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Larval Black Crappie Distribution: Implications for Sampling Impoundments and Natural Lakes

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Abstract.—An understanding of larval fish distributions is essential for developing an appropriate sampling design to monitor larval abundances. We monitored abundance of larval black crappie *Pomoxis nigromaculatus* to assess spatial differences in Richmond Lake (a 336-ha impoundment) and Brant Lake (a 405-ha natural lake), South Dakota, during 1994–1996. Age-0 black crappies were collected with a 500-μm mesh ichthyoplankton trawl from fixed sites within each water body. In the impoundment, larval black crappies were collected over a longer period at the upper site than at the dam site during 1994 and 1995. In the natural lake, larval black crappie abundances were similar between east and west sites during all 3 years. In light of our results, biologists should spatially stratify sampling sites when collecting larval black crappies in impoundments such as Richmond Lake, whereas random sites may be more appropriate in natural lakes such as Brant Lake.

An understanding of larval fish distribution is essential in determining an appropriate sampling design to monitor larval abundance. Distributions of larvae vary temporally and spatially (Kelso and Rutherford 1996), and this variation should be considered when designing a study. Numerous studies have examined temporal and spatial variations of larval fishes in freshwater lentic systems (e.g., Werner 1969; Storck et al. 1978; Tuberville 1979; Faber 1980; Conrow et al. 1990). Mitzner (1987) examined spatial differences of larval (<15 d) crappies *Pomoxis* spp. in Rathbun Lake, Iowa. Although white crappies *P. annularis* and black crappies *P. nigromaculatus* are similar in a number of characteristics, several important differences exist between these two species. For example, temporal differences exist between larval abundances of white and black crappies, with larval black crappies consistently collected earlier than larval white crappies in southeastern Louisiana waters (Chatry and Conner 1980). In addition, juvenile white crappies primarily fed near the bottom, while juvenile black crappies fed near the surface in Rough River Lake, Kentucky (Overmann et al. 1980), which suggests that spatial differences in juvenile white and black crappies also exist. Because temporal and spatial differences probably exist between white and black crappies, a distributional assessment of larval black crappies was still needed. Thus, we monitored larval black crappie abundances to assess spatial differences in Richmond and Brant lakes, South Dakota, during 1994–1996.

Study Sites

Richmond Lake is a 336-ha impoundment in northeastern South Dakota (Brown County). The impoundment has a shoreline development index of 5.8, mean depth of 4.6 m, maximum depth of 8.8 m, morphoedaphic index of 71, and does not thermally stratify during summer. The watershed is primarily agricultural land, of which 48% is cropland and 52% is pasture (Koth 1981). The black crappie population is characterized by high density (Guy and Willis 1993), slow growth (Guy and Willis 1995a), and relatively consistent recruitment (Guy and Willis 1995b).

Brant Lake is a 405-ha natural lake in eastern South Dakota (Lake County). The lake has a shoreline development index of 1.2, mean depth of 3.4 m, maximum depth of 4.3 m, morphoedaphic index of 191, and does not thermally stratify during summer. The watershed is primarily agricultural land, of which 93% is cropland and 7% is pasture (Koth 1981). The black crappie population is characterized by low density (Guy and Willis 1993), fast growth (Guy and Willis 1995a), and inconsistent recruitment (Guy and Willis 1995b).

Methods

Larval black crappies were sampled weekly from late spring through summer with a 0.76-m-diameter ichthyoplankton net (bar mesh size = 500 μm) towed (mean tow speed ±SE of all trawls made during 1994–1996 was 1.0 ± 0.001 m/s) just under the surface during daylight. Two consecutive tows were collected at four standardized sites in each water body on each sampling date (Figures 1, 2). Thornton's reservoir zonation model (Thorn-

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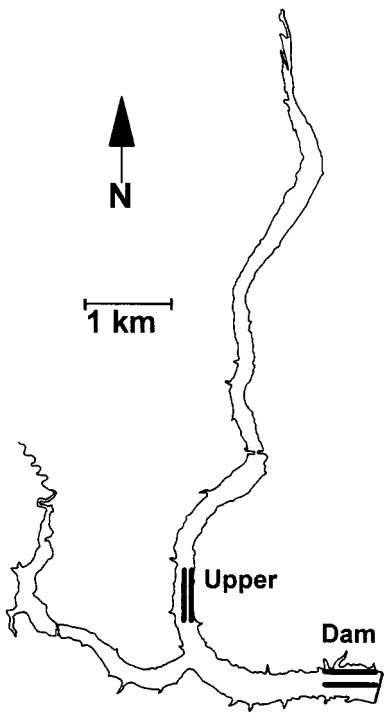

FIGURE 1.—Surface trawl sites (dark bars) for larval black crappies during 1994–1996 at Richmond Lake, South Dakota, showing upper and dam sites. Nearshore and open-water trawls were made at each location, and two consecutive trawls were made at each site (i.e., each bar).

