DENSITY AND DISTRIBUTION OF LARVAL FISH IN AN OKLAHOMA POWER PLANT COOLING WATER RESERVOIR*

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Larval fish collections from Sooner Lake in April, 1981 showed several relationships to elevated water temperatures in the heated areas of the reservoir. First time of collection, densities, larval lengths, and distributions indicated some spawning took place in heated areas as much as two weeks earlier than in unheated areas. By mid-April when unheated areas warmed to levels equal to heated areas in the discharge canal, larval densities were found to be greater in the main part of the reservoir.

INTRODUCTION

Research into the effects of warm-water power plant discharges on fish eggs and larvae has been limited. Most studies dealt with attraction (1, 2, 3) or avoidance (4, 5) on the part of adult fishes. Previous work shows fecundity and reproductive cycles were essentially the same for fishes from heated versus unheated areas (6, 7, 8). The present study was conducted to determine the effects of the Sooner Lake Oklahoma electric generating plant's warm-water discharge on larval fish abundance and distribution in heated and unheated areas of the reservoir.

METHODS

Larval fishes were collected during April 1981 from Sooner Lake, a power plant cooling water reservoir (2185 hectare) located in North-central Oklahoma on Greasy Creek 35 km north of Stillwater in Noble and Pawnee counties. Heated waters flow from the power plant down a 3.5-km discharge canal where they mix with waters of the main part of the reservoir. Heated waters were cooled to ambient levels approximately 2 km down the discharge canal (Fig. 1). A 0.5-m diameter bridled larval net of 00 and 000 mesh nylon and a General Oceanics Model 2030 flowmeter were towed for 2 min at 16 stations (Fig. 1). Following procedures similar to those of Taber (9), Downey (10), and Van Den Avyle and Fox (11), daytime surface tows, 0.5 m below the surface, were made to give more representative samples. Representative stations were selected to cover the discharge canal area with emphasis on the north and east windward shores as suggested by Downey (10). Eight additional stations in unheated areas of the discharge canal and the main body of the reservoir were similarly sampled. Samples were preserved in l0% formalin and returned to the laboratory for analysis using larval fish keys by May and Gasaway (12) and Hogue et al (13). Data analysis included determination of species composition, numbers, density, lenth-frequencies, and mean lengths. Very large samples were sorted by species, counted, then subsamples of 50 - 100 larvae were measured for total length. Hypotheses were tested using standard nonparametric statistical tests with an alpha-level of 0.05 (14).

RESULTS

Eight stations were sampled on April 7 with only station 1, located closest to the discharge outlet, producing larvae. These were identified as shad (*Dorosoma* spp.) but owing to their small size could not be accurately identified as gizzard shad (*D. cepedianum*) or threadfin shad (*D. petenense*), both of which occur in Sooner Lake. Lengths were not measured on these larvae. Larval shad and inland silversides (*Menidia beryllina*) were collected by sampling 12 stations each, on April 17 and April 24.

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Shad made up 45-100% of the catch at each station whereas silversides accounted for 0-55%. Statistical analysis showed no significant differences in larval shad densities between collections on the 17th and 24th (3.7 and 3.8 larvae/m^3, respectively; Table 1). Silversides were, however, significantly more dense on the 17th (0.6 versus 0.14 larvae/m^3 on the 24th). Comparisons between heated and unheated areas showed shad to be more dense in unheated areas only on the 24th (6.2 versus 0.4 larvae/m^3 in heated areas). Windward tows produced greater larval shad densities, but not silversides.

Length-frequencies for shad on the 17th and 24th indicated ranges in length from 4.0 to 10.2 mm, with means of 5.9 and 5.6 mm for each date, respectively (Fig. 2). Inland silverside lengths ranged from 4.0 to 7.4 mm, with means of 4.7 and 5.8 mm on April 17 and 24, respectively. Length-frequency distributions were often multi-modal, with stations in the discharge area showing two to three modes indicating spawning pulses. Shad were significantly longer on the 17th (5.9 mm versus 5.6 mm on the 24th) and silversides were longer on the 24th (5.8 mm versus 4.7 on the 17th). In general, unheated areas held longer larvae than heated areas. As was the case with larval density, windward tows generally produced longer shad while leeward and open lake tows produced longer silversides.

