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Mechanisms of Recruitment Failure in Bluegill Ponds

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Abstract.–A series of eight experiments was conducted to study the factors influencing year-class failure in high-density bluegill ponds. Ponds were considered to have successful bluegill reproduction if age-1 fish were present at spring pond draining 1 year after stocking. Experiment 1 varied total bluegill stocking density to evaluate its effect on adult relative weight (W_r), gonadosomatic index (GSI), fecundity of females, and on reproduction. Three ponds were stocked at each of three densities: 56 ("low"), 134 ("medium") and 336 ("high") kg/ha; of the specified total, 37 kg/ha was fish >127 mm total length. There was a year-class failure in all three high-density ponds, in one medium-density pond, in two low-density ponds. Of the three successful ponds, two had received the lowest stocking density of fish <51 mm. A total of 469 adult bluegills was sampled by hook and line. The sex ratio among fish 152 mm or greater was 9:1 (males:females). The W_r of males and females was significantly greater at lower stocking densities. For fish sampled in June, the 6-fold range of stocking densities produced a 3-fold range in mean GSI of females, from 3.0% at high density to 9.3% at low density, but there was no significant effect of stocking density on male GSI. The June number of eggs per gram body weight of female varied from 120±11 (mean±SE) at low density, to 83±11 at medium density, to 40±12 at high density. This indicates that fewer eggs are produced per female as density increases. Experiment 2 evaluated the effect on reproduction of age-1 density. The three treatments were 0 (four ponds), 5.6 (two ponds), and 17 (three ponds) kg/ha of age 1, each with 56 kg/ha of small (102-151 mm) adults. Reproduction was successful in all six ponds with 0 and 5.6 kg/ha of age 1s, but failed in all three ponds with age 1s at 17 kg/ha. Experiment 3 further evaluated the effect of age-1 density on reproduction, using age-1 densities of 0, 17, and 50 kg/ha (three ponds at each density); adults were stocked at 56 kg/ha. Most adults came from experiment 2, and were 1 year older and about 25 mm longer. Reproduction was successful in all six ponds at 0 and 17 kg/ha; reproduction failed in two of three ponds at 50 kg/ha. Experiment 4 evaluated the ability of adults in poor condition to reproduce. One pond was stocked with small adults (102-151 mm) with a very low relative weight (64±6.5%, mean±SD); they came from ponds stocked the previous year at 336 kg/ha. Though some nests were observed, no fry were produced; the year class failed. Experiment 5 also tested adults that spent the previous year in ponds stocked at 336 kg/ha. Unexpectedly, not all adults were in poor condition. Whereas for small adults (102-151 mm) the average W_r was 70-75%, the W_r of 203-253 mm fish was 82-87%, and three fish 254-278 mm long had a W_r of 96%. The year class was successful in all three ponds stocked with these fish. Thus, any carry-over effect of previous high density is not sufficient to cause year-class failure if some adults are in good condition. Experiment 6 used a 2×2 cross-classified design to evaluate effects of both adult size and age-1 density. Ponds received either only small (102-151 mm) adults or both small and large (>151 mm) adults, combined with either 0 or 17 kg/ha of age-1 bluegills. Reproduction was successful in 11 of the 12 ponds, failing only in one of three ponds that received small adults and 17 kg/ha of age 1s. Experiment 7 evaluated the effect of age-2 and age-1 density on reproduction. Nine ponds received adults at 56 kg/ha. Three of these ponds were stocked with no juveniles. Two ponds were stocked with age 2s at 78 kg/ha and another received 30 kg/ha. The last three ponds received age-1 bluegills at 17 kg/ha; two of these received age 2s at 78 kg/ha and the other received age 2s at 30 kg/ha (there was a shortage of age 2s at stocking). Reproduction was successful in all ponds except one receiving age 1s at 17 and age 2s at 78 kg/ha. Experiment 8 was similar to experiment 7, testing the effect of age 2s and age 1s on reproduction. Nine ponds received adults at 56 kg/ha. Three of these ponds were stocked with no juveniles, three ponds with age 1s at 17 and age 2s at 28 kg/ha, and three ponds with age 1s at 17 and age 2s at 78 kg/ha. Reproduction was successful in seven of nine ponds, failing in one pond each of the latter two treatments. Year-class failure in bluegill ponds is clearly associated with the presence of juvenile bluegills, that is, age-1 and age-2 bluegills, less than about 100 mm. Of the 61 pond-year occasions in this study, reproduction failed on 16 occasions. For ponds without juveniles, reproduction failed on only 1 of 23 occasions, for a failure rate of 4%; this was the single pond stocked with small adults in very poor condition. For ponds stocked with juveniles, reproduction failed on 16 of 38 occasions, for a failure rate of 39%, not significantly different from the failure rate of 22 of 45 occasions observed by Clark and Lockwood (1990). The mechanism of year-class failure does not appear to be starvation of age 0s after hatching, nor overwinter mortality, nor cannibalism on fry larger than 20 mm. It does not appear to be adult lack of adequate energy for reproduction, except in extreme cases. While not causing failure, these mechanisms can influence year-class strength. This study and experiments by Gray (1991) suggest that predation by juvenile bluegills, on eggs and larvae in the nest and on fry soon after leaving the nest, is the major mechanism producing recruitment failure in high-density bluegill ponds.

Slow-growing bluegill populations are a common problem in southern Michigan lakes. Successful methods for improving growth in these populations are likely to involve reductions in the number of young bluegills surviving their first year of life (Beard 1971; Schneider 1981). Clark and Lockwood (1990), in experiments at the Saline Fisheries Research Station, observed cases of failed recruitment in ponds with stunted bluegill populations whenever the standing crop exceeded 224 kg/ha. Understanding the mechanisms causing recruitment failure in high-density bluegill ponds may suggest improved methods for reducing recruitment in lakes and ponds with stunted bluegill populations.

In Clark & Lockwood’s study, nine ponds were followed for five years, and yearlings were missing at the spring pond draining on 22 of 45 occasions (Appendix 1). Recruitment to age 1 failed half the time. At least three ponds produced young each year, and at least three ponds failed to produce young each year, indicating the importance of factors operating within the pond.

Several hypotheses can be advanced to explain the failure of recruitment in high-density bluegill ponds, as was observed by Clark and Lockwood at the Saline Fisheries Research Station. These hypotheses are not mutually exclusive.

H_1: *Not Enough Energy for Successful Reproduction*

H_{1a}: *Females have inadequate energy to develop mature eggs.*–A high density of bluegills might reduce the available food to such low levels that females cannot obtain enough energy to develop mature eggs. In his review of environmental influences on gonadal activity, Lam (1983) said that "a reduced food supply retards or inhibits gonadal development in