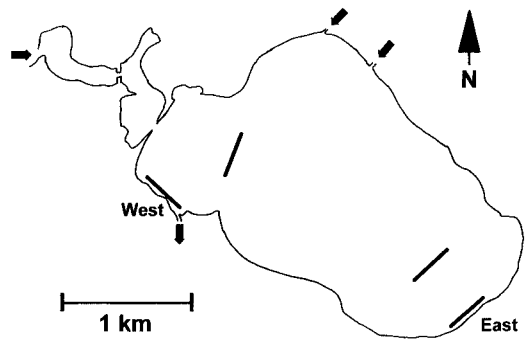

FIGURE 2.—Surface trawl sites (dark bars) for larval black crappies during 1994–1996 at Brant Lake, South Dakota, showing east and west sites. Nearshore and open-water trawls were made at each location, and two consecutive trawls were made at each site (i.e., each bar). Water inflows and outflow are indicated with arrows.

ton et al. 1981; Thornton 1990) recognizes a longitudinal gradient along reservoirs. Thus, sites were stratified by location (upper and lower) for Richmond Lake. Sites were stratified by location (east and west) for Brant Lake because water flow differed in these two areas (i.e., most water enters Brant Lake from the northwest and the outflow is on the southwest end; Figure 2). Tows were made in nearshore (≤20 m from shore) and open-water (80–130 m from shore for Richmond Lake and ≥400 m for Brant Lake) habitats at both locations of each water body. A flowmeter mounted in the mouth of the net allowed estimation of the volume of water filtered, and hence, larval density (number/m^3). Differences in larval black crappie abundances between sites (i.e., upper and dam for Richmond Lake; east and west for Brant Lake) within each year were analyzed with a split-plot repeated-measures analysis of variance (Maceina et al. 1994). Each sample collected was used as a replicate observation for analyses.

Results

Larval black crappie abundances in Richmond Lake peaked 1 week earlier at the dam site than at the upper site during 1994 (Figure 3). The reverse occurred during 1995. Peaks were simultaneous during 1996. No significant differences in larval abundances were found between dam and upper sites within a given year ($P > 0.16$; Table 1). However, the treatment × date interactions were significant during 1994 and 1995 ($P \leq 0.025$) but not during 1996 ($P = 0.64$). Larval black crappies were collected over a longer period at the upper site than at the dam site during 1994 and 1995.

In Brant Lake, the timing of peak larval black crappie abundances was similar between east and west sites during 1994 and 1996 (Figure 4). Larval black crappie abundances were not significantly different between east and west sites during 1994, 1995, or 1996 ($P > 0.5$; Table 1), and the treatment × date interactions were not significant ($P > 0.2$).

Discussion

Biologists should consider trawl site selection when collecting larval black crappies. Temporal differences were observed in larval black crappie abundance between dam and upper sites in Richmond Lake. This may be a result of black crappies not spawning uniformly throughout a water body. For example, Pope and Willis (1997) found suspected nests of ultrasonic-tagged male black crappies in the upper arms of Richmond Lake but not in small coves near the dam. In addition, Mitzner (1987) related spatial differences between abun-

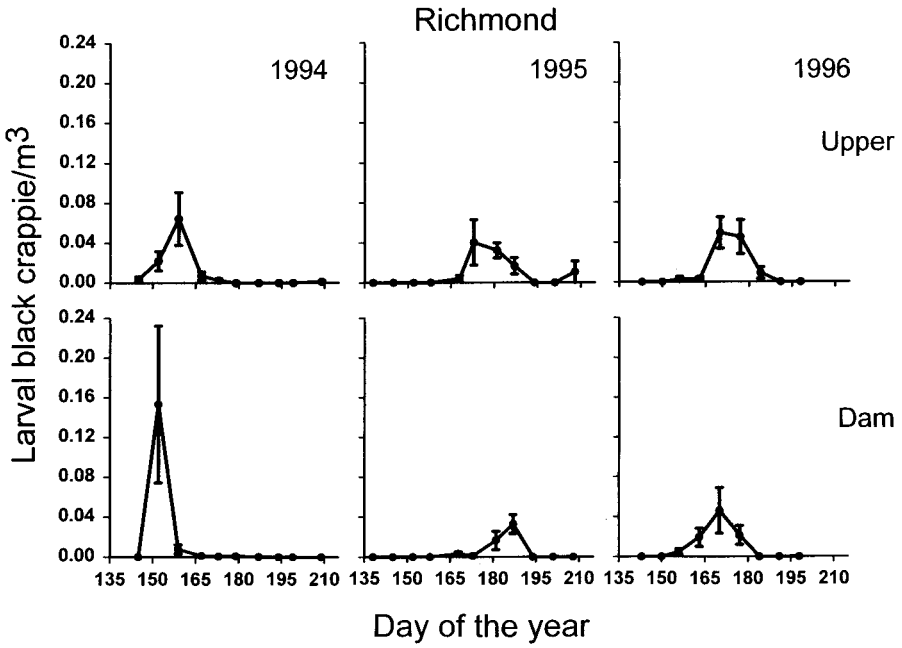

FIGURE 3.—Larval black crappie abundance (mean ± SE) in Richmond Lake, South Dakota, during 1994–1996 at stratified sites of upper and dam. Day of year 150 is 30 May 1994, 30 May 1995, and 29 May 1996; day of year 180 is 29 June 1994, 29 June 1995, and 28 June 1996.

