FISH MANAGEMENT REPORT 109

SURVIVAL AND GROWTH OF ADULT FEMALE BLUEGILLS STOCKED IN A RECLAIMED LAKE

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ABSTRACT

To improve the quality of a panfish sport fishery, female bluegills were stocked at the rate of 100/acre in a 15.7-acre soft water landlocked lake, Wildwood Lake, Vilas County. This lake had previously been reclaimed with rotenone. The growth and survival of the bluegills was monitored for 2 1/2 years. A positive response in growth was achieved. In 2 years, fish from the 1st stocking increased their average weight an estimated 347%. After 16 months, the 2nd introduction displayed an average weight increase of 369%. The 1st introduction, after 2 years, attained an average total length increase of 43% (6.1 to 8.7 inches) and the 2nd introduction, after 16 months, displayed an average total length increase of 53% (5.8 to 8.9 inches). Condition factors of these fish were higher than those found for bluegills in other comparable lakes of the region having normal populations of male and female bluegills.

High annual total mortality was observed. The 1st stocking suffered a total mortality of 62% after 3 months in the lake. After 1 year, total mortality reached 80% and after the 2nd year, 96%. The 2nd introduction displayed a total mortality of 94% after 1 year in the lake.

The stocking rate of 100 female bluegills/acre did not appear to cause overgrazing of zooplankton as the density and size of zooplankton was greater than that of a comparable lake having an abundant male and female bluegill population.

Although only female bluegills were introduced, male bluegills were discovered in the population during the 2nd year of the study. This circumstance was attributed to an error in either sex determination or the sorting process for the fish originally stocked in the lake. Subsequently, 2 natural year classes of bluegills were established. They exhibited excellent growth with Age 1+ fish averaging 5.0 inches total length. No other fish species were captured or observed during the study period.

The total mortality observed precluded the maintenance of a satisfactory sport fishery after 1 year with respect to the number available. This management strategy provided only short-term benefits, although excellent average growth was achieved among the survivors. Angler harvest was not determined, thus this impact was not measured. Nevertheless the provision of a satisfactory bluegill population in these circumstances to meet sport fishery needs would appear to require annual maintenance stocking provided alleviation of natural reproduction could be assured.

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INTRODUCTION

Counties in the northern half of the North Central District have a large number of small, infertile (land-locked) seepage lakes capable of sustaining a variety of fish fauna, usually largemouth bass and panfish. Overabundance and slow growth of panfish are problems in many of these ecosystems. Therefore it is desirable to increase their growth potential through various management strategies and/or population manipulation. Consequently, a project was initiated where only female bluegills (Lepomis macrochirus) were introduced into a lake reclaimed with rotenone. The use of only female bluegills was intended to alleviate natural reproduction and thereby preclude overabundance. No companion fish species was stocked.

The objective of this investigation was to determine growth and survival of adult female bluegills transferred into a chemically reclaimed environment having no other fish species. Wildwood Lake, located in Township 41 North, Range 7 East, Section 33 in Vilas County, was selected for this study (Fig. 1). Sampling was conducted during the open water periods from 1977 through 1979.

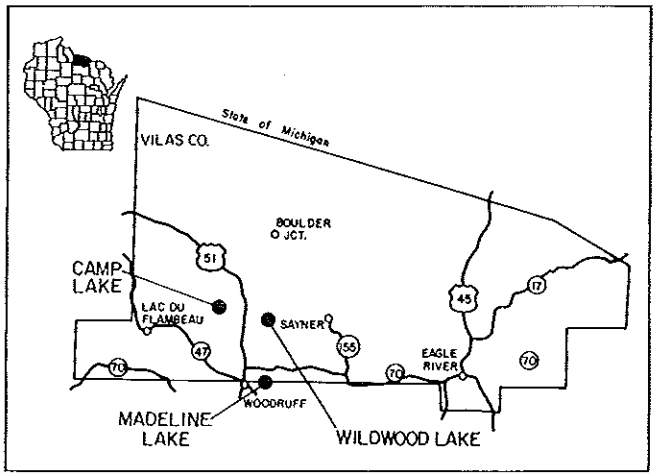

FIGURE 1. Location of the study lake, Wildwood Lake, and the 2 lakes, Madeline and Camp, from which bluegills were taken for introduction into Wildwood.

DESCRIPTION OF THE STUDY AREA

Wildwood Lake is a 15.7-acre seepage lake with very soft water and a maximum depth of 32 ft. It has clear, slightly acid water of high transparency (Table 1). The littoral materials are primarily sand with some gravel and muck. The entire basin lies within public ownership (Northern Highland-American Legion State Forest) and boat access is unimproved and/or difficult. Rooted aquatic pants are relatively sparse, with water shield (Brasenia schreberi), bur-reed (Sparganium sp.), and yellow water lily (Nuphar variegatum) being the most common.

Madeline Lake (T39N, R7E, Sec. 5), Oneida County, and Camp Lake (T41N, R6E, Sec. 27), Vilas County were the source of the adult female bluegills for Wildwood Lake. The morphological, chemical, and fishery characteristics of these lakes are also noted in Table 1.

TABLE 1. Morphological, chemical, and fishery characteristics of Wildwood, Madeline, and Camp lakes.

