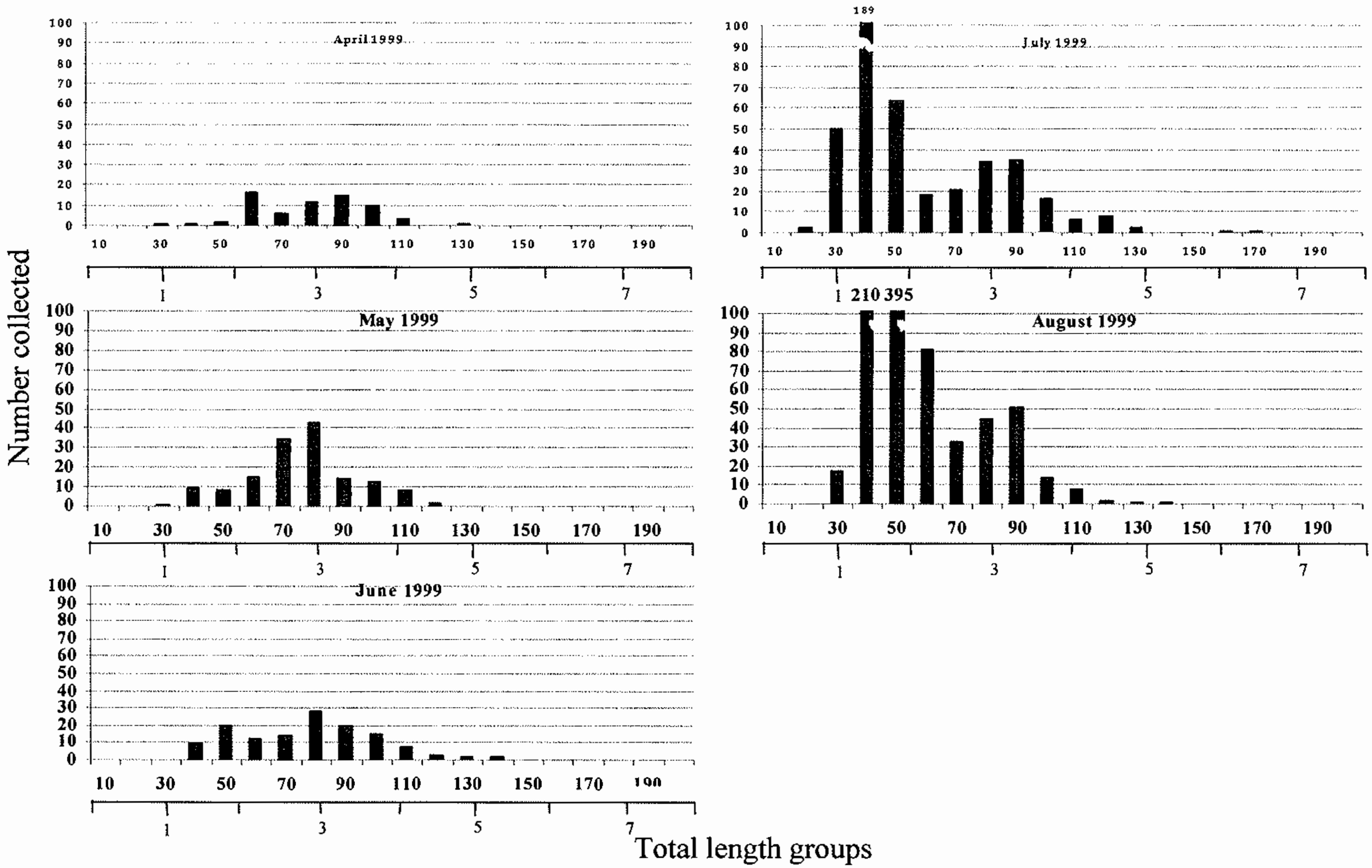


Figure 12.19. Length frequencies of all bluegill collected using seine hauls in Lake of Egypt during April through August 1999. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

