STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-35-R-24

Study No.: 669 **Title:** Prey selection and predation rate of piscivorous fish

Period Covered: April 1, 1998 to September 30, 1999

Study Objective: To estimate survival of juvenile bluegills in ponds as a function of bluegill size and density and predator size and density, and to concurrently measure predator survival and growth.

Summary: No pond experiments were completed. Temporary assignment to other duties greatly reduced work on this project in this reporting period. Additional work was done on Job 4. During summer and fall 1998 a lab experiment was conducted to evaluate gape limitation by adult bluegills preying on juvenile bluegills of various sizes. The purpose was to compare the observed maximum size of prey ingested by bluegills with the maximum size predicted from predator mouth gape and prey maximum body depth. The maximum size of prey successfully ingested by adult bluegills was larger than predicted. Further investigation revealed that the gape of large bluegills was underestimated by the equation obtained from the literature. A new equation was developed that included data on gape of bluegills up to 255 mm TL. This information will allow better estimation of the gape limitation of adult bluegills. This study was amended to extend the study to allow completion of the intended experiments and analysis.

Job 1. Title: Stock ponds with bluegills and predators.

Findings: No pond experiments were completed this reporting period.

Job 3. Title: Drain ponds.

Findings: No pond experiments were completed this reporting period.

Job 4. Title: Measure capture probability as a function of prey body depth and predator gape for a range of predator and prey sizes.

Findings: This job was not scheduled to be active this reporting period, but the opportunity arose to gather additional information using help from two students at the University of Michigan. A lab experiment was conducted in summer and fall 1998 to evaluate gape limitation of adult bluegills preying on juvenile bluegills of various sizes. The purpose was to compare the observed maximum size of prey ingested by bluegills with the maximum size predicted from predator mouth gape and prey maximum body depth.

Twelve adult bluegills were held in individual 10-gallon aquaria at the Saline Fisheries Research Station from June 2 to November 9, 1998. None of these fish died. The fish ranged in size from

154 to 253 mm TL (Table 1). They were fed juvenile crayfish, fathead minnows, and juvenile bluegills during acclimation to lab conditions and between periods of data collection. The experiments took several months because only the first prey item consumed each trial day gave useful data. A fish that had consumed one or more prey items was much less likely to attack and ingest a second large prey item that day, though smaller prey items would often be accepted. The fish needed to be hungry to obtain useful measures of the maximum size of prey that they would ingest. Fish were starved about 24 h between trials, longer over weekends. If a prey was offered that was too large, the fish often refused similar-sized prey offered the same day. Larger and larger prey were offered as the first prey of the day. If a prey item was not attacked, or attacked but not ingested, then smaller prey were offered on the next occasion.

Predicted values of maximum prey size were estimated in two steps. First, I used the equation of Werner (1974) to predict bluegill mouth gape (G, mm) from standard length (SL, mm),

$$G = 0.217 + 0.093*(L / 1.278),$$

where the term in parentheses uses Beckman's (1948) factor to convert total length (L, mm) to SL. Second, I used the following equation to predict prey length from maximum body depth (D, mm) of bluegills (Schneider and Breck 1997), assuming D equal to predator gape, G. In this regression equation D is the independent variable and prey length is the dependent variable.

$$\log_{10} L = 0.728 + 0.8383*\log_{10} D,$$

where $N = 416$, $r^2 = 0.997$, for bluegill D ranging from 4.1 to 89 mm.

The observed maximum size of prey successfully ingested by adult bluegills was consistently larger than predicted (Table 1, Figure 1). Further investigation revealed that gape was underestimated, especially for large bluegills, by the equation obtained from the literature. In my measurements of bluegill gape I recorded both the vertical and horizontal dimensions of a fully opened mouth, and new regression equations were developed for each measurement.

$$\log_{10} G_V = 0.245 - 0.348*\log_{10} L + 0.350*(\log_{10} L)^2,$$

$$\log_{10} G_H = 0.962 - 1.254*\log_{10} L + 0.606*(\log_{10} L)^2,$$

where G_V (mm) is gape measured in the vertical dimension, $N = 79$, adjusted $r^2 = 0.98$, and G_H (mm) is gape measured in the horizontal dimension, $N = 79$, adjusted $r^2 = 0.98$, for bluegill ranging from 43 to 255 mm in length. According to these equations, the horizontal gape is greater than the vertical gape for fish larger than 183 mm (Figure 1). Using these new equations to estimate maximum prey size, most of the data could be explained. Some discrepancy remains for bluegills near 150-160 mm. This information will allow better estimation in simulation models of the sizes of juvenile bluegill vulnerable to predation by adult bluegills.

Literature Cited:

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Gray, T. R. 1991. The competitive and predatory effects of juvenile bluegill on bluegill year-class strength. Masters Thesis. School of Natural Resources, University of Michigan, Ann Arbor.