Lake and County	Surface Acres	Maximum Depth (ft)	Shoreline Development Factor	Miles Shoreline	Alkalinity** (mg/l)	Conductivity (micromhos at 77 F)	pH	Color	Fishery***
Wildwood Vilas Co.	15.7	32	1.26	0.7	1.5	14	6.0	Clear	Chemically treated
Madeline Oneida Co.	154.4	25	1.84	3.2	52.0	118	7.0	Clear	M,WE,LMB,YP,BG BC, RB, PS
Camp Vilas Co.	59	31	2.42	2.6	2.0	16	6.2	Clear	M,LMB,BG,PS,YP

* Ratio of shoreline to lake area with 1.00 describing a circle. As the value increases, there is either greater shoreline irregularity or more shoreline in relation to water area. Formula used:

$$SDF = 7.136 \times \frac{1}{\sqrt{A}} \times S_L$$

where SDF = shoreline development factor, A = area in acres, and S_L = shore length in miles.

** Wildwood and Camp - methyl orange alkalinity (MOA); Madeline - methyl purple alkalinity (MPA).

*** M = muskellunge, WE = walleye, LMB = largemouth bass, YP = yellow perch, BG = bluegill, BC = black crappie, RB = rock bass, PS = pumpkinseed.

METHODS

Initial surveys of Wildwood Lake in 1975 and 1976 suggested that a low value panfish population comprised of yellow perch existed (Wendt 1976). Wildwood Lake was chemically treated during the late fall of 1976 with Pro-Noxfish at a rate of 2.5 ppm synergized rotenone or 210 total gal. Pro-Noxfish ingredients are as follows: rotenone (2.5%), other cube extractions (5.0%), N-octyl sulfoxide of isosofrole (sulfoxide)(2.2%), related compounds (0.3%), and inert ingredients (90.0%).

Shortly after ice-out in the spring of 1977, several cages containing 2-4 bluegills each were lowered to various depths throughout the lake. These cages remained in the lake for a period of 1 week to insure that detoxification had occurred. Also during this same period, 3 4-ft. small mesh fyke nets were fished for 4 days to determine if elimination of the fish population had been achieved. No fish were captured.

During 1-10 June 1977, large mesh fyke nets (5-ft) were fished in Madeline Lake to obtain specimens for stocking. All adult bluegills captured were sexed by gently squeezing the abdominal cavity to observe sex products. All females were held in an oxygenated tank truck and transferred to Wildwood Lake when sufficient numbers had been collected or at the end of each netting day. A random sample (122) of the female bluegills was measured to the nearest 0.1 inch total length to determine average length at the time of stocking. No weight data were collected.

The aforementioned procedure was utilized during 6-7 June 1978 at Camp Lake. Length and weight data of a sample of these fish were collected within a week after stocking. It was assumed that little or no growth occurred during their initial week in Wildwood Lake.

Four-foot large mesh (1 inch) and small mesh (3/8 inch) fyke nets were utilized during all sampling periods with the exception of the fall 1978 and 1979 nettings (Fig. 2). In addition, during October 1978 and 1979, small mesh (1/4 inch) fyke nets with a 30-inch hoop were substituted for shoreline seining to determine if any bluegill reproduction and/or reintroduction of minnow species had occurred. All bluegills captured were given a bottom caudal clip, measured to the nearest 0.1 inch total length, and weighed to the nearest whole gram.

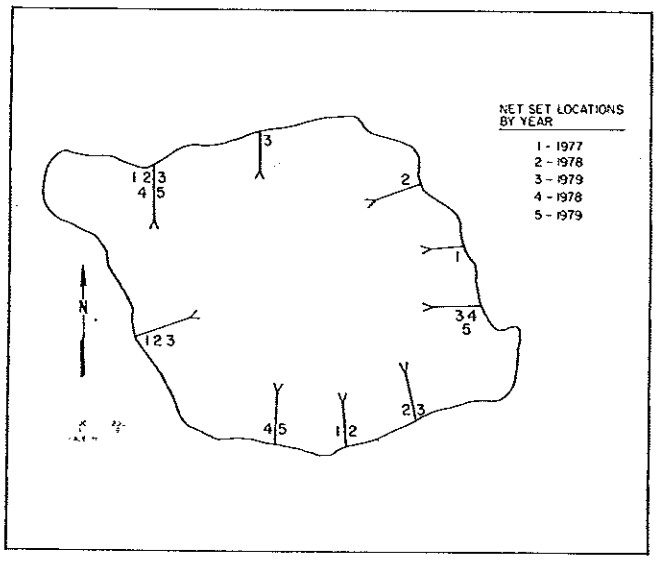

FIGURE 2. Net locations in Wildwood Lake from 1977 to 1979.

Scales were removed in the spring of 1978 from a random sample of the 1977 and 1978 stocked bluegills to determine their age structure at time of stocking. All scales were taken on or just below the lateral line approximately 3/4 inch posterior to the left pectoral fin.

On 13 July 1978, 1 vertical tow with a Clarke-Bumpus No. 10 mesh net was made over the approximate location of the maximum depth to determine the size and species (Pennak 1953) of zooplankton available as a food base for the adult bluegills.

Graphs denoting length-weight relationships were constructed for the bluegills 1 year after each of the 2 introductions into Wildwood Lake. Calculated weights for given lengths of female bluegills in Wildwood Lake were also determined using the length-weight regression formula, $\log W = 4.131 \log L - 1.477$, $r = 0.957$ (1978) and $\log W = 3.430 \log L - 0.802$, $r = 0.984$ (1977). Condition factors (R) and (C) of the female bluegills were calculated using the following formulas:

$$R = \frac{W \times 10}{L^3}$$

where R = condition factor, W = weight to nearest gram, and L = total length to nearest 0.1 inch; and

$$C = \frac{W \times 10^5}{L^3}$$

where C = condition factor, W = weight to nearest 0.01 lb, and L = total length to nearest 0.1 inch.