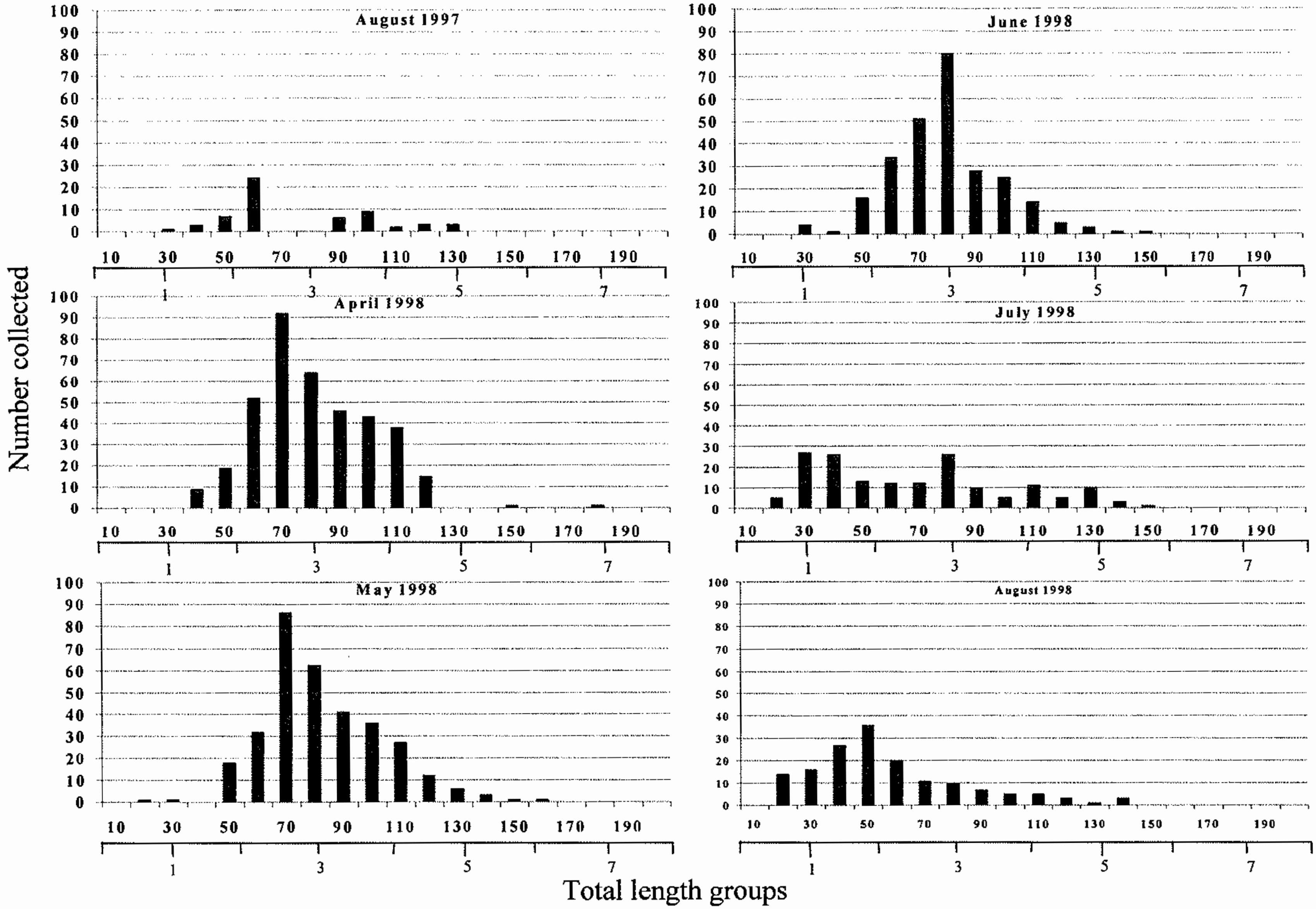


Figure 12.20. Length frequencies of all bluegill collected using seine hauls in Coffeen Lake during August 1997 and April through August 1998. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).