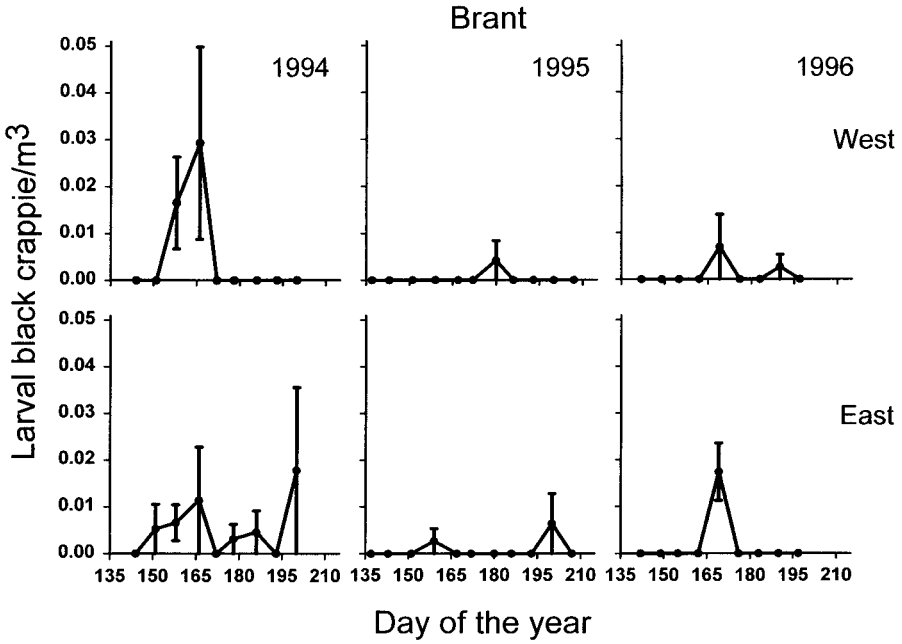

FIGURE 4.—Larval black crappie abundance (mean ± SE) in Brant Lake, South Dakota, during 1994–1996 at stratified sites of east and west. Day of year 150 is 30 May 1994, 30 May 1995, and 29 May 1996; day of year 180 is 29 June 1994, 29 June 1995, and 28 June 1996.

TABLE 1.—Statistical comparisons (split-plot repeated-measures analysis of variance; Maceina et al. 1994) of larval black crappie abundance (number/m^3) estimated from collection with a 500-μm-mesh ichthyoplankton net in Richmond and Brant lakes, South Dakota. Statistical tests were made between locations (upper and dam for Richmond Lake; east and west for Brant Lake) within each year of sampling. The *F*-value (*F*), degrees of freedom (df), and the probability (*P*) of observing a larger test statistic are provided for treatment and for the treatment × date interaction; *P*-values ≤0.05 are marked with an asterisk.

	Treatment			Treatment × date		
Year	*F*	df	*P*	*F*	df	*P*
			Richmond Lake			
1994	2.28	1,6	0.182	7.11	9,51	0.0001*
1995	2.53	1,6	0.163	2.27	10,60	0.025*
1996	0.27	1,6	0.624	0.76	8,48	0.635
			Brant Lake			
1994	0.01	1,6	0.912	0.80	8,47	0.604
1995	0.43	1,6	0.535	1.05	10,60	0.417
1996	0.48	1,6	0.515	1.41	8,48	0.216

dances of larval (<15 d) crappies (white and black combined) to nearby available spawning habitat.

In Brant Lake, no differences in larval black crappie abundance existed between east and west sites during 1994–1996. Thus, site stratification does not appear necessary for future larval black crappie sampling in Brant Lake, even though black crappies spawned in the west bay of Brant Lake (Pope and Willis 1997). Larval black crappies appeared to have little difficulty dispersing throughout the entire lake basin. Dispersion of the larvae may be facilitated by wind and wave turbulence that is common in water bodies that have a low shoreline development index, such as Brant Lake.

Based on our results, biologists should consider sampling site selection when collecting larval black crappies. In waters where larval black crappies are dispersed quickly throughout the entire system (such as Brant Lake), a completely randomized sampling design appears appropriate and should simplify statistical analyses. However, in waters where black crappies spawn in specific areas and larvae do not quickly disperse throughout the entire system (such as Richmond Lake), a stratified sampling design is appropriate. Fixed or random stations within a stratified area should be selected on the basis of the researcher's needs. If biologists are unaware of the biology of larval black crappie in the water body of interest, then we recommend that they develop a stratified sampling design and determine whether spatial and temporal differences exist.

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