Total mortality and standing crop estimates of bluegills in Wildwood Lake were determined over the 2 1/2-year study period. The Schnabel (1977 estimate) and Petersen (1978 and 1979 estimates) methods of estimating population size were used during the investigations as follows:

Schnabel method: $$P = \frac{\Sigma M (u + r)}{\Sigma r}$$

where P = estimated number in population, M = number of fish marked, u = number of unmarked fish in sample, and r = number of recaptured fish in sample; and

Petersen method: $$P = \frac{M C}{R}$$

where P = estimated number in population, M = number of fish marked, C = number of fish in sample, and R = number of marked fish in sample.

Only the 1978 stocked bluegills from Camp Lake were given a permanent fin clip (right pectoral) to differentiate them from the unmarked 1977 fish from Madeline Lake.

TABLE 2. Population density, mortality, and standing crop of the female bluegills stocked in 1977 and 1978 in Wildwood Lake, Vilas County.

Sampling Date	No. Stocked	Population Estimate*	Percent Total Mortality	Standing Crop No./Acre	Standing Crop Lb/Acre	Avg. Total Length (inches)	Avg. Weight (g)
1977 Stocking							
7-10 Jun 1977	1,562		-	100	13.2 (est.)	6.1	60.0 (est.)
13-15 Sep 1977		597 (544-648)	62	38	14	7.6	167.8
6-8 Jun 1978		Marking period	-	-	-	7.6	184.2
20-21 Jun 1978		309 (303-315)	80	20	8	7.9	189.3
12-15 Jun 1979		Marking period	-	-	-	8.7	268.0
27-28 Jun 1979		61 (60-62)	96	4	2	8.7	268.0
16 Oct 1979		None captured	-	-	-	-	-
1978 Stocking							
6-7 Jun 1978	1,600		-	102	12	5.8	54.4
12-15 Jun 1979		108 (106-110)	94	7	3	7.5	178.0
16 Oct 1979		Too few captured	-	-	-	8.9	253.4

* 95% confidence limits in parentheses. Population for 13-15 Sep 1977 sampling was determined using the Schnabel method. All other population estimates were determined using the Petersen mark and recapture method.

Six large adult female bluegills were removed from Wildwood Lake in September 1977 to analyze their stomach contents and determine the variety of food organisms in their diet.

RESULTS

A total of 1,562 (100/acre) adult female bluegills averaging 6.1 (range 4.7-7.7) inches total length were stocked during early June of 1977. The average weight of these fish was not determined but was estimated to be 60 g for a stocking rate of about 13.2 lb/acre.

In September 1977, approximately 3 months after stocking, a population estimate revealed that 597 fish (38/acre) remained, representing a total mortality of 62% (Table 2). Their average length was 7.6 inches (range 5.6-8.7), an increase of 1.5 inches. The average weight of these bluegills was 167.8 g ($\bar{C}$ = 84.3).

The 1977 stocked bluegill population was again estimated in early June 1978. There were 295 fish captured during the marking period. The average length of these fish remained at 7.6 inches (range 6.7-8.8). Their average weight was 184.2 g ($\bar{C}$ = 93.4), representing a slight overwinter increase of 16.4 g (9%). The recapture survey was initiated in late June 1978 and the population estimate revealed that 309 bluegills (20/acre) remained from the 1977 stocking, representing a total mortality of 80% after 1 year in the lake. During the 2-week period between marking and recapture a slight increase in length (0.3 inches) and weight (5.1 g) was evident.

On 6-7 June 1978, a total of 1,600 (102 fish and 12.2 lb/acre) female bluegills (2nd stocking) were again introduced. These bluegills ranged in size from 5.0 to 7.3 inches (average 5.8) and their average weight was 54.4 g ($\bar{C}$ = 61.5).

The 3rd and final estimate of population size of the 1977 stocked bluegills was made in June 1979. The estimated number remaining was 61 (4/acre) bluegills ranging in size from 6.8 to 9.6 inches (average 8.7). Their average weight was 268.0 g ($\bar{C}$ = 89.6), an increase of 47% from their 1978 average. The total mortality of the 1977 stocked bluegills after 2 years in Wildwood Lake was 96%. Their average length, after 2 years in the lake, increased from 6.1 to 8.7 inches, a gain of nearly 43%. Although no average weight was obtained at the time of stocking, it is likely that these fish increased their average weight by at least 300%.

Also during June 1979, the 1st population estimate of the 1978 stocked bluegills was

TABLE 3. Length-frequency distribution during the survey period of the female bluegills stocked in Wildwood Lake in 1977.

Size Range (in Inches)	No. Fish in each Size Range by Sampling Date				
	7-10 Jun 1977*	13-15 Sep 1977	6-8 Jun 1978	12-15 Jun 1979	16 Oct 1979
4.5-4.9	2				
5.0-5.4	7				
5.5-5.9	36	1			
6.0-6.4	53	3			
6.5-6.9	16	18	8	1	
7.0-7.4	6	144	71		
7.5-7.9	2	188	161		
8.0-8.4		46	48	10	
8.5-8.9		3	7	34	
9.0-9.4				15	
Total	122	403	295	60	0**

*A length-frequency sample of the 1,562 female bluegills captured in Madeline Lake prior to their stocking in Wildwood Lake in 1977.
**None captured.

TABLE 4. Length-frequency distribution during the survey period of the female bluegills stocked in Wildwood Lake in 1978.