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Werner, E. E. 1974. The fish size, prey size, handling time relation in several sunfishes and some implications. Journal of the Fisheries Research Board of Canada 31:1531-1536.

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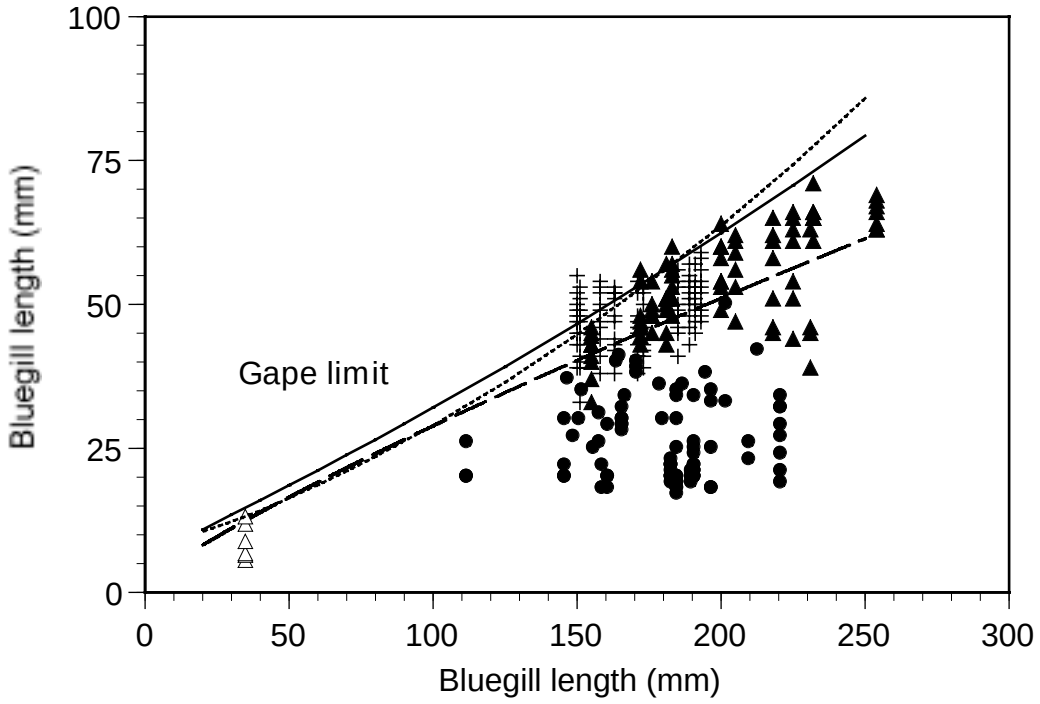

Figure 1.–Sizes of juvenile bluegill ingested by larger bluegill. The lines represent predicted maximum prey lengths based on maximum body depth of the prey (Schneider and Breck 1997) and estimated gape limitation of the predator (dashed line: Werner 1974, Beckman 1948; solid line: vertical gape, this study; dotted line: horizontal gape, this study). Points represent observations from several experiments (solid triangles: lab experiments from this study conducted in 1998; crosses: lab experiments from this study, reported in 1997; open triangles: lab experiments of Gray 1991; solid circles: bluegill prey from stomachs of bluegills captured at pond draining, Breck 1996).

Table 1.–Final length, observed and predicted vertical and horizontal gape, and maximum prey depth and length ingested by adult bluegill in lab experiments conducted at the Saline Fisheries Research Station from June to November, 1998.

	Observed		Predicted			Observed	
Length (mm)	Vertical gape (mm)	Horizontal gape (mm)	Gape[a] (mm)	Vertical gape[b] (mm)	Horizontal gape[b] (mm)	Maximum prey *D* (mm)	Maximum prey *L* (mm)
154	15.4	13.8	11.5	13.66	13.11	13.1	46
168	17.4	15.0	12.7	15.14	14.83	17.5	56
177	17.7	15.7	13.0	16.12	16.00	15.8	50
180	17.4	16.8	13.4	16.46	16.40	17.5	57
186	18.5	18.3	13.5	17.13	17.22	18.0	60
199	18.7	21.0	14.8	18.63	19.07	20.0	64
206	18.4	19.4	15.1	19.45	20.12	19.3	62
217	21.1	22.3	16.1	20.78	21.82	20.5	65
224	21.8	23.1	16.6	21.64	22.95	20.4	66
226	21.6	24.5	17.0	21.89	23.27	20.7	63
229	23.1	26.2	17.1	22.27	23.77	23.2	71
253	25.6	29.2	18.7	25.37	27.97	23.0	69

[a] Predicted gape based on Werner (1974) and Beckman (1948).
[b] This study.