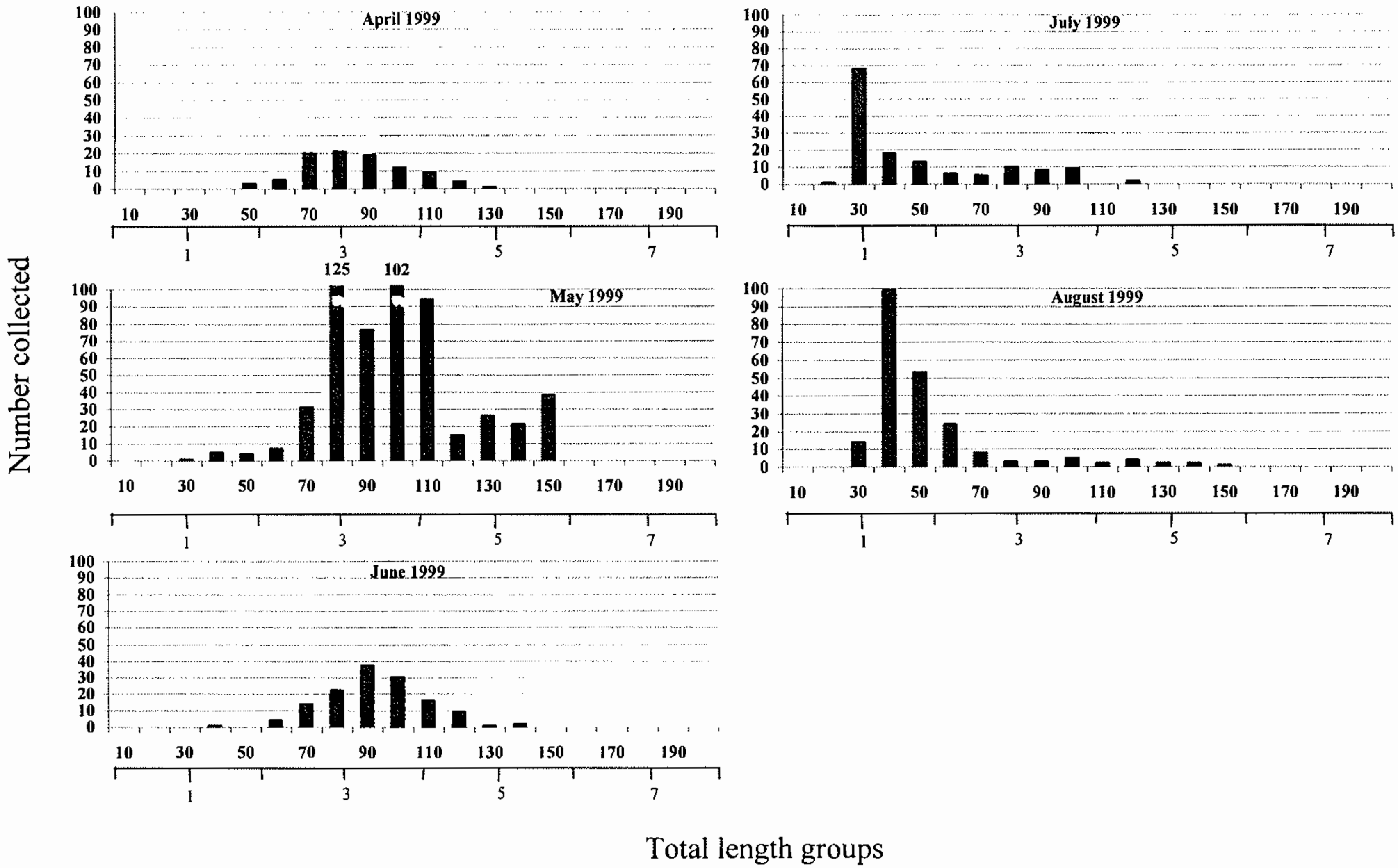


Figure 12.21. Length frequencies of all bluegill collected using seine hauls in Coffeen Lake during April through August 1999. Total length groups are given in inches (lower x-axis) and millimeters (upper x-axis).