Size Range (In Inches)	No. Fish in each Size Range by Sampling Date		
	6-7 Jun 1978*	12-15 Jun 1979	16 Oct 1979
5.0- 5.4	25		
5.5- 5.9	106		
6.0- 6.4	32		
6.5- 6.9	11	1	
7.0- 7.4	3	21	
7.5- 7.9		44	
8.0- 8.4		31	1
8.5- 8.9		9	5
9.0- 9.4		1	3
9.5- 9.9			1
Total	177	107	10

*A length-frequency sample of the 1,600 female bluegills captured in Camp Lake prior to their stocking in Wildwood Lake in 1978.

made. Their average length when stocked was 5.8 inches (spring 1978) and this increased to 7.5 inches by the spring of 1979, an increase of 1.7 inches the 1st year. During this same period, their average weight increased from 54.4 g (C = 61.5) to 178.0 g (C = 92.4), a gain of 123.6 g (227%). Their population size was estimated at 108 bluegills (7/acre), representing a total mortality of 94% after 1 year in Wildwood Lake.

Growth, both in length and weight, during the 1st year after introduction of the 1977 and 1978 bluegills was comparable; however, a higher mortality (14%) of the 1978 fish was evident (Table 2). Length-frequency characteristics of these fish at various times during the study are found in Tables 3 and 4.

No immediate mortality was observed after the 1977 stocking. One day after the bluegills were stocked in 1978, 89 dead fish were counted in the littoral area, representing a minimum initial mortality of 5.6%.

During the late June sampling period in 1978 several adult male bluegills were captured and removed. Sexing and/or sorting procedures at the time of collection from Madeline or Camp lakes were suspected as the origin of the male bluegill introduction. Obviously this jeopardized the management strategy of maintaining population control through the

TABLE 5. Length-frequency, average length, average weight, and condition of fingerling and Age 1+ bluegills resulting from natural reproduction (sampling date = 16 October 1979).

Group and Size Range (inches)	No. Fish	Avg. Total Length (inches)	Avg. Weight (g)	Condition Factor (C)
Fingerlings				
2.3	2			
2.4	5			
2.5	9			
2.6	7			
2.7	14			
2.8	17			
2.9	13			
3.0	20			
3.1	13			
3.2	18			
3.3	21			
3.4	7			
3.5	11			
3.6	6			
3.7	8			
Total	171	3.0	8.8	74.1
Age 1+				
3.8	4			
3.9	1			
4.0				
4.1	2			
4.2	4			
4.3	1			
4.4	5			
4.5	11			
4.6	12			
4.7	10			
4.8	12			
4.9	4			
5.0	32			
5.1	10			
5.2	16			
5.3	26			
5.4	21			
5.5	11			
5.6	13			
5.7	6			
5.8	2			
5.9	1			
Total	204	5.0	29.3	48.0

alleviation of natural reproduction. Subsequently, 3 small mesh (1/4-inch) fyke nets (30-inch diameter) were fished for 2 days in October 1978 to determine if any natural reproduction had occurred. Approximately 20 fingerling bluegills averaging 2.4 inches in length were captured and removed.

During the spring netting period in 1979, 2 small (3/8-inch) fyke nets (4-ft diameter) yielded high number of yearlings (637) showing little or no increase in growth from the fall of 1978. Three small mesh (1/4-inch) fyke nets (30-inch diameter) were again fished in October 1979 and 171 fingerlings and 204 yearling bluegills were captured with average lengths of 3.0 and 5.0 inches, respectively (Table 5).

Individual weights were taken on the 1-year plus bluegills and they averaged 29.3 g (C = 48.0). The average weight of the fingerlings was 8.8 g (C = 74.1).

Stomach analysis of the 6 female bluegills collected in early fall 1977 provided the following information: Four stomachs were completely empty and the contents may have been regurgitated after netting. The remaining 2 fish were full of damselfly nymphs (order Odonata, suborder Zygoptera), beetle adults and larvae (order Coleoptera), and dobsonflies (order Megaloptera, family Corydalidae). Because the stomach contents were not immediately preserved in Formalin, continuing digestion made identification of zooplanters impossible.

DISCUSSION

Mortality

Excellent growth was attained by the female bluegills 1 year after each of the 2 introductions (Figs. 3 and 4). Their weight after introduction significantly exceeded that of bluegills in other area lakes (Tables 6 and 7). However, both stockings suffered a very high total mortality during the 2-year study period.

It is not uncommon for bluegill populations to exhibit a low annual survival rate. A study conducted on Murphy Flowage (Rusk County), in which bluegill were the dominant panfish, revealed high natural mortalities of catchable fish. Data for 2 consecutive years revealed that an average of 36% of the preseason stock survived 1 year. The total mortality of 64% was comprised of 19% angling and 45% natural mortality (Snow et al. 1970).

A Michigan study (Beyerle 1977) conducted over a 5-year period on 3 small ponds also found annual natural mortalities of bluegills, ranging from 43 to 69% throughout the study period. A Michigan experiment utilizing hybrid (bluegill x green sunfish) fry stocked in 3 chemically reclaimed lakes closed to fishing resulted in more than 80% natural mortality over a 2-year period (Laarman 1978). In Camp Lake from which the bluegills stocked in 1978 were obtained, Serns (1979a) found an 80.6% total annual mortality rate for Age V and older bluegills.

The aforementioned data suggests that we can expect high annual total mortalities. Therefore, to sustain a sport fishery with desirable numbers of bluegills utilizing this management strategy, it will be necessary to provide annual stocking for population maintenance. Prior to implementation of a re-occurring stocking project of this type it is imperative that angler harvest be assessed and a better method of sex identification be developed.