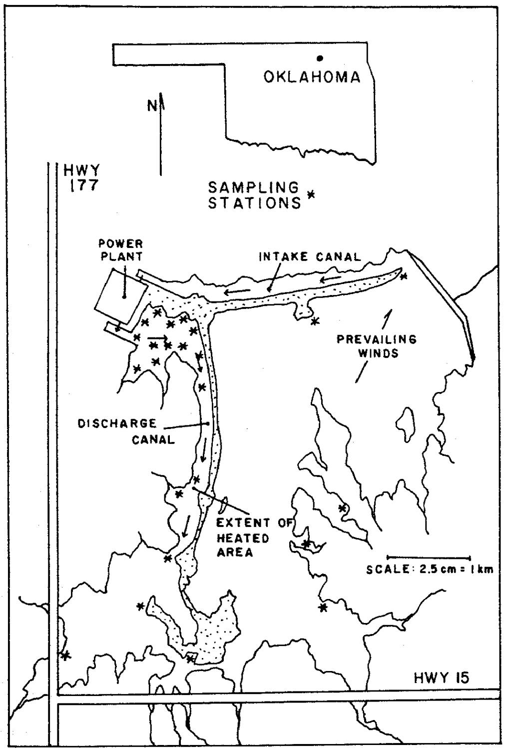

FIGURE 1. Map of Sooner Lake, Oklahoma, with sampling stations marked (*), and direction of flow marked (→).

The maximum difference in water temperature between heated and unheated areas during this study was 4.5 C. By April 1, however, the discharge area had warmed to 17 C whereas the rest of the reservoir did not reach this temperature until at least April 20. There were no statistically significant correlations between water temperature and larval density or mean length

TABLE 1. *Mean numbers, density, and total length for larval shad and silversides collected on April 7, 17, and 24, 1981 from Sooner Lake.*

Date and Stations	Temp., C	Shad			Silversides		
		N(SD)	N/m^3(SD)	TL(SD)	N(SD)	N/m^3(SD)	TL(SD)
April 7							
Heated	17	6(0)	0.2(0)	n/a[a]	0	0	0
Unheated	13	0	0	0	0	0	0
Combined		6(0)	0.1	0	0	0	0
April 17							
Heated	18	83(128)	3.3(5)	5.9(0.3)	14(20)	0.6(0.7)	4.6(0.4)
Unheated	15	173(0)	7.4(0)	6.2(0)	11(0)	0.5(0)	5.1(0)
Combined		91(125)	3.7(5)	5.9(0.3)	14(19)	0.6(0.7)	4.7(0.4)
April 24							
Heated	21	9(7)	0.4(0.4)	5.3(0.3)	2(3)	0.1(0.1)	5.5(2)
Unheated	19	151(148)	6.2(6)	5.8(0.4)	4(2)	0.2(0.1)	6.0(2)
Combined		82(133)	3.8(5)	5.6(0.4)	3(2)	0.1(0.1)	5.8(2)

[a] Lengths not recorded.

although indirect effects such as those mentioned above were noted.

DISCUSSION

Waters in the discharge area warmed earlier in the spring and probably attracted spawning adults as noted by Bennet and Gibbons (6). Our sampling methods may have missed the larvae of other species that might have been spawning at the same time. Shelton (15) noted white bass (*Morone chrysops*) were spawning at the same time as shad in Lake Texoma. Since the preferred spawning temperature of gizzard shad is approximately 17 C and threadfin shad don't spawn until waters reach 19 C, the shad larvae we collected were probably gizzard shad (15, 16). Although preferred spawning temperatures for silversides are not available, Mense (17) noted them spawning from late March through the summer in Lake Texoma. This period would include the time of this study, but without complete water temperature data, direct comparisons are impossible.