If high angler exploitation occurs, it may be necessary to regulate harvest. Possibly reduced bag limits would extend fishing opportunity and provide larger, trophy-sized fish. However, other strategies might also have to be implemented to prevent overexploitation.

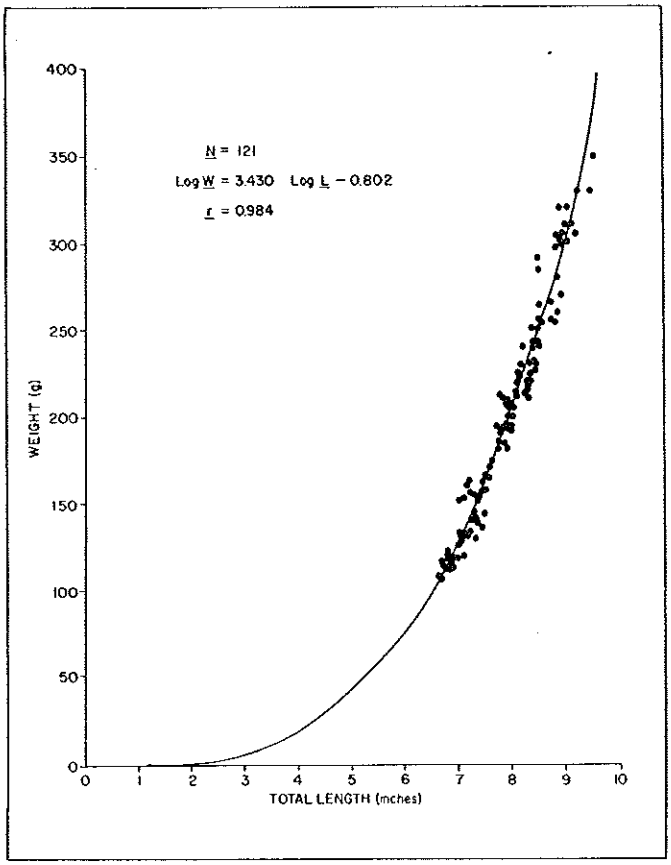

FIGURE 3. Length-weight relationship of female bluegills stocked in 1977 after 1 year in Wildwood Lake.

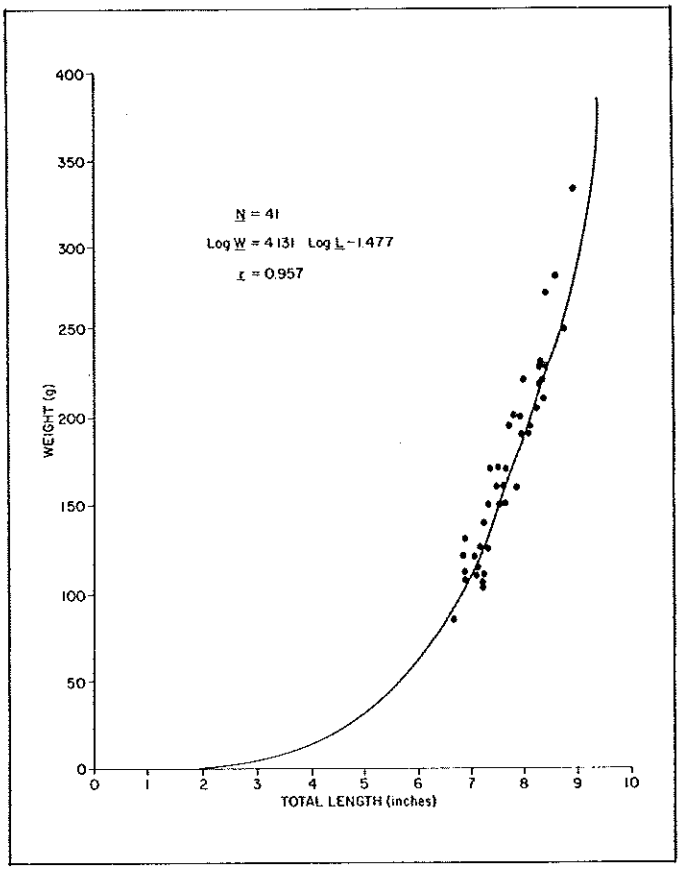

FIGURE 4. Length-weight relationship of female bluegills stocked in 1978 after 1 year in Wildwood Lake.

TABLE 6. Calculated weights for given lengths of the female bluegills stocked in 1977 and collected in Wildwood Lake during 20-21 June 1978, compared with weights for bluegills from 5 other Vilas County lakes.

Parameter	Wildwood Lake	Emerald Lake*	Camp Lake	Flora Lake	Bragonier Lake	Shannon Lake
Length-weight Regression Formula	Log W=3.430 Log L-0.802	Log W=3.208 Log L-0.654	Log W=3.080 Log L-0.765	Log W=3.213 Log L-0.852	Log W=2.900 Log L-0.513	Log W=2.930 Log L-0.560
N	121	70	212	250	200	264
Total length (inches)	Weight (g)					
1.0	0.1	-	-	-	-	-
2.0	1.7	2.0	1.5	1.3	2.3	2.1
3.0	6.8	7.5	5.1	4.8	7.4	6.9
4.0	18.3	18.9	12.3	12.1	17.1	16.0
5.0	39.4	38.8	24.4	24.8	32.7	30.8
6.0	73.6	70.0	42.8	44.4	55.5	52.5
7.0	124.9	114.0	68.9	72.9	86.8	82.4
8.0	197.5	175.0	103.9	111.9	127.9	121.9
9.0	295.8	255.4	149.4	163.7	180.0	172.2
10.0	424.6	-	-	-	-	-
11.0	588.8	-	-	-	-	-

*Stocked male bluegills only.

TABLE 7. Calculated weights for given lengths of the female bluegills stocked in 1978 and collected in Wildwood Lake during 12-13 June 1979, compared with weights for bluegills from 4 other Vilas County lakes.

Parameter	Wildwood Lake	Camp Lake	Flora Lake	Bragonier Lake	Shannon Lake
Length-weight	Log W=4.131	Log W=3.080	Log W=3.213	Log W=2.900	Log W=2.930
Regression Formula	Log L-1.477	Log L-0.765	Log L-0.852	Log L-0.513	Log L-0.560
N	41	212	250	200	264
Total length (inches)	Weight (g)				
2.0	0.6	1.5	1.3	2.3	2.1
3.0	3.1	5.1	4.8	7.4	6.9
4.0	10.2	12.3	12.1	17.1	16.0
5.0	25.7	24.4	24.8	32.7	30.8
6.0	54.6	42.8	44.4	55.5	52.5
7.0	103.2	68.9	72.9	86.8	82.4
8.0	179.3	103.9	111.9	127.9	121.9
9.0	291.7	149.4	163.7	180.0	172.2
10.0	450.8	-	-	-	-

TABLE 8. Average length and weight characteristics of Wildwood Lake female bluegills and Emerald Lake male bluegills (1977 and 1978 stockings).

Parameter	Wildwood Lake (Females only)	Emerald Lake (Males only)*
Length (in inches)		
1977 Stocking		
1977 length	6.1	6.0
1979 length	8.7	7.8
Length increase	2.6 (+43%)	1.8 (+30%)
1978 Stocking		
1978 length	5.8	5.9
1979 length	8.9	7.6
Length increase	3.1 (+53%)	1.7 (+29%)
Weight (g)		
1977 Stocking		
1977 weight	60 (est.)	60 (est.)
1979 weight	268	203
Weight increase	208 (+347%)	143 (+238%)
1978 Stocking		
1978 weight	54	49
1979 weight	253	155
Weight increase	199 (+369%)	106 (+216%)

*From Smith and Andrews (Wis. Dep. Nat. Resour., Woodruff Area files, unpubl. data).

Comparison to Other Lakes

A comparable study (Smith and Andrews, Wis. Dep. Nat. Resour., Woodruff Area files, unpubl. data) utilizing male bluegills was conducted in nearby Emerald Lake during this same time period. When comparing both lakes it was evident that the 1977 stocked female bluegills in Wildwood Lake exhibited better average growth throughout the 2-year study period

TABLE 9. Qualitative zooplankton analysis of Camp, Wildwood, and Emerald lakes, Vilas County, 13 July 1978.

Taxa	Number of Organisms		
	Camp Lake	Wildwood Lake	Emerald Lake
Cladocera			
Cididae			
Diaphanosoma sp.	50 (0.8)*	21 (0.8)	15 (0.6)
Holopedidae			
Holopedium gibberum		4 (1.3)	53 (0.9)
Daphnidae			
Daphnia sp.	8 (1.0)	6 (1.2)	23 (1.3)
Bosminidae			
Bosmina sp.	2 (0.7)		13 (0.5)
Copedpoda			
Calanoida (excluding *Epischura*)	90 (0.8)	108 (0.8)	65 (0.7)
Epischura lacustris		1 (2.0)	
Cyclopoida		10 (0.9)	2 (1.0)
Diptera			
Chaoboridae			
Chaoborus sp.			16

*Mean length (mm) noted in parentheses.

(Table 8). Conversely, the males exhibited better survival during their 1st year; however, total mortality surpassed that of the females by the end of the investigation period.

The 1978 stockings in both lakes suffered high losses during the 1st year after introduction. The Wildwood Lake females demonstrated substantially better growth than the Emerald Lake males. Female bluegills evidently achieve better growth than their male counterpart; however, differential availability or size of plankton may contribute to growth differences between these experimental lakes.

The qualitative zooplankton analysis of Wildwood, Emerald, and Camp lakes can be found in Table 9. The mean length of the *Holopedium gibberum* in Wildwood Lake was larger than those in Emerald Lake and none were found in Camp Lake. The *Daphnia* sp. in Wildwood and Emerald lakes were larger than those in Camp Lake and a large *Epischura lacustris* was found only in Wildwood Lake. The presence of larger zooplankton in Wildwood Lake suggests that the number of stocked adult bluegill may have been below the level capable of overgrazing these species.

The age data revealed that the predominant year class stocked in 1977 and 1978 was 7 (range 4-8) and 5 (range 4-7), respectively (Tables 10 and 11). Because most bluegills probably do not live beyond 7 years of age (Snow et al. 1970), it would seem logical to select smaller (i.e., younger) adult fish, after determining their age structure, to insure greater longevity. However, the bluegills stocked in 1978 were a somewhat younger population than those stocked in 1977, and suffered the highest total mortality during their 1st year in the lake.

The mean lengths of the 1977 Wildwood Lake bluegills were slightly below the north central Wisconsin average (H. W. Carlson, Wis. Dep. Nat. Resour., Woodruff Area files, unpubl. data) for comparable age classes as noted in Table 12. However, their 1979 condition substantially exceeded that for bluegills in other lakes in the area (Table 13). In order to compare condition (C) to normal populations, the male and female bluegill condition (C) data from both Wildwood and Emerald lakes were combined. In this circumstance, their condition (C) also was greater than that found in the other area lakes (Table 14).