Distribution of larvae is strongly dependent on currents and wind (16, 18), so weak-swimming larvae probably did not remain in the discharge area. Flow towards the main body of the reservoir and prevailing winds would account for the concentrations down the canal and in windward tows. On the basis of growth information for larval shad from Taber (9) and Shelton (15), the multi-modal length frequencies found at stations in the canal would represent spawning pulses 3-5 days apart. By 7-14 days the larvae would have grown to 10-13 mm total length and greater mobility would make them less vulnerable to netting.

Higher larval densities in unheated areas are probably due to a greater percentage of windward tows being made in these areas (83% versus 17% of the tows made in open water stations). Unlike McNeely and Pearson (19), we found silversides to be more dense in heated areas although longer larvae were concentrated in unheated areas later in the study.

Shad and silversides are important forage fishes in Sooner Lake, and relative abundances are usually low in early spring (20). An early spawn of these species would pro-

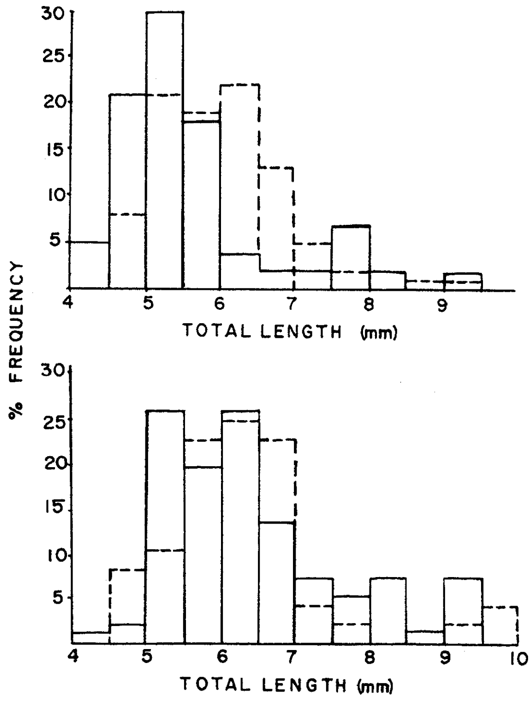

FIGURE 2. Length-frequencies for shad collected from Sooner Lake on April 17th (bottom) and 24th (top); with heated stations in solid lines, unheated stations in dashed lines.

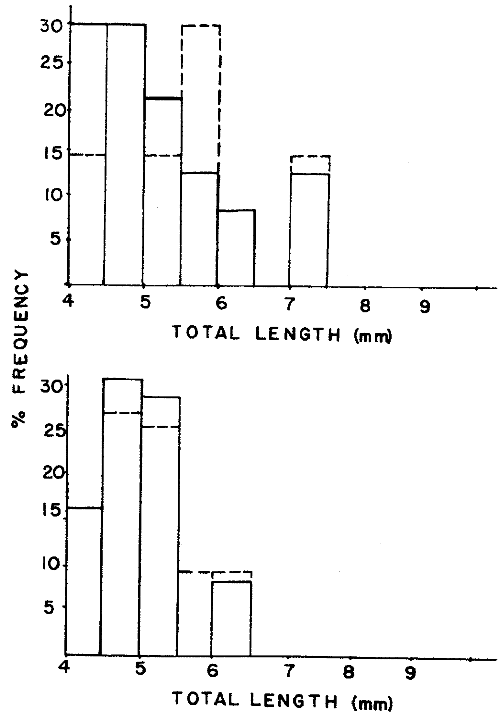

FIGURE 3. Length-frequencies for silversides collected from Sooner Lake on April 17th (bottom) and 24th (top); with heated stations in solid lines, unheated stations in dashed lines.

vide suitably small forage for the yearling white bass and striped bass × white bass hybrids (*M. saxatilis* × *M. chrysops*) that are strongly attracted to this area in late winter and early spring. Although shad and silversides in the discharge area are only a small portion of the total forage base in the reservoir, increased forage availability resulting from earlier spawns should give the predators in this part of the lake an advantage and possibly result in their attaining harvestable size more quickly.

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