Manuel and Baker lakes (contiguous waters), Vilas County and Schlecht Lake, Oneida County have low numbers of bluegills but these are large and fast growing. Those 6 inches and larger average 8.3 and 9.0 inches, respectively. The standing crop for Manuel and Baker lakes (Carlson 1978) was 3.6/acre (1.8 lb) and for Schlecht Lake (Serns 1979b) it was 4.0/acre (2.0 lb). After 2 years in Wildwood Lake, the bluegills stocked in 1977 had declined to 4.0/acre (2.0 lb) and after 1 year, the fish stocked in 1978 were reduced to 7.0/acre (3.0 lb). Therefore, if competition or density dependent interactions are critical limiting factors, low densities of large bluegills might be expected from this type of management in soft water lakes having minimal cover.

Comparison of total length in inches for the fingerling and yearling bluegills in Wildwood Lake with bluegills from other lakes in the northern Midwest revealed excellent growth (Table 15). Both year classes of Wildwood Lake bluegills were sampled in early October 1979, therefore lengths may not represent completed growing seasons.

TABLE 10. Age and back-calculated lengths of the bluegills stocked in Wildwood Lake in 1977 and collected 21 June 1978.

Year Class	No.	Mean Total Length at Capture (inches)	Back-calculated Total Length (in inches) at Annulus 1	2	3	4	5	6	7	8	9
1973	1	6.9	1.1	2.2	3.4	4.7	6.9				
1972	2	6.9	0.8	1.8	2.8	3.6	4.6	6.9			
1971	21	7.5	1.0	2.2	3.5	4.4	5.2	6.1	7.4		
1970	43	7.8	1.0	2.2	3.4	4.2	4.8	5.4	6.1	7.7	
1969	8	8.5	0.9	1.9	3.0	4.0	4.8	5.5	6.3	7.3	8.5
Avg. back-calculated total length (in inches)			1.0	2.1	3.2	4.2	5.3	6.0	6.6	7.5	8.5
No. in sample			(75)	(75)	(75)	(75)	(75)	(74)	(72)	(51)	(8)
Avg. growth increments (in inches)			1.0	1.1	1.1	1.0	1.1	0.7	0.6	0.9	1.0

TABLE 11. Age and back-calculated lengths of the bluegills stocked in Wildwood Lake in 1978 and collected 22 June 1978.

Year Class	No.	Mean Total Length at Capture (inches)	Back-calculated Total Length (in inches) at Annulus 1	2	3	4	5	6	7
1973	3	5.3	1.2	2.7	3.7	4.5			
1972	16	5.6	1.2	2.7	4.1	4.9	5.4		
1971	11	6.4	1.2	2.7	4.0	5.0	5.6	6.2	
1970	5	7.0	1.0	2.1	3.4	4.5	5.5	6.1	6.6
Avg. back-calculated total length (in inches)			1.2	2.6	3.8	4.7	5.5	6.2	6.6
No. in sample			(35)	(35)	(35)	(35)	(32)	(16)	(5)
Avg. growth increments (in inches)			1.2	1.4	1.2	0.9	0.8	0.7	0.4

TABLE 12. Average total length of 1977 stocked Wildwood Lake bluegills of various ages compared to ages of bluegills from other north central Wisconsin seepage lakes.*

Seepage Lakes	Age IV	V	VI	VII	VIII
Wildwood (1977 stocking only)	-	6.9	6.9	7.4	7.7
Bragonier	5.4	6.3	7.0	7.6	7.9
Camp	5.4	6.0	6.5	7.4	7.9
Flora	4.6	5.3	5.9	6.6	7.2
Manuel	7.6	-	9.1	10.0	10.2
Schlecht	7.2	7.8	8.4	8.8	9.1
Shannon	5.3	6.1	7.2	7.5	8.0
Squash	5.6	6.8	8.2	9.5	9.8
average**	5.9	6.4	7.5	8.2	8.6

*Note: Lengths (inches) were back-calculated for a given age.

*Source = H. W. Carlson (Wis. Dep. Nat. Resour., Woodruff Area files, unpubl. data).

TABLE 13. Mean condition factors of female bluegills stocked in 1978 and captured in Wildwood Lake on 12 June 1979 compared with condition factors of bluegills (both sexes) in 4 other Vilas County lakes.

Total Length Range (inches)	Wildwood R	Wildwood C	Camp C	Shannon C	Flora C	Bragonier C
6.0-6.9	2.70 (1)*	60.4 (1)	43.5 (123)	54.4 (65)	49.6 (157)	54.4 (164)
7.0-7.9	3.22 (20)	73.5 (20)	46.1 (15)	53.6 (64)	51.6 (119)	56.2 (93)
8.0-8.9	3.73 (19)	82.2 (19)	55.8 (1)	54.7 (58)	51.6 (1)	59.3 (16)
9.0-9.9	4.38 (1)	96.9 (1)	62.9 (1)	-	-	-

*Sample size is noted in parentheses.

TABLE 14. Condition factors (C) of Wildwood Lake (female) and Emerald Lake (male) bluegills, sexes combined, compared to condition factors of both sexes in 4 other Vilas County lakes.

Total Length Range (inches)	Emerald-Wildwood (combined)	Camp	Shannon	Flora	Bragonier
6.0-6.9	74.4 (28)*	43.5 (123)	54.4 (65)	49.6 (157)	54.4 (64)
7.0-7.9	78.4 (39)	46.1 (15)	53.6 (64)	51.6 (119)	56.2 (93)
8.0-8.9	81.8 (37)	55.8 (1)	54.7 (58)	51.6 (1)	59.3 (16)

*Sample size is noted in parentheses.

SUMMARY

This investigation revealed that growth in length was below the north central Wisconsin average; however, condition exceeded that in other bluegill lakes in the area. Survival, as in most other bluegill populations having large adult fish, was extremely low. Angler harvest was not determined, therefore natural mortality was not assessed; however, other data suggest that a high rate of natural mortality can be expected. Why a modest adult bluegill population free from predation and competition with other species should suffer heavy mortalities is unknown. If better survival can be achieved, this type of management strategy should benefit the angler.

A problem common to chemically treated lakes is the re-introduction or survival of undesirable fish species. The accidental introduction of male bluegills into Wildwood Lake ultimately led to the establishment of natural year classes. Due to this circumstance, we continued to monitor the fishery beyond the scheduled study completion date of October 1979.

Brief investigations were conducted in October 1980 and July 1981. These surveys revealed strong natural year classes of bluegills and a declining growth rate (Table 16). In October 1979 the 1st natural year class of Age I+ bluegills exhibited an average length of 5.0 inches. Age I+ bluegills in 1980 averaged 4.2 inches and in July 1981, 2.5 inches. The 1981 sampling of Age I+ fish was earlier than that in 1979 and 1980. Therefore it is likely that by October their average length would have increased slightly, probably less than 1 inch.

A length-frequency summary of the 1979-81 bluegill catch is provided in Table 17. The 1980 and 1981 data find a portion of the bluegill population moving upward into acceptable size ranges for a sport fishery (6 inches +). However, it was our opinion that an overabundant slow growing fishery would shortly materialize. Consequently, the lake was again chemically treated with rotenone during the fall of 1981. A revised management strategy is under consideration, that being a smallmouth bass and brown trout fishery.

To achieve the objectives of the type of management strategy tested in this study, it is imperative that the procedures used in the sexing and sorting of bluegills, or any other species, be improved. In this investigation, males and females were sexed and sorted

TABLE 15. Comparison of total lengths (in inches) for fingerling and yearling bluegills in Wildwood Lake with total lengths of bluegills from other lakes in the northern Midwest.

Lake	No. Fish	Length at Annulus or after Growing Seasons Completed 1	2
Wildwood, WI*	375	3.0	5.0
Shannon, WI** (Serns 1977)	145	1.8	2.5
Bragonier, WI** (Serns 1977)	101	1.9	3.0
Flora, WI** (Serns 1977)	329	2.2	2.9
Bucks, WI*** (Snow 1969)	790	1.8	3.8
Murphy FLowage, WI*** (Snow 1969)	5,888	1.5	2.9
Clear, WI*** (Snow 1969)	1,115	1.4	2.2
Northern Wisconsin Average*** (Snow et al. 1970)	-	2.1	3.8
Buckeye, OH** (Morgan 1951)	-	1.6	2.9
Murphyresboro, IL** (Louder and Lewis 1957)	212	1.7	2.9
Red Haw, IA** (Lewis 1950)	133	1.4	3.4

*Based on known age fish prior to growing seasons completed.

**Lengths were back calculated.

***Lengths are average length of scale-aged fish at end of growing season.

TABLE 16. Length frequency of Age 1+ bluegills captured in Wildwood Lake in 1979-81.

Size Range (In Inches)	No. Fish In each Size Range by Sampling Date 16 Oct 1979	14 Oct 1980	28 Jul 1981
2.0-2.4			124
2.5-2.9			131
3.0-3.4		2	3
3.5-3.9	5	40	
4.0-4.4	12	107	
4.5-4.9	49	40	
5.0-5.4	105		
5.5-5.9	33		
Total	204	189	258
Avg. length (inches)	5.0	4.2	2.5
Avg. weight (g)	29.3	17.3	No data
Condition (C)	48	54	No data

TABLE 17. Length-frequency of bluegills captured in Wildwood Lake in 1979-81.

Size Range (inches)	No Fish in each Size Range by Sampling Date			
	12-15 Jun 1979	16 Oct 1979	14 Oct 1980	28 Jul 1981
1.5-1.9			*	86
2.0-2.4	61	7	*	351
2.5-2.9	26	60	*	131
3.0-3.4		79	2	3
3.5-3.9		30	42	16
4.0-4.4		12	107	143
4.5-4.9		49	93	217
5.0-5.4		105	192	165
5.5-5.9		33	189	120
6.0-6.4			65	53
6.5-6.9	1		6	9
7.0-7.4	23**			3
7.5-7.9	44			
8.0-8.4	41	1	1	
8.5-8.9	43	5	2	
9.0-9.4	17	3	1	
9.5-9.9	1	1		
No. measured	257	385	700	1,297
No. counted	449	None	401	1,160
Total catch	706	385	1,101	2,457

Stocked (1977 and 1978) ↓ natural ↑

*Bluegills less than 3 inches (1980 fingerlings) were not vulnerable to capture due to fishing of 3/8 inch mesh size net only.

**Includes 21 females and 2 males.

simultaneously as the males were to be used in a companion study in another lake (Emerald). It is recommended that either 1 sex be processed at a particular time or 2 separate crews sorting either male or female, but not both, be used. In addition, it would be advisable to use separate tank trucks for the transfer. These suggested procedures do not alleviate the probability of a mistake in identification or sorting. A practical method of sterilization would provide the best means of meeting this requirement.

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